Honeywell

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June 22, 2011

To: Holly Sammon, Onondaga County Public Library (1 bound)
Samuel Sage, Atlantic States Legal Foundation (1 bound)
Cara Burton, Solvay Public Library (1 bound)

Re: Letter of Transmittal – Wastebeds 1-8 Site Document Repository Addition

The below document has been approved by the New York State Department of Environmental Conservation (NYSDEC) and is enclosed for your document holdings:

- Wastebeds 1-8 Human Health Risk Assessment Revised Report, O'Brien & Gere, April 2011.

Sincerely,
John P. McAuliffe by CCC
John P. McAuliffe, P.E.
Program Director, Syracuse

Enc.

cc: Tracy A. Smith – NYSDEC (ltr only)

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
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Joe Martens
Commissioner

June 13, 2011

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

Re: Wastebeds 1-8 Human Health Risk Assessment

Dear Mr. McAuliffe:

The New York State Department of Environmental Conservation has reviewed the "Human Health Risk Assessment - Wastebeds 1 through 8 Site" (HHRA) dated April 2011. Based on our review, the HHRA is approved. If you have any questions, please contact me at 518-402-9796.

Sincerely,

Tracy A. Smith

Tracy A. Smith
Project Manager

ecc:	J. Gregg, NYSDEC	R. Nunes, USEPA	M. Sergott, NYSDOH
	H. Kuhl	J. Shenandoah	J. Heath, Esq.
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	F. Kirshner	D. Crawford, OBG	T. Conklin, OBG

REVISED REPORT

Human Health Risk Assessment Wastebeds 1 through 8 Site Geddes, New York

Honeywell

April 2011

Job No. 1163.39642

REVISED REPORT

Human Health Risk Assessment
Wastebeds 1 through 8 Site
Geddes, New York

Honeywell

Douglas M. Crawford, P.E.
Vice President

April 2011

O'BRIEN & GERE

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List of Acronyms

1,1,1-TCA - 1,1,1-Trichloroethane
1,1-DCE - 1,1-Dichloroethene
ABS - Dermal Absorption Factor
ABS_{GI} - Gastrointestinal Absorption Efficiency
ADAF - Age Dependent Adjustment Factor
AF - Soil/Sediment-to-Skin Adherence Factors
ARAR - Applicable or Relevant and Appropriate Requirements
AT - Averaging Time
AT-C - Averaging Time for Exposure to Potentially Carcinogenic Compounds
AT-NC - Averaging Time for Exposure to Non-Carcinogens
ATSDR - Agency for Toxic Substances and Disease Registry
ATV – All-terrain Vehicle
B - Beta Constant
B&B - Blasland & Bouck
BW - Body Weight
CalEPA - California Environmental Protection Agency
CAS - Chemical Abstract Service
CDI - Chronic Daily Intake
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE - cis-1,2-Dichloroethene
COPC - Constituents of Potential Concern
CSF - Cancer Slope Factor
CT - Central Tendency
delta-BHC - delta-Benzenehexachloride
DL - Detection Limit
ED - Exposure Duration
EF - Exposure Frequency
EPAR - Exposure Pathway Analysis Report
EPC - Exposure Point Concentration
ET - Exposure Time
EU - Exposure Unit
EV - Event Frequency
FA - Fraction Absorbed
FS - Feasibility Study
HEAST - USEPA Health Effects Assessment Summary Table
HHRA - Human Health Risk Assessment
HSDB - Hazardous Substances Data Bank
InR - Inhalation Rate
IR - Ingestion Rate
IRIS - Integrated Risk Information System
IRM - Interim Remedial Measure
IRsoil - Incidental Ingestion Rate for soil
IRwater (potable) - Ingestion Rate for Drinking Water
IUR - Inhalation Unit Risk
K_p - Permeability Coefficient
LOAEL - Lowest Observed Adverse Effect Level

MMOA - Mutagenic Mode of Action
MRL - Minimal Risk Levels
NAPL - Non-aqueous Phase Liquids
NCEA - USEPA National Center for Environmental Assessment
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL - No Observed Adverse Effect Level
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
PAH - Polycyclic Aromatic Hydrocarbon
PCB - Polychlorinated Biphenyls
PCDD - Polychlorinated Dibenzo-p-dioxin
PCDF - Polychlorinated Dibenzofuran
PCE - Perchloroethylene
PEF - Particulate Emission Factor
PPRTV - Provisional Peer-Reviewed Toxicity Values
PRG - Preliminary Remediation Goal
PSA - Preliminary Site Assessment
RAGS - Risk Assessment Guidance for Superfund
RBC - Risk Based Concentration
RCP - Reinforced Concrete Pipe
RfD - Reference Dose
RI -Remedial Investigation
RME - Reasonable Maximum Exposure
ROS - Regression on Order Statistics
SA - Skin Surface Area
STSC - USEPA Superfund Technical Support Center
SVOC - Semivolatile Compound
t* - Time to Reach Steady State
TCE - Trichloroethene
TCLP - Toxicity Characteristic Leaching Procedure
TEF - Toxic Equivalency Factors
TEQ - Toxic Equivalent Concentration
t_{event} - Event Duration
τ_{event} - Lag Time Per Event
UCL - Upper Confidence Level
USEPA - United States Environmental Protection Agency
USEPA OSWER - USEPA Office of Solid Waste and Emergency Response
ve - Viable Epidermis
VF - Volatilization Factor
VOC - Volatile Organic Compound

Executive Summary

The Wastebeds 1-8 Site ("Site") is along Onondaga Lake's southwest shoreline and is adjacent to Ninemile Creek (NMC). As such, remedial efforts at Wastebeds 1-8 are closely linked to both the lake and Ninemile Creek sites. The Record of Decision (ROD) for the Onondaga Lake Bottom Site (NYSDEC and USEPA July 2005) acknowledges that controlling contamination from upland sites is integral to the overall remediation of Onondaga Lake and that there is a need to coordinate remedial efforts that could impact lake remediation efforts. Achieving the goals of the ROD and the community's vision of a restored Onondaga Lake requires a healthy and sustainable watershed.

At other upland sites once considered sources of contamination, Honeywell has made significant progress improving the watershed and developing a lake-sustaining Green Corridor. Restored wetlands at the remediated former LCP site in Geddes support native plant species that are attracting wildlife. A growing "Willow Farm" at the old Solvay Settling Basins supports healthier habitat and holds the promise of becoming a source of renewable energy. Plans are moving forward to remediate Geddes Brook and NMC and re-establish important habitat in those tributaries to Onondaga Lake. Groundwater is being collected along the southwest shoreline and pumped underneath I-690 to the Willis Avenue Groundwater Treatment Plant (GWTP) for treatment. Treated water is being tested to meet state standards before being returned to the lake.

The Wastebeds 1-8 Site is another upland site that is a source or potential source of contamination to both Onondaga Lake and NMC. These wastebeds (also called settling basins) consist primarily of inorganic wastes resulting from the production of soda ash using the Solvay process. Other waste materials associated with a variety of production processes from former Solvay Process, and later Allied Signal, operations were also likely disposed at the wastebeds.

An interim remedial measure (IRM) is planned at the Site to address potential impacts from the Site to the Onondaga Lake and NMC remedies. This IRM represents an important step toward the overall remediation of the Site, and brings an opportunity to expand this Green Corridor by linking and creating restored habitats from lower Geddes Brook to the shores of Onondaga Lake. The IRM will protect human health and the environment, and support a healthy lake watershed by improving habitat, and create new opportunities for recreation for the people of Central New York.

The entire Wastebeds 1-8 Site was deeded to the people of New York in 1953 and is currently owned by the State of New York and Onondaga County. The New York State Fair uses a portion of the Site for parking. Onondaga County is planning on extending the west side bike trail across the portion of the Site that it currently owns. Honeywell has been working closely with the County to fully integrate the trail with the Site-wide remedy at Wastebeds 1-8. This collaborative effort will result in new recreational opportunities for the people of Central New York.

This human health risk assessment (HHRA) is one step in the on-going remedial effort at this Site. This HHRA assesses potential risks to human health associated with Site-related chemical substances under current and reasonably foreseeable future land uses and to facilitate the consideration and evaluation of possible future remedial actions. Health risks were evaluated for potential trespassers (transient, lunchtime, fisherperson, and ATV recreator), workers (utility/sewer, ditch maintenance, construction, state fairgrounds maintenance, and commercial/industrial) recreational visitors (state fairgrounds attendee), and hypothetical residents under current and future exposure scenarios.

Estimation of risks to human health that may result from exposure to constituents in the environment is a complex process. Each assumption used in estimating cancer risks and non-cancer hazards, whether it is the toxicity value for a particular chemical or the value of a parameter in an exposure equation, has a degree of variability and uncertainty associated with it. In each step of the risk assessment process, beginning with the data collection and analysis and continuing through the toxicity assessment, exposure assessment, and risk characterization, conservative assumptions are made that are intended to be protective of human health and to ensure that risks and hazards are not underestimated.

This document uses the Exposure Unit (EU) concept to refine estimates of quantitative risk. An EU is defined as an area over which receptors are expected to integrate exposure when routinely present at the Site. For example, if a future construction worker has been identified as a potential receptor, that worker is assumed to be exposed randomly to Site media in an area equal to the area over which construction is possible. This area may include more than one of the defined sub-areas (exposure areas) of the Site: 1) State Fair Parking Areas, 2) the Lakeshore Area, 3) the Upland Old Field Successional Area, 4) the Biosolids Area, 5) the Ponded Area, 6) the Ditch A – South, and 7) the Site Ditches. As such, each receptor is associated with an EU that accounts for their potential exposure in all areas where the receptor may be expected to come in contact with environmental media.

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, 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 Ground Water)

Future land use at this Site is likely to include all of the current uses listed above, as well as some industrial or commercial activities. The Onondaga County Department of Transportation is proposing to extend the Lake Canalways Trail Section 1 roughly 1.5 miles along the lake shore over the wastebeds. It is also possible, though extremely unlikely, that future residents and commercial/industrial workers could use Site ground water as potable water. Based on these considerations, the following receptors were identified under reasonably foreseeable future conditions:

- Older child transient trespasser (Exposure Unit 1 – NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, 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)
- 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 Ground Water)
- 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 Ground Water)

Exposure media considered in both current and future scenarios include soil, sediment (seep and ditch sediment), surface water (including seep water), ground water, and ambient air. Receptors that may be exposed to surface soils (0-2 ft below ground surface [bgs]) include trespassers, commercial/industrial workers, state fairgrounds maintenance workers, and state fairgrounds attendees. Construction workers, commercial/industrial workers, and utility/sewer workers may contact upper soils (0-10 ft bgs). Trespassers, utility/sewer workers, construction workers, and ditch maintenance workers may be exposed to surface sediment (0-1 ft bgs). Trespassers, utility workers, construction workers, ditch maintenance workers may be exposed to surface water. Construction workers, utility/sewer workers, and commercial/industrial workers may contact shallow ground water (0-10 ft bgs).

Risk and Hazard Summary

Because of the uncertainties inherent in the risk assessment process, none of the exposure and risk calculations presented here should be interpreted as precise measures of the true risk. Rather, all risks and hazards should be interpreted as uncertain estimates. Because many (but not all) of the approaches for dealing with uncertainty are intended to be conservative (*i.e.*, are more likely to overestimate than underestimate), the risk and hazard values in this report should generally be thought of as high-end estimates of the true risks and hazards, and actual values are probably somewhat lower than the calculated values.

Hazard indices (HI) and cancer risks (CR) were derived based on the reasonable maximum exposure (RME) and central tendency (CT) exposure parameters for the identified receptor scenarios. The HHRA indicated that cancer risks and non-cancer hazards were within acceptable limits for the older child transient trespasser, lunchtime trespasser, adult state fairgrounds attendee, older child state fairgrounds attendee, younger child state fairgrounds attendee, state fairgrounds maintenance worker, drainage ditch worker, and trespasser/fisherperson (note: for the latter, this statement does not apply to fish consumption, which was covered under the Onondaga Lake HHRA (NYSDEC 2002a)). Non-cancer hazards exceeded the acceptable threshold for the utility workers, commercial/industrial workers, older child trespasser/ATV recreator, young adult trespasser/ATV recreator, and construction workers under the RME scenarios.

Although the Site is zoned industrial, deeded for "park purposes or other public use," and future use of ground water for potable water is unlikely, potential future exposure to ground water as potable water by residents and commercial/industrial workers was evaluated and found to pose unacceptable cancer risks and non-cancer hazards. The calculated cancer risks and non-cancer hazards are summarized in the table below.

Table ES.1. *Summary of Current/Future Exposure Scenario Cancer Risks and Non-cancer Hazards.*

			Cancer Risk		Non-Cancer Hazards	
Timeframe	**Receptor**	**Exposure Medium**	**RME**	**CT**	**RME**	**CT**
Current/ Future	Older Child Transient Trespasser	Surface Soil	2 E-05	6 E-06	4 E-01	4 E-01
		Outdoor Air	5 E-09	1 E-09	9 E-04	2 E-04
		Surface Sediment	1 E-07	9 E-09	3 E-03	3 E-04
		Seep Sediment	1 E-06	6 E-08	1 E-01	4 E-03
		Seep Surface Water	5 E-06	5 E-06	2 E-01	2 E-01
		All Media	2 E-05	1 E-05	7 E-01	6 E-01
Current/ Future	Lunchtime Trespasser	Surface Soil	7 E-06	7 E-07	2 E-01	6 E-02
		Outdoor Air	3 E-09	4 E-10	2 E-04	1 E-04
		Seep Sediment	8 E-08	9 E-09	3 E-03	9 E-04
		Seep Surface Water	2 E-06	3 E-07	5 E-02	2 E-02
		All Media	9 E-06	1 E-06	3 E-01	8 E-02
Current/ Future	Utility Worker	Surface/Subsurface Soil	7 E-06	5 E-08	2 E-01	4 E-03
		Outdoor Air	2 E-08	3 E-10	1 E-03	5 E-05
		Seep Sediment	2 E-07	2 E-08	5 E-03	2 E-03
		Seep Surface Water	6 E-06	1 E-07	9 E-02	4 E-03
		Shallow Ground Water	6 E-05	1 E-06	9 E-01	5 E-02

Table ES.1. *Summary of Current/Future Exposure Scenario Cancer Risks and Non-cancer Hazards.*

			Cancer Risk		Non-Cancer Hazards	
Timeframe	**Receptor**	**Exposure Medium**	**RME**	**CT**	**RME**	**CT**
		All Media	7 E-05	1 E-06	1 E+00	6 E-02
Future	Commercial/ Industrial Worker	Surface Soil	5 E-05	6 E-06	1 E+00	5 E-01
		Outdoor Air	2 E-07	6 E-08	2 E-02	1 E-02
		All Media	5 E-05	6 E-06	1 E+00	5 E-01
Current/ Future	Older Child Trespasser/ ATV Recreator	Surface Soil	9 E-06	1 E-06	1 E+00	2 E-01
		Outdoor Air	1 E-05	7 E-06	5 E+00	3 E+00
		Seep Sediment	3 E-07	3 E-08	4 E-02	3 E-03
		Seep Surface Water	4 E-06	6 E-07	2 E-01	4 E-02
		All Media	3 E-05	9 E-06	7 E+00	3 E+00
Current/ Future	Young Adult Trespasser/ ATV Recreator	Surface Soil	7 E-06	2 E-06	4 E-01	1 E-01
		Outdoor Air	9 E-06	4 E-06	2 E+00	7 E-01
		Seep Sediment	2 E-07	3 E-08	1 E-02	1 E-03
		Seep Surface Water	3 E-06	4 E-07	9 E-02	1 E-02
		All Media	2 E-05	6 E-06	2 E+00	8 E-01
Future	Construction Worker	Surface/Subsurface Soil	3 E-06	3 E-07	1 E+00	1 E-01
		Outdoor Air	4 E-06	2 E-06	5 E+00	2 E+00
		Seep Sediment	6 E-08	3 E-08	2 E-02	8 E-03
		Seep Surface Water	3 E-06	1 E-06	5 E-01	2 E-01
		Shallow Ground Water	3 E-05	2 E-06	6 E+00	5 E-01
		All Media	4 E-05	6 E-06	1 E+01	3 E+00
Current/ Future	Adult State Fair Attendee	Surface Soil	4 E-07	8 E-08	1 E-02	4 E-03
		Outdoor Air	1 E-09	4 E-10	2 E-04	5 E-05
		All Media	4 E-07	8 E-08	1 E-02	4 E-03
Current/ Future	Older Child State Fair Attendee	Surface Soil	1 E-06	1 E-07	4 E-02	6 E-03
		Outdoor Air	9 E-10	3 E-10	3 E-04	8 E-05
		All Media	1 E-06	1 E-07	4 E-02	6 E-03
Current/ Future	Younger Child State Fair Attendee	Surface Soil	5 E-06	6 E-07	1 E-01	3 E-02
		Outdoor Air	1 E-09	4 E-10	8 E-04	2 E-04
		All Media	5 E-06	6 E-07	1 E-01	3 E-02
Current/ Future	State Fair Maintenance Worker	Surface Soil	1 E-06	6 E-08	5 E-02	9 E-03
		Outdoor Air	4 E-08	4 E-10	6 E-03	1 E-04
		All Media	1 E-06	6 E-08	5 E-02	9 E-03
Current/ Future	Ditch Maintenance Worker	Ditch and Seep Sediment	7 E-07	1 E-07	2 E-02	8 E-03
		Ditch and seep water	2 E-07	3 E-08	3 E-02	2 E-02
		All Media	9 E-07	1 E-07	5 E-02	3 E-02
Current/ Future	Fisherperson/ Trespasser	Surface Soil	1 E-06	6 E-07	1 E-02	7 E-03
		Outdoor Air	8 E-08	3 E-08	2 E-03	8 E-04
		Surface Sediment	2 E-08	8 E-09	5 E-05	2 E-05
		Seep Sediment	5 E-07	2 E-07	7 E-03	3 E-03
		Seep Surface Water	5 E-07	2 E-07	2 E-01	7 E-02
		All Media	2 E-06	1 E-06	2 E-01	8 E-02
Future	Adult Resident	Potable Water	1 E-02	2 E-03	2 E+02	8 E+01

Table ES.1. *Summary of Current/Future Exposure Scenario Cancer Risks and Non-cancer Hazards.*						
			Cancer Risk		**Non-Cancer Hazards**	
Timeframe	**Receptor**	**Exposure Medium**	**RME**	**CT**	**RME**	**CT**
		All Media	1 E-02	2 E-03	2 E+02	8 E+01
Future	Child Resident	Potable Water	1 E-02	4 E-03	7 E+02	2 E+02
		All Media	1 E-02	4 E-03	7 E+02	2 E+02
* Highlighted cells indicate values that exceed the range for acceptable cancer risk (10^{-6} to 10^{-4}) or acceptable non-cancer hazards (below 1).						

For a number of exposure scenarios and exposure pathways, the estimated current and future cancer risks and non-cancer hazards are within the acceptable limits (*i.e.*, cancer risk of 10^{-4} to 10^{-6}, hazard index of <1). For those scenarios that exceed these thresholds, RAGS Table 10 provides a description of those constituents that are considered risk drivers.

1. Introduction

This is the Human Health Risk Assessment (HHRA) Report for the Wastebeds 1-8 Site (Site) in Geddes, New York. A Site location plan is included as **Figure 1**. This HHRA was performed pursuant to the Administrative Consent Order (D-7-0002-02-08) between the New York State Department of Environmental Conservation (NYSDEC) and Honeywell International, Inc. (Honeywell) dated April 10, 2000 (NYSDEC 2000). This HHRA reflects decisions made in the following meetings and documents:

- February 21, 2007 – Honeywell submitted HHRA Risk Assessment Guidance for Superfund (RAGS) Part D, Tables 1 and 4 to the NYSDEC (O'Brien & Gere 2007a).

- May 4, 2007 – The NYSDEC provided Honeywell with a comment letter regarding the HHRA RAGS Tables 1 and 4.

- May 18, 2007 – Honeywell responded to the May 4, 2007 NYSDEC comment letter.

- February 25, 2008 – Honeywell submitted RAGS Tables 1 through 6 to the NYSDEC (O'Brien & Gere 2008a).

- April 1, 2008 – The NYSDEC provided a comment letter on the RAGS Tables 1-6 submittal.

- March 14, 2008 - A meeting was held in Albany, New York between the NYSDEC, New York State Department of Health (NYSDOH), United States Environmental Protection Agency (USEPA), Honeywell, and O'Brien & Gere to discuss issues related to the Wastebed B/Harbor Brook Site and the Wastebeds 1-8 Site.

- May 1, 2008 – Honeywell provided a response letter to the NYSDEC's April 1, 2008 comments.

- May 9, 2008 - The NYSDEC provided comments to Honeywell's May 1, 2008 letter via conference call.

- July 31, 2008 – Honeywell provided an interim HHRA deliverable that presented an analysis of speciated chromium data.

- September 29, 2008 – The NYSDEC provided a letter in response to the July 31, 2008 chromium analysis.

- October 10, 2008 – A teleconference was conducted between the NYSDEC, USEPA, Honeywell and O'Brien & Gere. During this teleconference agreements were reached regarding the analysis and implications of speciated chromium data.

- October 14, 2008 – A teleconference was between the USEPA and O'Brien & Gere regarding chromium speciation and the hexavalent/total chromium ratios to the used in the HHRA.

- October 15, 2008 – Honeywell provided a response to the September 29, 2008 response letter and outlined the agreements made during the teleconference held on October 10, 2008, as well as the subsequent October 14, 2008 teleconference.

- October 29, 2008 – The NYSDEC provided a letter accepting Honeywell's October 15, 2008 letter.

- November 20, 2008 – Honeywell submitted the final interim HHRA deliverable, RAGS Part D Series Tables 1-10 (O'Brien & Gere 2008b).

- February 5, 2009 – The NYSDEC provided comments on the RAGS Part D Series Tables 1-10.

- March 9, 2009 – Honeywell provided a response to the NYSDEC's February 5, 2009 comments. In this letter, Honeywell highlighted the fact that the completion of the full HHRA report was on hold pending the collection of additional data requested in the NYSDEC's October 21, 2008 Remedial Investigation (RI) Report comment letter.

- March 31, 2009 – Electronic mail from Sue Edwards (NYSDEC) to Honeywell giving conditional approval of Honeywell's March 9, 2009 response to comments.

- October 22, 2009 – Honeywell submitted a letter report to the NYSDEC describing the evaluation of the 2009 SRI data. In this letter, Honeywell concluded that the 2009 SRI data should be included with the HHRA dataset.

- December 4, 2009 – Electronic mail from Sue Edwards (NYSDEC) to Tom Conklin (O'Brien & Gere) stating that the NYSDEC concurs with the October 22, 2009 letter regarding the use of the SRI dataset in the HHRA.

- June 4, 2010 – The NYSDEC provided comments on the February 2010 Wastebeds 1-8 HHRA Report.

- June 28, 2010 – Honeywell provided responses to the NYSDEC's June 4, 2010 comments.

- July 19, 2010 – Electronic mail from Sue Edwards (NYSDEC) to Doug Crawford (O'Brien & Gere) providing additional comments on Honeywell's June 28, 2010 responses.

- September 3, 2010 – Honeywell provided revised Wastebeds 1-8 HHRA Report.

- November 3, 2010 – The NYSDEC provided comments on September 2010 revised Wastebeds 1-8 HHRA Report.

- January 7, 2011 – Honeywell provided responses to the NYSDEC's November 3, 2010 comments.

- February 15, 2011 – The NYSDEC provided additional comments on the September 2010 revised Wastebeds 1-8 HHRA Report.

- March 16, 2011 – Honeywell provided responses to the NYSDEC's February 15, 2011 comments

- April 13, 2011 – The NYSDEC provided comments on the February 15, 2011 comment responses.

1.1. Site Description and Background

Historically, Wastebeds 1-8 (**Figure 1**) 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 Solvay waste materials.

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). On November 25, 1943, a dike along Wastebed 7 failed and an area along State Fair Boulevard was flooded with Solvay waste. This failure led to the closure of Wastebeds 1 through 8.

Waste from the following sites may have been disposed of in Wastebeds 1-8.

- **Main Plant** – This plant manufactured various products including soda ash and related products from 1884 until 1986, and benzene, toluene, and xylenes from 1917 to 1970.

- **Willis Avenue Plant** – This plant manufactured chlorinated benzenes and chlor-alkali products from 1918 until 1977. Additional operations reportedly took place at the Willis Avenue Plant including production of hydrochloric acid, caustic soda, caustic potash, and chlorine gas (O'Brien & Gere 1990).

- **Benzol Plant** - This plant operated from 1915 to 1970 and produced benzene, toluene, xylenes, and naphthalene by the fractional distillation of coke "light oil".

- **Solvay Process Company** – This company operated a coke plant from 1892 through 1923.

- **Phenol Production Plant** – This plant operated from 1942 to 1946 (PTI 1992).

Solvay waste (calcium carbonate, gypsum, sodium chloride, and calcium chloride) generated at the former Main Plant 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 infiltration and evaporation (BBL 1989).

Compounds associated with operations at the Willis Avenue Plant, the Benzol Plant, the Solvay Process Company, and the Phenol Production Plant may have been placed 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.

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. From 1925 to 1978, the City of Syracuse and Onondaga County utilized a portion of Wastebeds 1 and 2 for sewage sludge disposal (Biosolids Area, **Figure 1**). The nature, volume, and exact boundaries of the disposal in the Biosolids Area are unknown.

An additional use of the Wastebeds 1-8 Site was the operation of a landfill on a portion of Wastebed 5 (**Figure 1**) by Crucible Specialty Metals (Crucible) from 1973 to 1988 (Calocerinos & Spina 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 (Calocerinos & Spina 1986). The landfill was used to contain the following wastes:

***Non-hazardous waste materials* (217,500 yd^3) (Calocerinos & Spina 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) (Calocerinos & Spina 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.

The entire Wastebeds 1-8 Site was deeded to the people of New York in 1953 and is currently owned by the State of New York and Onondaga County (Calocerinos & Spina 1986). The New York State Fair uses a portion of the Site for parking. While the part used as parking is gravel covered, the remainder of the Site is currently vegetated, except the wastebed slopes along the shore of Onondaga Lake and east of the mouth of Ninemile Creek that contain exposed Solvay waste and minimal vegetation.

An Interim Remedial Measure (IRM) is currently proposed for this Site. The proposed IRM consists of shallow and intermediate ground water collection along the eastern shore to Onondaga Lake, collection of seeps along the Eastern Lakeshore Area and Ninemile Creek, stabilization of exposed Solvay waste along the eastern shore/surf zone to Onondaga Lake, and rehabilitation in the lower reach of Ditch A. These actions are being performed to mitigate potential impacts to the adjacent Onondaga Lake sediment management unit (SMU)-3 and SMU-4, and Ninemile Creek Operable Unit 2 remedies as well as potential risks to human health and the environment in the areas addressed by the proposed IRM. Recognizing this, the Feasibility Study Report will document how implementation of the IRM will impact the potential risks and hazards presented in this Human Health Risk Assessment Report.

1.2 Site Exposure Areas

The Wastebeds 1-8 Site comprises seven exposure areas identified in the RI Report: 1) Biosolids Area, 2) New York State Fair Parking Areas, 3) Lakeshore Area, 4) Upland Old Field Successional Area, 5) Ponded Area, 6) Site Ditches, and 7) Ditch A – South. These areas are presented in the Site plan (**Figure 1**)**.** It should be noted that an "exposure area" is a discrete area defined by location and similar characteristics and is distinct from an "exposure unit," which is a group of one or more exposure areas to which a specific receptor may be exposed.

A brief description of the exposure areas is presented in this section.

1.2.1. Biosolids Area

The Biosolids Area is located within the boundaries of the Upland Old Field Successional Area on Wastebeds 1 and 2 (**Figure 1**). The City of Syracuse and Onondaga County utilized a portion of these wastebeds from 1925 to 1978 for sewage sludge disposal. However, the nature, volume, and exact boundaries of the disposal are unknown. The habitats that characterize the Biosolids Area are successional old field, successional northern hardwoods, and successional shrubland. The topography of this area is generally flat. Access to the Biosolids Area is possible from the upper lot of the NYS Fair Parking Areas and foot paths established in the western portion of the Site.

1.2.2. New York State Fair Parking Areas

The locations of the New York State Fair Parking Areas are shown in **Figure 1**. The annual New York State Fair uses a portion of this exposure area for parking. The majority of this exposure area is covered with gravel, but a portion of this area contains grassy cover. The topography of these areas is generally flat. The upper parking areas are located on Wastebeds 1, 2, 3, and 4, and the lower areas are on Wastebeds 7 and 8. A smaller parking area is located south of Wastebeds 4 and 5 near Ninemile Creek. The upper and lower portions of the NYS Fair Parking Areas can be accessed via different means. The upper areas are accessed from three points: 1) a gated entrance road from the southwest, 2) two gated entrances from the I-690 off-ramp to Route 695, and 3) a foot bridge from the lower area.

The lower area has access points via a gated entrance from the I-690 off ramp to State Fair Boulevard and two entry points from State Fair Boulevard. A 6-ft high fence extends along the southern boundary of the Site along the I-690/Route 695 interchange, but access is not restricted to foot traffic to the upper parking areas or to vehicle or foot traffic to the lower area. The NYS Fairgrounds provides security for these parking areas throughout the year. This security includes checks for trespassers.

1.2.3. Lakeshore Area

The Lakeshore Area extends approximately 6,100 ft along the shore of Onondaga Lake to the north of Wastebeds 1-5 (**Figure 1**). This area is sparsely vegetated with invasive species such as the common reed and purple loosestrife. There is exposed Solvay waste present in this exposure area. There is a sharp change in surface elevation between the Lakeshore Area and the Upland Old Field Successional Area, which defines the boundary between these two areas. Ground water seeps from the face of the boundary and contributes to the presence of surface water in the Lakeshore Area. Individuals using all-terrain vehicles (ATVs) have been observed in this area. This area can be accessed via a footpath established on the southeastern end near the Ditch A – South exposure area, footpaths down the northern berms, and via boat from Onondaga Lake.

1.2.4. Upland Old Field Successional Area

This exposure area covers the majority of the Site and extends from the southeastern end near the Ditch A – South exposure area to the northwestern end near Ninemile Creek and Onondaga Lake (**Figure 1**). This exposure area includes Lakeview Point, surrounds the Crucible Landfill, and is on Wastebeds 1-6 and their berms. The habitat in this exposure area has been classified as successional old field, successional northern hardwoods, successional shrubland, urban structure exterior (paved and unpaved path/road), and former landfill. The topography is variable with numerous topographic highs and lows that range from 363 ft above mean sea level (MSL) at the shore of Onondaga Lake to 430 ft above MSL at the highest point. Access to this area is similar to the NYS Fair Parking Areas: 1) a gated entrance from the southwest and the I-690 off-ramp to Route 695, 2) a foot bridge from the lower area, and 3) by boat via Ninemile Creek and Onondaga Lake.

1.2.5. Ponded Area

The Ponded Area is located near Ninemile Creek at the 90^{o} bend south of the Crucible Landfill (**Figure 1**). This is a small area (0.14 acres) that is partially vegetated. This exposure area is periodically inundated when the water levels in Ninemile Creek are high. Access to this exposure area can occur via foot traffic from the Site or via boat from Ninemile Creek.

1.2.6. Site Ditches and Ditch A - South

These two exposure areas comprise different portions of Ditch A (**Figure 1**). These exposure areas are aquatic habitats classified as ditches/artificial intermittent streams (drainage ditches). Ditch A extends along Wastebeds 7 and 8 and drains into Onondaga Lake via the Ditch A – South exposure area and Ninemile Creek via a pipe extending west from the northwest end of Ditch A. Both of these exposure areas include vegetated and unvegetated sections. Access to these areas can occur via foot traffic as neither exposure area is surrounded by fencing or gates.

1.2.7. Hypothetical Potable Water Source Area (Site-Wide)

The use of ground water at the Site for potable applications is considered hypothetical. The Site is zoned as industrial and is deeded for “park purposes or other public use,” so it is unlikely to be developed as a residential area. Further, Site ground water is unlikely to be used as an industrial drinking water supply in the future, since the area is supplied by municipal water from OCWA. In addition, the yield of the overburden ground water unit is inadequate for water supply wells and the high salinity of the deep aquifer (3,000 mg/l chloride) precluded its use as drinking water. This pathway has been evaluated, however, because the use designation for this aquifer is classified as a potable water supply, and the National Contingency Plan states the ground water must be returned to its most beneficial use. Therefore, this source area is represented by all ground water data collected at the Site from any depth. It should be noted that “Site-Wide” for this exposure medium refers to all exposure areas.

1.3. Wastebeds 1 – 8 Investigation History

Data utilized for this evaluation are the result of the data collection efforts targeted to support the characterization of the Site through the RI/FS process and investigations performed prior to the onset of Site PSA/RI/FS. As a result, analytical data have been collected over significant spatial and temporal scales by multiple investigators. These investigations data are described in this section.

As part of the investigation data discussions, the inclusion or exclusion of the data from the risk assessment is included at the end of each section. Data selection was based on certain factors including:

- Only TCL/TAL data were considered for the HHRA dataset.
- Toxicity Characteristic Leaching Procedure (TCLP) data, water quality parameters, and other non-TCL/TAL data (*e.g.*, percent solids, total organic carbon) were excluded.
- Data had to have been collected as part of the RI/FS process or within the last ten years with validated results.
- The data had to be from defined exposure areas (*i.e.*, Lakeshore Area, Biosolids Area, *etc.*).
- Soil data were from 0 to 10 ft below ground surface (bgs), while all groundwater and surface water were included.

Data collected in support of the Geddes Brook/Ninemile Creek program were not included.

Table 1 presents a summary of the data collected during the previous investigations at the Wastebeds 1-8 Site. A copy of the Wastebeds 1-8 dataset used for this HHRA is provided as **Appendix A** (**electronic**). **Appendix A** also includes a detailed discussion of the previous investigations summarized below. A comprehensive list of samples used in this assessment, sorted by exposure area, is provided as **Appendix B** (**electronic**). Because of the size of these appendices, both of these appendices are provided only as electronic files in this submittal; no print copies have been supplied.

1.3.1. Revised Landfill Closure Plan (Volumes 1 & 2)

Crucible Specialty Metals conducted a quarterly ground water monitoring program for its landfill on-site. The ground water quarterly monitoring program results were included in the *Revised Landfill Closure Plan Volumes 1 & 2* for a time period between 1982 and 1985 (Calocerinos & Spina 1986). The analyses performed are provided in **Appendix A**, and an investigation summary is presented in **Table 1**.Analytical results included phenols, metals, and water quality parameters. These data were not used in the risk assessment since these data were not collected as part of the RI/FS process and are greater than ten years old.

1.3.2. Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area

As part of the hydrogeologic assessment (Blasland, Bouck & Lee 1989), surface water and ground water samples were collected. Surface water and ground water samples were analyzed for water quality parameters and included locations that pertain to the Site. The analyses performed are provided in **Appendix A**, and an investigation summary is presented in **Table 1**. These data were not used in the risk assessment since these data were not collected as part of the RI/FS process and are greater than ten years old.

1.3.3. TAMS 1995 and NYSDEC 2003

TAMS (1995) performed an investigation of Wastebeds 1 through 8 in 1995 on behalf of the NYSDEC (2003a). Samples collected from the Site and selected outfalls included ground water, waste material, surface water/seeps, and outfall and seep sediment (TAMS 1995). The analyses performed are provided in **Appendix A**, and an investigation summary is presented in **Table 1**.Analyses included volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals. These 1995 data were not used in the risk assessment since these data were greater than ten years old and more recent data were available in these areas.

Based on the 1995 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 (NYSDEC 2003a). The supplemental sampling included seep and soil/sediment sampling from two locations, (101-01 and 101-02), and two additional surface water only samples (101-03 and 101-04) were collected. The analyses performed are provided in **Appendix A**, and an investigation summary is presented in **Table 1**. Analyses included VOCs, SVOCs, and metals. These 2003 data were used in the risk assessment.

1.3.4. Geddes Brook/Ninemile Creek Remedial Investigation

This remedial investigation was performed in two parts, which included the remedial investigation (NYSDEC 2003b) and a sediment interim remedial measure (IRM) sampling program by Blasland, Bouck & Lee (BBL) in 2001. The work performed for the RI included surface water sampling, sediment sampling, floodplain soil sampling, fish communities, sediment toxicity testing, and benthic macroinvertebrate community analysis. Work performed under the sediment IRM included sediment and floodplain soil sampling. The analyses performed are provided in **Appendix A**, and an investigation summary is presented in **Table 1**. Analyses included VOCs, SVOCs, pesticides, polychlorinated biphenyls (PCBs), metals, polychlorinated dibenzo-p-dioxin and dibenzofurans (PCDD/Fs), and other parameters. These data were not used in the risk assessment since the data were collected outside the limits of the Wastebeds 1-8 Site.

1.3.5. Ninemile Creek Supplemental Sampling Program

This 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, 2002b). This work was performed as a supplemental investigation to the Geddes Brook/Ninemile Creek Remedial Investigation. The sampling locations related to the Site included those transects between the 90^o bend near the I-690 overpass and the outlet of the creek located within the Site boundaries. The samples were selectively submitted for laboratory analyses; the target analyses included SVOCs, mercury, PCDD/Fs, and TOC. The focus of the SVOC analysis was on polycyclic aromatic hydrocarbons (PAHs) and hexachlorobenzene. The analyses performed are provided in **Appendix A**, and an investigation summary is presented in **Table 1**. These data were not used in the risk assessment since the data were collected outside the limits of the Wastebeds 1-8 Site.

1.3.6. Onondaga Lake Remedial Investigation/Feasibility Study

The analyses performed are provided in **Appendix A**, and an investigation summary is presented in **Table 1**. Analyses included VOCs, SVOCs, pesticides, PCBs, metals, PCDD/Fs, and other parameters. These data were not used in the risk assessment since the data were collected outside the limits of the Wastebeds 1-8 Site.

1.3.7. Preliminary Site Assessment (PSA)

The Preliminary Site Assessment (PSA) included field activities performed between the summer and winter of 2004, as well as a ground water sampling event in the summer of 2005 (O'Brien & Gere 2004a, 2004b, 2005a, 2005b). PSA sampling included surface soils, subsurface soils via soil borings and test pits, ground water, surface water, sediment, and seep surface water and sediment. The number of samples collected and analyses performed are provided in **Appendix A**; an investigation summary is presented in **Table 1**. These data were used in the risk assessment if they met the selection criteria. The TCL/TAL data generated for this investigation were used in the HHRA, with the exception of isolated data points for individual analytes which were rejected during validation.

1.3.8. Bike Trail Surface Soil and Plant Tissue Sampling

Concurrent with the PSA sampling, ten surface soil samples and two woody tissue samples were taken at the Site for the proposed bike trail. The number of samples collected and analyses performed are provided in **Appendix A**; an investigation summary is presented in **Table 1**. The soil data were used in the risk assessment, but the tissue data were not used.

1.3.9. Focused Remedial Investigation

The FRI included field activities conducted between the summer of 2005 and the spring of 2006 and included collecting subsurface soil samples via soil borings, ground water screening samples, and ground water samples (O'Brien & Gere 2005c, 2007b). The number of samples collected and analyses performed are provided in **Appendix A**; an investigation summary is presented in **Table 1**. These data were used in the risk assessment if they met the selection criteria. The TCL/TAL data generated for this investigation were used in the HHRA, with the exception of isolated data points for individual analytes which were rejected during validation.

1.3.10. Remedial Investigation

The RI field activities were performed from January 2007 through August 2007 and included collecting surface soil samples, subsurface soil samples via soil borings, ground water screening samples, ground water samples, surface water samples, and sediment samples (O'Brien & Gere 2005c, 2006a, 2006b, 2007c). The number of samples collected and analyses performed are provided in **Appendix A**; an investigation summary is presented in **Table 1**. These data were used in the risk assessment if they met the selection criteria. The TCL/TAL data generated for this investigation were used in the HHRA, with the exception of isolated data points for individual analytes which were rejected during validation

1.3.11. Chromium Speciation Evaluation

In 2008, a chromium speciation investigation was initiated to evaluate the ratio of hexavalent chromium (Cr^{+6}) to total chromium (Cr Total) in surface (including seep surface soils) and subsurface soils at the Site. To determine this ratio, subsurface and surface soil samples (0 to 2 ft bgs) were collected and analyzed for hexavalent chromium and total chromium. The number of samples collected and analyses performed are provided in **Appendix A**; an investigation summary is presented in **Table 1**. These data were used in the risk assessment.

1.3.12. Supplemental Remedial Investigation

The SRI field activities were performed in June 2009 and August 2009 and included collecting surface soil samples, subsurface soil samples via soil borings, and ground water samples. The number of samples collected and analyses performed are provided in **Appendix A**; an investigation summary is presented in **Table 1**. These data were used in the risk assessment if they met the selection criteria.

The TCL/TAL data generated for this investigation were used in the HHRA, with the exception of isolated data points for individual analytes which were rejected during validation.

1.4. Risk Assessment Overview

The approach to the risk assessment is presented as outlined below:

- Section 2 – This section presents the human health conceptual site model through which potential exposure pathways are identified.
- Section 3 – This section presents database definitions, media specific considerations, the approach used to identify Constituents of Potential Concern (COPCs) in the screening process, and the results of constituent screening.
- Section 4 – This section presents the human receptors selected for evaluation as well as the exposure pathways, grouping of exposure units, and development of exposure point concentrations. This section also contains details relating to exposure assumptions, values, and equations used in risk/hazard estimation.
- Section 5 – Non-cancer and cancer toxicity data, including oral, dermal, and inhalation parameters are presented in this section.
- Section 6 – In Section 6, the characterization of risk and hazards for reasonable maximum exposure and central tendency scenarios is presented.
- Section 7 – Uncertainties in the estimates of risk associated with various elements of the risk assessment process are presented in this section.
- Section 8 – Conclusions regarding potential population exposures are presented in Section 8.
- Section 9 – References are provided in Section 9.

2. Human Health Site Conceptual Model

This section identifies the most significant potential exposure pathways through which individuals may be exposed to the constituents of concern at the Site. An exposure pathway analysis describes the transport of a chemical from the source of release to the exposed individual. An exposure pathway links the sources, locations, and types of environmental patterns to determine significant pathways of human exposure. As defined in USEPA's RAGS (1991), an exposure pathway has four elements:

- A source and mechanism of chemical release to the environment.
- An environmental transport medium (*e.g.*, ground water) for the released chemical and/or mechanism of transfer of the chemical from one medium to another.
- A point of potential human contact with the contaminated medium (exposure point).
- Exposure route at the contact point (*i.e.*, ingestion, inhalation, or dermal contact).

The identification of potential release mechanisms and receiving media were determined utilizing site histories and data from existing reports. The fate and transport of the chemicals from release media were also considered to identify media that may receive site-related chemicals. Points of potential contact with chemically contaminated media (or sources) by human receptors were then considered and defined based on current and potential future uses of the site. The demography of local populations and land use characteristics were taken into consideration when the pathways were developed. If a pathway could potentially be complete between the source of contamination and a human receptor, it was retained for further quantitative evaluation. This risk assessment identified exposure pathways assuming that no site remediation occurs and that no additional restrictions to site access or use exist. The goal was to establish whether it is feasible for individuals to engage in activities resulting in exposure to site-related contaminants. **Figure 1B** summarizes the Site Conceptual Model.

This document utilizes the Exposure Unit (EU) concept to refine estimates of quantitative risk. An EU is defined as an area over which receptors are expected to integrate exposure when routinely present at the Site. For example, if a future construction worker has been identified as a potential receptor, that worker is assumed to be exposed randomly to Site media in an area equal to the area over which construction is possible. This area may include more than one of the defined sub-areas (exposure areas) of the Site (*e.g.*, Lakeshore Area, Upland Old Field Successional Area, *etc*.). As such, each receptor is associated with an EU that accounts for their potential exposure in all areas where they may be expected to come in contact with environmental media.

The following sections describe the possible sources, receptors, and exposure pathways relevant to the Site considering both current and potential future land use. An identified pathway does not imply that exposures are actually occurring, only that the potential exists for the pathway to be complete.

This section comprises the following subsections:

- In Section 2.1, potential human receptors that may be currently active at the Site are identified and described. Receptors associated with potential future land use scenarios are also discussed in this subsection.

- In Section 2.2, potential exposure pathways for each Exposure Unit/receptor combination are identified.

2.1. Exposure Setting and Receptor Populations

The first step in evaluating the potential human exposure at a site is to characterize it with respect to its physical characteristics, current and potential land uses, and human populations on or near the Site. A detailed description of this information is provided in Section 1 of this HHRA and is summarized below as well as in RAGS Tables 1.1 through 1.7, provided in **Attachment A.** This information was used to identify possible exposure pathways for potentially exposed populations and to determine appropriate exposure intake parameters to quantify exposure.

2.1.1. Current Land and Site Use

The Wastebeds 1-8 Site is currently owned by the State of New York and Onondaga County. The New York State Fairgrounds uses a portion of the Site for parking during the annual Great New York State Fair. Access to the Site during the rest of the year is limited due to existing security patrols and the fact that this area is separated from nearby residential areas by highway I-690. However, the gates to the Site are not locked, and it has been reported that ATV riders use the Site on a regular basis. Evidence of ATV use can be seen in the Lakeshore Area and along the well-worn trails present on the northwestern portion of the Site. Site ditches are periodically maintained (*e.g.*, accumulated sediment is removed) to permit stormwater flow during precipitation events. Currently, ground water at the Site is not used for any purpose; however, utility workers may inadvertently come into contact with shallow ground water during the course of their excavations.

2.1.2. Potential Current Receptors

Under current conditions, the most likely potential receptors for the Wastebeds 1-8 Site are as follows:

- Older Child Transient Trespasser – Transient trespassers can access many areas of the Site.
- Adult Lunchtime Trespasser – Trespassers can access many areas of this Site during their lunch hour.
- Utility/Sewer Worker – Utility/sewer workers may be exposed to Site constituents during the installation or repairing of underground utilities/sewers.
- Older Child and Young Adult Trespasser/ATV Recreator – ATV riders have been reported to use the Site on a regular basis.
- Adult, Older Child, and Younger Child State Fairgrounds Attendee – The New York State Fairgrounds uses a portion of the Site for parking during the annual fair. Adult, older child, and younger child receptors attend this fair.
- State Fairgrounds Maintenance Worker – Maintenance workers access the Site year round.
- Ditch Maintenance Worker – Periodic maintenance of the Site drainage ditches is needed to ensure ditch functionality. Therefore, the drainage ditch worker is evaluated in this assessment.
- Trespasser/Fisherperson – Trespassers, such as fisherpersons, may access Onondaga Lake from the Lakeshore Area. Note that for the purpose of this site-specific HHRA, this receptor is limited to exposure to on-site soils within Wastebeds 1 through 8. Exposures to fish, lake water, and lake sediment were evaluated in the Onondaga Lake HHRA (NYSDEC, 2002a).

Potential current receptors and their associated Exposure Units are summarized below in **Table 2.1**.

Table 2.1. *Current Exposure Scenarios.*

Exposure Unit: Exposure Areas	Receptors	Rationale
Exposure Unit 1: NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, Ponded Area, and Ditch A – South	Older Child Transient Trespasser	Currently, these receptors may access this Exposure Unit.
Exposure Unit 2: NY State Fair Parking Area, Upland Old Field Successional Area, and Biosolids Area	Lunchtime Trespasser and Utility/Sewer Worker	Currently, these receptors may access this Exposure Unit.
Exposure Unit 3: NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, and Lakeshore Area	Older Child and Young Adult Trespasser/ATV Recreator	Currently, these receptors are accessing this Exposure Unit.
Exposure Unit 4: NY State Fair Parking Area	State Fairgrounds Attendee and State Fairgrounds Maintenance Worker	Currently, these receptors are accessing this Exposure Unit during the NY State Fair.
Exposure Unit 5: Site Ditches	Ditch Maintenance Worker	Currently, the Ditch Maintenance Worker has access to this Exposure Unit.
Exposure Unit 6: Lakeshore Area and Ditch A – South	Trespasser/Fisherperson	Currently, Trespassing Fisherpersons have access to this Exposure Area.
Exposure Unit 7: Site Wide Shallow Ground Water	Utility/Sewer Worker	Currently, the utility/sewer worker may be exposed to ground water while working below ground.

2.1.3. Future Land Use

Future land use at this Site is likely to include all of the activities outlined in Section 2.1.2. In addition, several land use activities have the potential to occur at this Site in the future. It is possible that industrial or commercial facilities will be present on the Site in the future. The Onondaga County Department of Transportation plans to extend the Lake Canalways Trail Section 1 roughly 1.5 miles along the lakeshore over the wastebeds. The proposed trail will be approximately 14 feet wide, bordered by landscaping ranging from 8 to 32 feet on both sides. The area along the bike trail would be planted with grass, wetland, or wildflower mix (see **Figure 1** for a map of the proposed bike trail). The potential risk to bike path recreators is not addressed in this assessment as this risk was evaluated in a separate HHRA (USEPA 2008b).

While not expected or likely, it is possible that residential use of the Site could occur in the future. Given the availability of municipal water and the high salinity content of the ground water, it is unlikely that any future residents and commercial/industrial workers would use Site ground water as potable water.

2.1.4. Potential Future Receptors

Under potential future conditions, the most likely receptors for the Site are as follows:

- Older Child Transient Trespasser – Transient trespassers are likely to continue to have access to much of this Site in the future.
- Adult Lunchtime Trespasser – Lunchtime trespassers are likely to continue to have access to this Site.

- Utility/Sewer Worker – A utility/sewer worker is likely to be exposed to Site constituents during future installation or repair of underground utilities/sewers.
- Older Child and Young Adult Trespasser/ATV Recreator – Older child and young adult ATV riders may not be restricted from using this Site in the future.
- Adult, Older Child, and Younger Child State Fairgrounds Attendee – A portion of this Site is likely to continue to be used as the grounds for the New York State Fair in the future.
- State Fairgrounds Maintenance Worker – A portion of this Site is likely to be used as the grounds for the New York State Fair in the future and regular maintenance activities will be required.
- Ditch Maintenance Worker – Periodic maintenance of the Site drainage ditches will be need in the future to ensure ditch functionality. Therefore, the drainage ditch worker is evaluated in this future scenario.
- Trespasser/Fisherperson – Trespassers such as fisherpersons are likely to continue to have access to Onondaga Lake from the Lakeshore Area in the future. Note that for the purpose of this site-specific HHRA, this receptor is limited to exposure to on-site soils within Wastebeds 1 through 8. Exposures to fish, lake water, and lake sediment were evaluated in the Onondaga Lake HHRA (NYSDEC, 2002a).
- Construction Worker – Future construction in many areas of this Site is possible, therefore this receptor is selected for evaluation in this scenario.
- Commercial Industrial Worker – In the future, businesses could be developed on this Site. Therefore, commercial/industrial workers may be exposed to Site-related constituents and are evaluated in this future scenario.
- Child and Adult Resident – Although residential use of the Site is not anticipated, it is possible that portions of the Site may be redeveloped for residential housing. As such, this assessment includes an evaluation of child and adult residents in the exposure scenario evaluated as a potential future pathway.

Potential future receptors and their associated Exposure Units are summarized below in **Table 2.2**.

Table 2.2. *Future Exposure Scenarios.*

Exposure Unit: Exposure Areas	Receptors	Rationale
Exposure Unit 1: NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, Ponded Area, and Ditch A - South	Older Child Transient Trespasser	In the future, these receptors may access this Exposure Unit.
Exposure Unit 2: NY State Fair Parking Area, Upland Old Field Successional Area, and Biosolids Area	Lunchtime Trespasser and Utility/Sewer Worker, Commercial/Industrial Worker	In the future, these receptors may access this Exposure Unit.
Exposure Unit 3: NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, and Lakeshore Area	Older Child and Young Adult Trespasser/ATV Recreator, Construction Worker	In the future, these receptors may access this Exposure Unit.
Exposure Unit 4: NY State Fair Parking Area	State Fairgrounds Attendee and State Fairgrounds Maintenance Worker	In the future, these receptors may access this Exposure Unit during the NY State Fair.
Exposure Unit 5: Site Ditches	Ditch Maintenance Worker	In the future, the Ditch Maintenance Worker may access this Exposure Unit.
Exposure Unit 6: Lakeshore Area and Ditch A – South	Trespasser/Fisherperson	In the future, Trespassing Fisherpersons may access this Exposure Area.

Table 2.2. *Future Exposure Scenarios.*

Exposure Unit: Exposure Areas	Receptors	Rationale
Exposure Unit 7: Site Wide Ground Water	Utility/Sewer Worker and Construction Worker, Child and Adult Resident	In the future, these workers may be exposed to shallow ground water while working below ground. Hypothetical residents may also be exposed to ground water.

2.2. Selection of Exposure Pathways

This section identifies potential exposure pathways for receptors and constituents selected for evaluation at the Site under current conditions and the recognized scope of reasonably foreseeable future planned use of the Site. An exposure pathway is the course a constituent takes from a source to an exposed receptor. As noted above, a complete exposure pathway consists of the following four elements:

- A source for the constituent (*i.e.*, affected media)
- A mechanism of release, retention, or transport of a contaminant in a given medium (*e.g.*, air, water, and soil)
- A point of human contact with the medium (*i.e.*, exposure point)
- A route of exposure at the point of contact (*e.g.*, incidental ingestion and dermal contact)

If any one of these elements is missing, the pathway is considered incomplete and does not present a means of exposure. **Figure 1B** and the RAGS Table 1 Series provided in **Attachment A** present the conceptual model used to identify exposure pathways evaluated in this HHRA.

2.2.1. Exposure Pathways, Receptors, and Media Evaluated for Exposure Unit 1

Exposure Unit 1 (EU-1) comprises the following exposure areas: NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, Ponded Area, and Ditch A – South. The only scenario considered for this Exposure Unit is the current/future transient trespasser. The transient trespasser may be exposed to surface soil (ingestion, dermal contact, fugitive dust or volatile emissions), sediment and surface water from the Ponded Area and Ditch A - South (dermal contact), seep sediment from the Upland Old Field Successional Area and Ponded Area (ingestion or dermal contact), and seep surface water from the Upland Old Field Successional Area and Ponded Area (dermal contact).

There are two types of sediment evaluated in this HHRA: 1) surface sediment and 2) seep sediment. Surface sediment was sampled from areas that typically are covered with standing water (Site Ditches, Ponded Area, and Ditch A-South). Seep sediments are associated with the various Site seeps located in the Lakeshore Area, the Upland Old Field Successional Area, and next to the Site Ditches. These sediments are typically moist but are not covered with standing water.

In this assessment, the transient trespasser is exposed to surface and seep sediment. For surface sediment, only the potential for dermal contact is considered. In contrast, the potential for incidental ingestion and dermal contact exists for seep sediment because sediments in these areas are not submerged and are more appropriately categorized as wet or saturated soil. Since the potential pathways differ for the two types of sediment (surface sediment: dermal; seep sediment: ingestion and dermal), it is necessary to obtain two different exposure point concentrations for these media (see RAGS Tables 3.2a and 3.2b for these EPCs).

In contrast, only the dermal exposure route is evaluated for surface water and seep surface water. Therefore, it is only necessary to derive one exposure point concentration for both media. The rationale applied here is that since the exposure parameters for surface water and seep surface water are identical and since risk will ultimately be combined for all media, the distinction is unnecessary. The locations of the various medium samples for EU-1 are shown on **Figure 2.**

2.2.2. Exposure Pathways, Receptors, and Media Evaluated for Exposure Unit 2

Exposure Unit 2 (EU-2) comprises the following exposure areas: NY State Fair Parking Area, Upland Old Field Successional Area, and Biosolids Area. The lunchtime trespasser and utility worker are the current/future scenarios, and the commercial/industrial worker is the future scenario considered for EU-2. The lunchtime trespasser may be exposed to surface soil (ingestion, dermal contact, fugitive dust or volatile emissions), seep sediment (ingestion or dermal contact), and seep surface water (dermal contact). The utility/sewer worker may be exposed to combined surface and subsurface soils (ingestion, dermal contact, fugitive dust, or volatile emissions), seep sediment (ingestion or dermal contact), and seep surface water (dermal contact). The commercial/industrial worker is potentially exposed to surface soil (ingestion, dermal contact, fugitive dust, or volatile emissions) and subsurface soil through the vapor intrusion pathway.

Potential future commercial/industrial worker occupying buildings may inhale vapors that may enter into future buildings from subsurface soil and shallow ground water. This potential for vapor intrusion was evaluated in two ways in this assessment. Primary insight into the potential for the vapor intrusion pathway to cause risk was gained by comparing Site-wide shallow ground water to USEPA OSWER (2002a) ground water to indoor air screening criteria. Secondary insight into the risks posed by vapor intrusion was gained by screening soil vapor data using the framework presented in USEPA (2004a): *Developing Indoor Air Decision Matrices for Screening and Interim Actions (Draft Final)*. The locations of the various medium samples for EU-2 are shown on **Figure 3.**

2.2.3. Exposure Pathways, Receptors, and Media Evaluated for Exposure Unit 3

Exposure Unit 3 (EU-3) comprises the following exposure areas: NY State Fair Parking Area, Upland Old Field Successional Area, Biosolids Area, and Lakeshore Area. In EU-3, three potential current/future and future receptors were considered. The current/future exposure scenario for this EU considers an older child (12-18 years) and young adult (18-30 years) ATV recreator who may be exposed to surface soil (ingestion, dermal contact, and inhalation of dust and vapors), seep sediment (ingestion and dermal contact) as well as seep surface water (dermal contact) during the course of his/her activities. Incidental ingestion of seep surface water during ATV use is considered to be *de minimis*. This scenario is also considered to be protective of the potential future recreator/bike path user.

A future construction worker may be exposed to surface and subsurface soil during construction and excavation activities as well as seep sediment, and seep surface water (dermal contact only). Incidental ingestion of seep surface water during construction and excavation activities is considered to be *de minimis*. The construction worker may also be exposed (dermal contact) to Site-wide shallow ground water while working at EU-3 (this pathway is evaluated in EU-7 – Site-wide ground water). The locations of the various medium samples for EU-3 are shown on **Figure 4.**

2.2.4. Exposure Pathways, Receptors, and Media Evaluated for Exposure Unit 4

Exposure Unit 4 (EU-4) comprises the NY State Fair Parking Area. Current/future receptors for the NY State Fair Parking Area include state fairgrounds attendees (adult, older child, and younger child), and a state fairgrounds maintenance worker. Each of these receptors may be exposed to NY State Fair Parking Area surface soil (ingestion, dermal contact and inhalation of dust and vapors). No seep sample locations were designated in the NY State Fair Parking Area. Seep sample locations in the vicinity of the NY State Fair Parking area were designated to the Site Ditches Exposure Area. The locations of the various medium samples for EU-4 are shown on **Figure 5.**

2.2.5. Exposure Pathways, Receptors, and Media Evaluated for Exposure Unit 5

Exposure Unit 5 (EU-5) comprises the Site Ditches. Current/future exposure scenarios for Site ditches are restricted to a ditch maintenance worker who may be exposed to seep and ditch sediment (ingestion and dermal) and seep and ditch surface water (dermal contact). Dermal contact with surface water will be evaluated, but incidental ingestion of surface water is expected to be *de minimis* and will not be evaluated. As per NYSDEC Specific Comment 2 (February 5, 2009), it is noted that the ditch maintenance worker can be exposed to some volatile organic compounds and semi-volatile organic compounds (*e.g.*, naphthalene) in surface water. Since there is no default approach to model volatilization from surface water, this pathway is discussed in the uncertainty section and is not evaluated quantitatively in this HHRA. The locations of the various medium samples for EU-5 are shown on **Figure 6.**

2.2.6. Exposure Pathways, Receptors, and Media Evaluated for Exposure Unit 6

Exposure Unit 6 (EU-6) comprises the Lakeshore Area and Ditch A – South. The fisherperson trespasser may visit the Lakeshore Area and Ditch A-South to access Onondaga Lake. Potential hazards and risks from exposure to Lakeshore Area media include ingestion and dermal contact with surface soil as well as inhalation of volatile emissions from surface soils. Ditch A-South media that the fisherperson trespasser may be exposed to include ditch surface sediment and ditch surface water. Fugitive dust exposure will not be evaluated for this EU because the soils in the Lakeshore Area and Ditch-A South are too moist to produce significant dust emissions. Incidental ingestion and dermal contact with seep sediments will be evaluated in the HHRA but only dermal contact will be considered for surface water. Incidental ingestion of seep surface water is considered to be *de minimis* and will not be evaluated. Similar to the Transient Older Child Trespasser (EU-1), the exposure routes differ for this receptor depending of the type of sediment (aquatic sediment, dermal; seep sediment, ingestion/dermal). Therefore, it is necessary to obtain two different exposure point concentrations for these media (RAGS Tables 3.16a and 3.16b). As only the dermal exposure route is evaluated for surface water and seep surface water, only one exposure point concentration is derived for both media. The locations of the various medium samples for EU-6 are shown on **Figure 7.**

2.2.7. Exposure Pathways, Receptors, and Media Evaluated for Exposure Unit 7

Exposure Unit 7 (EU-7) consists of ground water data for all areas of the Site, regardless of the depth interval from which the data were collected. The construction worker (future) and utility/sewer worker (current/future) are the only receptors that may potentially come in contact with ground water. Due to the dynamic nature of ground water, a Site-wide exposure area is selected for this exposure pathway, regardless of whether these receptors access the entire site. The construction worker and utility/sewer worker potentially may be exposed to shallow ground water via dermal contact. Ingestion of shallow ground water was determined to be *de minimis* and will not be evaluated.

Two future scenarios also exist in the Site-wide ground water. The commercial/industrial worker may inhale constituents in shallow ground water through vapor intrusion into buildings located in EU-2. Also, as requested by NYSDEC (Comment G.4, May 4, 2007), a future drinking water scenario is evaluated for potential future Site residents. A child and adult receptor may be exposed to Site-wide ground water at all depths through potable water use. Exposure may occur through ingestion of potable water, inhalation of vapors during showering/bathing, and dermal contact with potable water through showering/bathing. The locations of the various medium samples for EU-7 are shown on **Figure 8.**

3. Screening for Constituents of Potential Concern

To select compounds to evaluate further in the HHRA analysis, a conservative screening process was applied using methods consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The following sections present considerations and assumptions made relative to specific compound groups and media types, the approach used to select COPCs, and the results of the screening process.

3.1. Database Considerations

Field investigation activities executed in support of the Site investigation and risk assessments involved the collection and analysis of a large number of samples of various media at the Site (surface soil, subsurface soil, surface sediment, seep sediment, ground water, surface water, seep water, and soil vapor). Samples have been analyzed for a range of analytes, including VOCs, SVOCs, metals, PCBs, pesticides, wet chemistry parameters, as well as other compounds. There were detectable levels of targeted compounds in each of the sampled media.

A copy of the HHRA database is provided as **Appendix A (electronic)**. A comprehensive list of samples used in this assessment, sorted by exposure area is provided as **Appendix B (electronic)**. This appendix presents information such as start and end depths, geographic coordinates, sample dates, and matrix type for each exposure area and medium. Since not all chemicals are present in each sample, the number of data points shown in the RAGS D Table 2 series may be smaller than the number of data points listed in **Appendix B**. **Attachment A** of this report includes the RAGS Part D Tables.

The table column headings used in **Appendix A (electronic)** are defined below.

Exposure Area: Refers to a specific area of the Wastebeds 1-8 Site. These include NY State Fair Parking Areas, the Lakeshore Area, the Upland Old Field Successional Area, the Biosolids Area, the Ponded Area, the Ditch A – South, and the Site Ditches. For the bulk of this assessment (RAGS Table 3 Series and beyond), these exposure areas were grouped into Exposure Units (See Section 2).

Sample Location: This column presents the specific field sample number that corresponds to the sample locations shown on **Figures 1 through 8**.

Start Depth: The depth interval from which the sample collection began (measured from the ground surface or the top of the sediment/water interface). For ground water samples, this value represents the top of the well screen. The vapor samples were collected from a discrete depth (the start depth and end depth are the same).

End Depth: The depth interval from which the sample collection ended (measured from the ground surface or the top of the sediment/water interface to the deepest part of the sample). For ground water samples, this value represents the bottom of the well screen. The vapor samples were collected from a discrete depth (the start depth and end depth are the same).

Sample Type Code: The following is a clarification of the sample type codes in the **Appendix A (electronic)** data set:

- GWS – Ground water screening sample collected at the water table from a temporary well installed in the soil boring during advancement of the boring
- MW – Monitoring well (ground water sample)
- PT – Plant Tissue
- QC – Quality control sample
- SB – Soil boring
- SC – Soil vapor
- SED – Sediment sample
- SP – Seep sample
- SS – Surface soil sample
- SW – Surface water sample
- TP – Soil sample collected from a test pit

Note that *field duplicates* were identified as quality control samples and included in the site dataset; however, only the 'parent' sample results were used for the purpose of this HHRA.

Sample Matrix: The sample matrix code is "Soil" for soil and sediment, "Soil Vapor" for soil gas samples, "Water" for surface water and ground water, and "Tissue" for plant tissue.

Sample Date: Date that the sample was collected.

CAS Number: Chemical Abstract Service (CAS) registry numbers are unique numerical identifiers for chemical compounds.

Chemical: Name of analyte.

Concentration: Value that represents the amount of a given substance in a given volume. In **Appendix A (electronic)**, the PCB concentrations are represented as individual Aroclors (instead of the "Less chlorinated", and "Highly chlorinated" groupings that appear in the RAGS Tables [see discussion below in Section 3.2]). The RAGS 2 Table Series presents the results of these conversions.

Note that *non-detect samples with high reporting and/or quantitation limits* were used in the derivation of EPCs for this HHRA. Non-detect samples were analyzed using ProUCL (Version 4.0) with regression-on-order statistics, which is less sensitive to high reporting limits than previous (simple substitution) methods.

A comparison of EPCs calculated using ProUCL Version 4.0 with ROS statistics versus EPCs calculated using simple substitution of non-detect samples is presented in Section 7.3.5. When this comparison was performed with and without removal of non-detect samples with high reporting limits, only a small difference (1-2%) was observed in the derived EPCs.

Unit: Unit of chemical concentration. All non-aqueous data are reported in mg/kg or µg/kg on a dry-weight basis. Surface water and ground water data are reported in mg/L or µg/L. Soil vapor data are reported in µg/m^3.

Detection Flag: This column indicates whether the result in the concentration column was identified as a detected concentration or not. If it was not detected, the concentration represents the reporting limit.

Interpreted Qualifier: Data with the following qualifiers were included in the quantitative analysis: No qualifier, J, UJ, U, Ja, JaN, a, JN, N, NJ, and JNA. Only B, D, and E NYSDEC data, which were validated were included.

3.2. Consideration for Specific Analyses

Mercury and Mercury (High Resolution): In Exposure Areas where both mercury and mercury (high resolution) were evaluated separately, these data were combined and integrated into a single "mercury" data set by retaining the analyte with the higher detected value.

Derivation of Hexavalent Chromium Concentrations from Total Chromium (for soil samples only): Historically collected total chromium (Cr Total) soil data were converted to hexavalent chromium (Cr^{+6}) by using one of two Site-specific Cr^{+6}/Cr Total ratios. These ratios were derived from 41 surface soil locations, five seep sediment locations, and twelve subsurface soil samples collected from the various exposure areas at the Site during a 2008 field effort. These samples were analyzed for hexavalent and total chromium to provide a Cr^{+6}/Cr Total ratio that could be applied to historically-collected total chromium data.

A review of this speciated chromium data by O'Brien & Gere and USEPA statisticians indicated that Cr^{+6} and Cr Total concentrations from the Biosolids Area were statistically higher than those from the rest of the Site. Therefore, the USEPA and the NYSDEC recommended one Cr^{+6}/Cr ratio for the Biosolids Area (11%) and another ratio for the remainder of the Site (1%). This protocol was used to derive hexavalent chromium data from historical total chromium data. Once derived, these data sets were used in the same manner as the majority of other data in this assessment, screened against the appropriate health-based value, and used to calculate exposure point concentrations and estimate risk or hazard.

Total chromium and hexavalent chromium results from soil were screened against their specific RBCs or PRGs and the chemical-specific TRV were used to calculate risk. However, because hexavalent chromium data were unavailable for some media (*e.g.*, shallow ground water, Lakeshore Area seep water, ditch sediment) appropriate Cr^{+6}/Cr Total ratios could not be generated and chromium results from these media were assumed to be hexavalent chromium for both the screening process and in the calculation of risks and hazards.

Unspeciated mercury and chromium: In cases where mercury was not speciated, RBCs and PRGs values for methylmercury were utilized. In media other than soil, where there is no appropriate Cr^{6+}/Cr Total ratio, RBCs and PRGs values for Cr^{+6} were utilized.

Polychlorinated Biphenyls: Calculation of PCB concentrations for use in exposure point concentrations combined individual Aroclors into two groups. Detected "less chlorinated" PCBs (Aroclors 1016, 1221, 1232, and 1242) were summed for screening (in the RAGS Table 2 Series against the screening values for Aroclor 1016) and for determination of the exposure point concentration. Detected "highly chlorinated" PCBs (Aroclors 1248, 1254, 1260, and 1268) were summed for screening (in the RAGS Table 2 Series against the screening values for Aroclor 1254) and for determination of the exposure point concentration. The range of detection limits for "less chlorinated" PCBs is based on Aroclor 1016 and the range of detection limits for "highly chlorinated" PCBs is based on Aroclor 1254. For noncancer hazard estimation, the constituent groups entitled "highly chlorinated" and "less chlorinated" PCBs were used in conjunction with toxicity values for Aroclor 1254 and 1016, respectively. For cancer risk estimation, the constituent groups entitled "total" PCBs were used in conjunction with toxicity values for Aroclor 1254.

Chlordane constituents: All chlordane constituents were summed and screened against the chlordane RBC and technical chlordane PRG criteria.

Xylenes: Some samples include a measurement of total xylenes, while others include separate measurements of o-xylene and m & p-xylene. In cases where only o-xylene and m & p-xylene are available, the sum will provide the total xylene value. When one xylene constituent is non-detect and another is detect, the non-detect is excluded from the sum. If both o-xylene and m & p-xylene are non-detect, one-half of the reporting limits are summed as the value for total xylene. All total xylene measurements were combined to calculate screening and EPC values.

Group A Carcinogens: All detected Group A carcinogens (arsenic, benzene, hexavalent chromium, and vinyl chloride) were retained as COPCs even if their maximum detected concentration did not exceed their respective screening criterion. In situations where both hexavalent chromium and total chromium were present for a particular media/exposure area combination, total chromium was not treated as a Group A carcinogen but hexavalent chromium was (*e.g.*, RAGS Table 2.1a). In contrast, in situations where only total chromium was included for that media/exposure area combination (*e.g.*, RAGS Table 2.4), total chromium was conservatively assumed to be all hexavalent chromium, and thereby treated as a Group A carcinogen.

3.3. Media Specific Considerations

This section describes the media that are relevant to this assessment. **Appendix B** provides a comprehensive list of samples used in this deliverable.

Surface Soil: Surface soil was defined as soil collected from 0 to 2 feet (ft) below ground surface (bgs). The soil database contained a start depth and an end depth for a given sample. Surface soil was sorted from the entire soil database by selecting samples with an end depth that was less than or equal to 2 ft. Thus, a sample collected from 1 ft (start depth) to 3 ft (end depth) would not have been included in the RAGS 2 Tables that evaluate surface soils.

Surface and Subsurface Soil: Two exposure scenarios (construction worker and utility/sewer worker scenarios) required the evaluation of surface and subsurface soil combined. This exposure medium was defined as soil collected from 0 to 10 ft bgs. Surface and subsurface soil combined was sorted from the entire soil database by selecting samples with an end depth that was less than or equal to 10 ft bgs.

Soil Vapor: Ten soil vapor samples were collected throughout the Site. These samples are WB18-VI-01 (8 ft bgs), WB18-VI-02 (4 ft bgs), WB18-VI-03 (4 ft bgs), WB18-VI-04 (8 ft bgs), WB18-VI-05 (8 ft bgs), WB18-VI-06 (3 ft bgs), WB18-VI-07 (4 ft bgs), WB18-VI-08 (3 ft bgs), WB18-VI-09 (3 ft bgs), WB18-VI-10 (3 ft bgs).

Seep Sediments: Sediments associated with the various Site seeps located in the Lakeshore Area, the Upland Old Field Successional Area, and next to the Site Ditches. The majority of these samples are designated as “SP” but there are two DEC samples (DEC 101-01 and DEC 101-02) and one “Pipe” sample (Pipe-08) included in this group. This exposure medium was defined as seep sediment samples collected from the 0 – 1 ft bgs soil horizon.

Ditch Sediments: Sediments associated with the Site Ditches **(Figure 1).** Ditch sediment samples were SED-02, SED-03, SED-04, SED-05, and SED-06.

Ponded Area Sediments: Sediments associated with the Ponded Area exposure area **(Figure 1).** Ponded Areas sediment samples were SED-01, SED-07, and SED-08.

Shallow Ground Water: Two exposure scenarios (construction and utility worker scenario) required the evaluation of direct exposure to shallow ground water. This exposure medium was defined as ground water samples collected from monitoring wells that contained a depth to water from 0 to 10 ft bgs. Shallow ground water was sorted from the Site database by selected data with a start depth less than or equal to 10 ft bgs. The start depth was used rather than the end depth to select for shallow ground water, because of the abundance of ground water samples with start depth less than or equal to 10 ft bgs but an end depth greater than 10 ft bgs. Thus, a sample with a start depth of 8 ft bgs and an end depth of 20 ft bgs would have been included in this evaluation.

Seep Surface Water: Surface water associated with the various Site seeps located in the Lakeshore Area, the Upland Old Field Successional Area, and next to the Site Ditches. The majority of these samples are designated as “SP” but there are four DEC samples (DEC 101-01, DEC 101-02, DEC 101-03, and DEC 101-04) and two “Pipe” samples (Pipe-07 and Pipe-08) included in this group.

Ponded Area Surface Water: Surface Water associated with the Ponded Area exposure area **(Figure 1).** Ponded Areas surface water samples were SW-01, SW-07, and SW-08.

Ditch Surface Water: Surface water associated with the Site Ditches **(Figure 1).** Ditch surface water samples were SW-02, SW-03, SW-04, SW-05, SW-06, DEC 101-03, and DEC 101-04.

Site-Wide Ground Water: One exposure scenario (hypothetical drinking water scenario) required the evaluation of all Site ground water collected, regardless of depth. This Site-wide (all depths) ground water dataset includes four metals (molybdenum, tin, titanium and boron) that were reported erroneously by the laboratory as these parameters were not requested at the time of sampling. Because this mistake only occurred for one well and one sampling event, only one sample point is available for these four analytes.

3.4. Identification of Constituents of Potential Concern

Unlike RAGS Table Series 1 and 3 that are organized by Exposure Units, the RAGS Table 2 series, which identifies COPCs, is organized by individual exposure areas (NY State Fair Parking Areas, Lakeshore Area, Upland Old Field Successional Area, the Biosolids Area, the Ponded Area, the Ditch A – South, and the Site Ditches). The RAGS Table 2 Series was organized in this way to increase the resolution for determining specific areas that drive risk at this Site. For example, knowing that the maximum concentration of a constituent is located in the Lakeshore Area is more useful for risk management decisions than knowing that the maximum value is somewhere in Exposure Unit 1. This approach also facilitates the examination of potential hot spots. Hot spots are discussed in greater detail in Sections 7.5 and 7.6.

Consistent with USEPA guidance (USEPA 1989), a conservative screening process was applied to the selection of constituents of potential concern (COPC). To develop the COPC list, the maximum detected concentrations of the detected constituents in surface soil, combined surface and subsurface soil, surface water, surface sediment, shallow ground water, and all ground water were compared to conservative screening values for the protection of human health.

The screening values utilized were the lowest of the USEPA Region 9 Preliminary Remediation Goals (PRGs) (USEPA 2004b) or the USEPA Region 3 Risk-Based Concentrations (RBCs) (USEPA 2007a). RBCs and PRGs for tap water were applied to screen surface water and ground water 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 ground water [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.

If the maximum detected concentration was less than the identified screening value, it was concluded that exposure to the constituent does not represent an unacceptable risk to human health, and no further evaluation of this constituent was necessary. If the maximum detected concentration exceeded the selected screening value, the constituent was selected as a COPC and retained for further evaluation in this assessment.

Naturally occurring compounds were eliminated from the COPC list if they were essential nutrients. Based on this consideration, calcium, magnesium, potassium, and sodium were not carried forward as COPCs for the risk assessment. Wet chemistry analytes and geochemical parameters (*e.g.*, chloride, nitrogen, and TOC) were not included in the risk assessment.

Constituents detected in media that do not have established RBCs or PRGs were carried forward for further evaluation in the risk assessment. Compounds that were not detected at any of the locations sampled were not included in the quantitative evaluation.

All detected Group A carcinogens (arsenic, benzene, hexavalent chromium, and vinyl chloride) were retained as COPCs even if their maximum detected concentration did not exceed their respective screening criteria. The unspeciated chromium was evaluated as hexavalent chromium as per the methods set forth in Section 3.2 for both the screening process and in the calculation of risks and hazards.

3.4.1. Indoor Air Pathway

The vapor intrusion pathway was evaluated in the HHRA for a current or future commercial/industrial worker. The RAGS Table 2 Series screening for the indoor air exposure was conducted in one of two ways. First, insight into the risks posed by vapor intrusion was obtained by comparing Site-wide shallow ground water to USEPA OSWER (2002a) ground water to indoor air criteria (RAGS Table 2.26).

Second, in situations where soil vapor data were available (New York State Fair Parking Area and the Upland Old Field Successional Area), these data were screened using the framework presented in USEPA (2004a). Ambient air criteria were obtained from Region 9 PRG and Region 3 RBC, except for those for PCE, TCE, carbon tetrachloride, vinyl chloride, 1,1,1-TCA, 1,1-DCE and cis-1,2-DCE, which were obtained from NYSDOH (2007). It should be noted that the matrix approach to evaluating the vapor intrusion pathway in USEPA (2004a) was adapted into the RAGS Table 2 Series format (RAGS Tables 2.9 and 2.17). Specifically, a decision on whether or not action is required was made using the following approach:

- If the minimum of the RBC and PRG screening value constituent was based on non-cancer hazards, the minimum of the RBC and PRG value was multiplied by 10 (default sub-slab to indoor air attenuation coefficient), and this value was compared to the maximum detected constituent concentration; an exceedance results in a decision to "monitor or pursue remediation;" otherwise, the decision was "no action." Non-cancer screening values were adjusted to an HI of 0.1 (excluding lead).

- If the minimum of the RBC and PRG screening value constituent was based on cancer risk, the minimum of the RBC and PRG value was multiplied by either 10, 100, or 1000 (corresponding to cancer risks of 10^{-6}, 10^{-5}, and 10^{-4}, respectively), and these values were compared to the maximum detected constituent concentration; if the 10^{-4} risk was exceeded, the decision was to "investigate or pursue remediation;" if the 10^{-5} risk is exceeded, the decision was to "monitor or pursue remediation;" if the 10^{-6} risk was exceeded, the decision was to "monitor;" otherwise, the decision was "no action." Constituents with no RBC or PRG are discussed in the uncertainty section.

3.5. Screening Results

Results of the COPC screening are presented below.

3.5.1. Lakeshore Area

Surface Soil: Analytical results of detected concentrations of surface soil samples from the Lakeshore Area are presented in RAGS Table 2.1. Approximately 29 samples were analyzed for 169 chemical constituents or constituent groups, of which 71 were detected and 21 COPCs were screened in, with 14 chemical constituents above screening levels, and four constituents screened in because there was no toxicity information (delta-BHC, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene). In addition, arsenic, hexavalent chromium, and benzene were retained because they are classified as Class A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Surface and Subsurface Soil: Analytical results of detected concentrations of subsurface soil samples from the Lakeshore Area are presented in RAGS Table 2.2. Approximately 84 samples were analyzed for 175 chemical constituents or constituent groups, of which 79 were detected and 24 COPCs were retained, with 17 chemical constituents above screening levels and four constituents retained because there was no toxicity information (delta-BHC, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene). In addition, arsenic, hexavalent chromium, and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Seep Sediment: Analytical results of detected concentrations of seep sediment samples from the Lakeshore Area are presented in RAGS Table 2.3. Approximately 15 samples were analyzed for 150 chemical constituents or constituent groups, of which 49 were detected and 16 COPCs were retained, with 11 chemical constituents above screening levels, and two constituents (phenanthrene and 2-

hexanone) were retained because there was no available toxicity information. In addition, arsenic, hexavalent chromium, and benzene were retained because they are Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Shallow Ground Water: Analytical results of detected concentrations of shallow ground water samples from the Lakeshore Area are presented in RAGS Table 2.4. Approximately 35 samples were analyzed for 181 chemical constituents or constituent groups, of which 58 were detected and 39 COPCs were retained, with 33 chemical constituents above screening levels and three constituents being retained because there was no toxicity information (phenanthrene, 2-hexanone, and propionic acid). In addition, arsenic, chromium, and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Seep Water: Analytical results of detected concentrations of seep water samples from the Lakeshore Area are presented in RAGS Table 2.5. Approximately 7 samples were analyzed for 181 chemical constituents or constituent groups, of which 44 were detected and 20 COPCs were retained for evaluation, with 14 chemical constituents above screening levels and three constituents retained because there was no toxicity information (4-nitrophenol, phenanthrene, and 2-hexanone). In addition, arsenic, chromium (assumed to be all hexavalent chromium), and benzene were retained because they are Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

3.5.2. New York State Fair Parking Areas

Surface Soil: Analytical results of detected concentrations of surface soil samples from the NY State Fair Parking Area are presented in RAGS Table 2.6. Approximately 28 samples were analyzed for 171 chemical constituents or constituent groups, of which 61 were detected and 22 COPCs were retained for evaluation, with 16 chemical constituents above screening levels and three constituents retained because there was no toxicity information (acenaphthylene, benzo(g,h,i)perylene, and phenanthrene). In addition, arsenic, hexavalent chromium, and benzene were retained because they are Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Surface and Subsurface Soil: Analytical results of detected concentrations of surface and subsurface soil samples from the NY State Fair Parking Area are presented in RAGS Table 2.7. Approximately 35 samples were analyzed for 175 chemical constituents or constituent groups, of which 65 were detected and 27 COPCs were screened in, with 21 chemical constituents above screening levels and three constituents screened in because there was no toxicity information (acenaphthylene, benzo(g,h,i)perylene, and phenanthrene). In addition, arsenic, hexavalent chromium, and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Shallow Ground Water: Analytical results of detected concentrations of shallow ground water samples from the NY State Fair Parking Area are presented in RAGS Table 2.8. Approximately five samples were analyzed for 179 chemical constituents or constituent groups, of which 38 were detected and 15 COPCs were retained, with ten chemical constituents above screening levels and two constituents retained because there was no toxicity information (phenanthrene and 2-hexanone). In addition, arsenic, chromium (assumed to be all hexavalent chromium), and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Soil Vapor: Analytical results of detected concentrations of soil vapor samples from the NY State Fair Parking Area are presented in RAGS Table 2.9. Six samples were analyzed for 64 chemical constituents or constituent groups, of which 26 were detected. The maximum detected concentrations were screened using the framework presented in USEPA (2004a). Four carcinogens (benzene, carbon tetrachloride, chloroform, and tetrachloroethene) exceeded the 10^{-6} risk threshhold. Five constituents lacked RBCs and PRGs and are discussed in the uncertainty section. The remaining 17 compounds were below the selected screening levels and require no further action.

3.5.3. Biosolids Area

Surface Soil: Analytical results of detected concentrations of surface soil samples from the Biosolids Area are presented in RAGS Table 2.10. Approximately 15 samples were analyzed for 171 chemical constituents or constituent groups, of which 66 were detected and 29 COPCs were retained, with 22 chemical constituents above screening levels and five constituents retained because there was no toxicity information (endrin aldehyde, 4-nitrophenol, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene). In addition, arsenic and hexavalent chromium were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Surface and Subsurface Soil: Analytical results of detected concentrations of subsurface soil samples from the Biosolids Area are presented in RAGS Table 2.11. Approximately 16 samples were analyzed for 171 chemical constituents or constituent groups, of which 69 were detected and 30 COPCs were retained, with 24 chemical constituents above screening levels and four constituents retained because there was no toxicity information (4-nitrophenol, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene). In addition, arsenic and hexavalent chromium were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

3.5.4. Upland Old Field Successional Area

Surface Soil: Analytical results of detected concentrations of surface soil samples from the Upland Old Field Successional Area are presented in RAGS Table 2.12. Approximately 42 samples were analyzed for 169 chemical constituents or constituent groups, of which 63 were detected and 23 COPCs were retained, with 17 chemical constituents above screening levels and four constituents retained because there was no toxicity information (4-nitrophenol, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene). In addition, arsenic and hexavalent chromium were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Surface and Subsurface Soil: Analytical results of detected concentrations of subsurface soil samples from the Upland Old Field Successional Area are presented in RAGS Table 2.13. Approximately 61 samples were analyzed for 169 chemical constituents or constituent groups, of which 80 were detected and 27 COPCs were retained, with 18 chemical constituents above screening levels and six constituents retained because there was no toxicity information (delta-BHC, 4-nitrophenol, acenaphthylene, benzo(g,h,i)perylene, phenanthrene, and 2-hexanone). In addition, arsenic, chromium (including hexavalent chromium), and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Seep Sediment: Analytical results of detected concentrations of seep sediment samples from the Upland Old Field Successional Area are presented in RAGS Table 2.14. Approximately 11 samples were analyzed for 150 chemical constituents or constituent groups, of which 51 were detected and 17 COPCs were retained, with 11 chemical constituents above screening levels, and three constituents (delta-BHC, phenanthrene, and 2-hexanone) retained because there was no available toxicity information. In addition, arsenic, hexavalent chromium, and benzene were retained because they are Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Shallow Ground Water: Analytical results of detected concentrations of shallow ground water samples from the Upland Old Field Successional Area are presented in RAGS Table 2.15. Approximately 10 samples were analyzed for 173 chemical constituents or constituent groups, of which 40 were detected and 16 COPCs were retained, with 10 chemical constituents above screening levels and three constituents retained because there was no toxicity information (4-nitrophenol, phenanthrene, and 2-hexanone). In addition, arsenic, chromium (assumed to be all hexavalent chromium), and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Seep Water: Analytical results of detected concentrations of seep water samples from Upland Old Field Successional Area are presented in RAGS Table 2.16. Approximately eight samples were analyzed for 181 chemical constituents or constituent groups, of which 39 were detected and 21 COPCs were retained, with 15 chemical constituents above screening levels and three constituents retained because there was no toxicity information (acenaphthylene, phenanthrene, and 2-hexanone). In addition, arsenic, chromium (assumed to be all hexavalent chromium) and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Soil Vapor: Analytical results of detected concentrations of soil vapor samples from the Upland Old Field Successional Area are presented in RAGS Table 2.17. Six samples were analyzed for 64 chemical constituents or constituent groups, of which 23 were detected. The maximum detected concentrations were screened using the framework presented in USEPA (2004a). Five carcinogens (benzene, carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene) exceeded the 10^{-6} risk threshold. Four constituents lacked RBCs and PRGs and are discussed in the uncertainty section. The remaining 14 constituents were below their selected screening levels and require no further action.

3.5.5. Site Ditches

Sediment and Seep Sediment: Analytical results of detected concentrations of sediment and seep samples from the Site Ditches are presented in RAGS Table 2.18. Eleven samples were analyzed for 150 chemical constituents or constituent groups, of which 54 were detected and 16 COPCs were retained, with 10 chemical constituents above screening levels, and four constituents retained because there was no available toxicity information (acenaphthylene, benzo(g,h,i)perylene, phenanthrene, and 2-hexanone). In addition, arsenic and chromium (assumed to be all hexavalent chromium) were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Surface Water: Analytical results of detected concentrations of surface water samples from Site Ditches are presented in RAGS Table 2.19. Approximately eight samples were analyzed for 153 chemical constituents or constituent groups, of which 30 were detected and 10 COPCs were retained, with 5 chemical constituents above screening levels and two constituents retained because there was no toxicity information (delta-BHC and phenanthrene). In addition, arsenic, chromium (assumed to be all hexavalent chromium), and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Seep Water: Analytical results of detected concentrations of surface water samples from Site Ditches are presented in RAGS Table 2.20. Approximately seven samples were analyzed for 181 chemical constituents or constituent groups, of which 38 were detected and 17 COPCs were retained, with 14 chemical constituents above screening levels. Arsenic, chromium (assumed to be all hexavalent chromium) and benzene were also retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

3.5.6. Ponded Area

Surface Sediment: Analytical results of detected concentrations of surface sediment samples from Ponded Area are presented in RAGS Table 2.21. Six samples on average were analyzed for 151 chemical constituents or constituent groups, of which 52 were detected and 13 COPCs were retained, with eight chemical constituents above screening levels and two constituents retained because there was no toxicity information (benzo(g,h,i)perylene and phenanthrene). In addition, arsenic, chromium (assumed to be all hexavalent chromium), and benzene were retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Surface Water: Analytical results of detected concentrations of surface water samples from Ponded Area are presented in RAGS Table 2.22. Approximately four samples were analyzed for 172 chemical constituents or constituent groups, of which 36 were detected and nine COPCs were retained, with six chemical constituents above screening levels and two constituents retained because there was no toxicity information (phenanthrene and 2-hexanone). In addition, benzene was retained because it is classified as a Group A carcinogen, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

3.5.7. Ditch A – South

Surface Sediment: Analytical results of detected concentrations of surface sediment samples from Ditch A - South are presented in RAGS Table 2.23. Two samples were analyzed for 152 chemical constituents or constituent groups, of which 41 were detected and 11 COPCs were retained, with 8 chemical constituents above screening levels. Arsenic, chromium (assumed to be all hexavalent chromium), and benzene were also retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Surface Water: Analytical results of detected concentrations of surface water samples from Ditch A - South are presented in RAGS Table 2.24. Two samples were analyzed for 153 chemical constituents or constituent groups, of which 29 were detected and 10 COPCs were retained, with eight chemical constituents above screening levels. Chromium (assumed to be all hexavalent chromium) and benzene were also retained because they are classified as Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

3.5.8. Ground Water (Site-Wide)

Shallow Ground Water: Analytical results of detected concentrations of shallow ground water samples from Site-wide ground water are presented in RAGS Table 2.25. Approximately 50 samples were analyzed for 181 chemical constituents or constituent groups, of which 62 were detected and 39 COPCs were retained, with 33 chemical constituents above screening levels and three constituents retained because there was no toxicity information (4-nitrophenol, phenanthrene, and 2-hexanone). In addition, arsenic, chromium (assumed to be all hexavalent chromium), and benzene were retained because they are classified because they are Group A carcinogens, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

Shallow Ground Water – Vapor Intrusion: Analytical results of detected concentrations of shallow ground water where compared to USEPA OSWER (2002a) ground water to indoor air criteria (RAGS Table 2.26). Approximately 50 samples were analyzed for 181 chemical constituents or constituent groups yielding 34 constituents that were detected at least once. Nineteen of these constituents were retained for further assessment, with 4 constituents above screening levels and 14 constituents retained because there was no toxicity information. In addition, benzene was retained because it is classified as a Group A carcinogen.

Hypothetical Drinking Water: Analytical results of detected concentration from Site-wide ground water are presented in RAGS Table 2.27. Approximately 302 samples were analyzed for 210 chemical constituents or constituent groups, of which 110 were detected and 68 COPCs were retained, with 59 chemical constituents above screening levels and eight constituents retained because there was no toxicity information (delta-BHC, 2-nitrophenol, 4-nitrophenol, benzo(g,h,i)perylene, phenanthrene, 1-phenyl-1-(2,4-dimethylphenyl)ethane, 1-phenyl-1-(4-methylphenyl)ethane and 2-hexanone). In addition, arsenic was retained because it is classified as a Group A carcinogen, and calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients.

4. Exposure Assessment

The goal of the exposure assessment is to estimate intake levels of each of the COPCs for each potential receptor in a given exposure unit. This calculation requires estimates of:

- The concentration of the COPCs encountered by the receptors (the exposure-point concentration).
- The manner and frequency of exposure.
- Receptor characteristics (body weight, ingestion rate, *etc*.).

These factors were combined to estimate the average daily dose potentially received by receptors.

USEPA defines two types of exposure estimates for Superfund risk assessments: reasonable maximum exposure (RME) and central tendency exposure (CT). The RME is defined as the highest exposure that reasonably could be expected to occur for a given exposure pathway at a site and is intended to account for both uncertainty in the chemical concentration and variability in the exposure parameters (such as exposure frequency or averaging time) (USEPA 1989). The CT is typically based on average exposure parameters.

This section comprises the following subsections:

- In Section 4.1, the concentrations of the constituents in the various affected media that Site-related receptors may be exposed to are quantified. This subsection discusses the calculation of 95% UCL, the shower model, calculation of particulate emission factors, and volatilization factors, among other parameters.
- In Section 4.2, the equations for the calculation of chronic daily intake are presented.
- Section 4.3 presents parameters for the quantification of exposure to the various affected media.

4.1. Development of Constituent Exposure Point Concentrations

Exposure point concentrations (EPCs) were calculated for all constituents that were retained in the RAGS Table 2 screening process. An exposure point concentration was calculated for any constituent that was retained for any one of the exposure areas comprising an exposure unit. For example, Exposure Unit 2 comprises three areas: 1) NY State Fair Parking Area, 2) Upland Old Field Successional Area, and 3) Biosolids Area. If a hypothetical compound was not retained in two of the three exposure areas but was retained for the third, an exposure point concentration was still calculated for that compound in Exposure Unit 2 using the data from all three of the component exposure areas.

4.1.1. General Approach for the Development of EPC Values

Statistical and procedural methods were applied to the data in order to develop an estimate of the EPC for COPCs selected for each Exposure Unit on a medium-specific basis. The general approach was as follows: where a given data set contained less than three sample points or only one unique detected sample, the maximum value for each analyte in that data set was used as the EPC; for sets with four or more data points and at least two unique detected samples, statistical methods were applied. In the latter case, the ProUCL statistical software package (Version 4.0; USEPA 2007b) was used to examine the data distribution and develop an upper confidence level (UCL) on the arithmetic mean. ProUCL was run using Regression on Order Statistics (ROS), which is a method used to account for non-detect samples in the data set. ROS infers values for non-detect samples based on the distribution of detected data, thus eliminating the influence of high detection limits. ProUCL recommends the most appropriate UCL to use given the distribution type. The UCL recommended by ProUCL was subsequently applied as the EPC. In cases where multiple recommendations were made by ProUCL, the first recommendation was selected and utilized in the HHRA. There was no statistical reason for this selection; this methodology was simply a way to standardize the selection of UCLs in situations where ProUCL provided more than one option. All ProUCL output files are contained in **Appendix C (Electronic)**.

It should be noted that in some cases the 95% UCL is less than the reported average concentration. This is because the arithmetic average reported in the RAGS Table 3 Series is the mean concentration of detects only (*i.e.*, does not include non-detects). In instances where the detection frequency is low and non-detect samples largely outnumber detected samples, the 95% UCL recommended by ProUCL Version 4 can be smaller than the mean detected concentration, since it reflects the large number of non-detect samples.

A comparison of EPCs calculated using ProUCL Version 4.0 with ROS statistics versus EPCs calculated using simple substitution of non-detect samples by half the reporting limit was conducted for constituents that were found to be associated with the most significant contributions to unacceptable levels of risk (presented in Section 7.3.5). This comparison was performed because simple substitution methods have long been in use in human health risk assessment and ROS methods have only been recently made available. For the constituents considered, the ratio of EPCs derived from simple substitution relative to ROS statistics ranged from approximately 1 to 3, indicating that EPCs would likely have been higher using simple substitution. Overall, ROS statistics are a more appropriate method of handling non-detect samples because they utilize the underlying distribution of the detected samples to estimate replacement values for non-detect samples. This preserves the variability in the sample data appropriate to a given distribution, whereas simple substitution can distort this variability by estimating the same replacement value for multiple non-detect samples that have the same reporting limit. The latter can have the effect of altering the distribution of the sample data. For this reason, simple substitution is generally not recommended in ProUCL Version 4.0.

4.1.2. Calculation of EPCs for Soil, Sediment, Surface Water, and Ground Water

For these media, the approach outlined in Section 4.1.1 was utilized.

4.1.2.1. Sediment and Surface Water in EU-1 and EU-6.

For aquatic sediment only, the potential for dermal contact exists; however, for seep sediment, the potential for incidental ingestion and dermal contact exists. Since the potential pathways differ for the two types of sediment (aquatic sediment: dermal; seep sediment: ingestion/dermal), it is necessary to obtain two different exposure point concentrations for these media (RAGS Tables 3.2a and 3.2b; 3.16a and 3.16b). However, for surface water and seep surface water only the dermal pathway is evaluated. Therefore, it was only necessary to derive one exposure point concentration for surface water types.

4.1.3. Calculation of EPCs for Shower Scenario

The inhalation of volatiles while showering or bathing was evaluated quantitatively for the child and adult resident in the Site-wide ground water exposure scenario for Exposure Unit 7. The Andelman model, as modified by Schaum *et al.* (1994), was used to derive the exposure point concentrations for this pathway (**Appendix D**).

The maximum air concentration in the bathroom ($C_{a\ max}$) was derived by applying the following equation from Schaum *et al.* (1994):

$$C_{a\max} = \frac{C_w fF_w t_1}{V_a}$$

The concentration of contaminant in the air (C_a) was derived by applying the following equation from Schaum *et al.* (1994):

$$C_a = \frac{(C_{a\max}/2)t_1 + C_{a\max}t_2}{t_1 + t_2}$$

Where (all scenarios): Fraction volatilized (f) = 1, C_w = constituent/exposure unit-specific ground water concentration, water flow rate (F_w) = 750 L/day, bathroom volume (V_a)= 12 m^3

Where (adult scenarios): time of shower (t_1) = 0.25 hr (RME), 0.1 hr (CT); time after shower (t_2) = 0.33 hr (RME), 0.15 hr (CT)

Where (child scenarios): time of shower (t_1) = 0.45 hr (RME), 0.14 hr (CT); time after shower (t_2) = 0.55 hr (RME), 0.19 hr (CT)

4.1.4. Calculation of EPCs for Ambient Air Exposure

The inhalation of air particulates and volatile compounds generated from Site soils was evaluated in this HHRA. The calculation of the Particulate Emission Factor (PEF) and the Volatilization Factor (VF) are discussed in this section.

Soil constituents that were eliminated in the RAGS Table 2 screening process were not considered to be constituents of concern for these air pathways, because the PRG screening criteria utilized are protective of multi-pathway exposure to soil. Of those soil constituents that were retained, volatile organic compounds were evaluated using the soil-to-air volatilization factor (**Appendix E**). Other types of constituents (metals, PCBs, pesticides, and SVOCs) were evaluated as particulate emissions (**Appendix F**). These two pathways are discussed below.

Inhalation of Fugitive Dust

The particle emissions factor (PEF) is required to calculate the constituent concentration in fugitive dust. A separate PEF was calculated for each exposure unit based on the size and percent vegetative cover for each exposure area comprising the exposure unit.

The following equation was used to derive concentrations of inorganics, semivolatiles, PCBs, and pesticides in outdoor air for inhalation exposure pathways (refer to **Appendix E**, **Table 1** for the proposed dust constituent list):

$$C_{air} = \left(\frac{C_{soil}}{PEF} \right)$$

where: C_{air}: Concentration of inorganic particulates in air (mg/m^3), C_{soil}: Concentration in soil (UCL, mg/kg), and PEF: Particle emission factor (m^3/kg)

The particle PEF converts concentrations of constituents in soil to concentrations in dust particles in the air as a result of fugitive dust emissions from bare surface soils. USEPA provides the methodology required to calculate the PEF in Appendix D of *Soil Screening Guidance: Technical Background Document* (USEPA 2002b). Three separate PEFs were calculated in this assessment. Equation E-18 (USEPA 2002b) was used to derive a PEF for the ATV trespasser fugitive dust scenario. Equation 5-5 (USEPA 2002b) was used to derive a PEF for the construction worker and utility/sewer worker scenario. Finally, Equation 4-5 (USEPA 2002b) was used to calculate the PEF for the remainder of the fugitive dust scenarios. The details of these calculations can be found in **Appendix F**.

Concern was raised as to whether the particulate emissions factor for the construction worker is applicable to the utility/sewer worker. USEPA (2002b*) Supplemental Guidance for Developing SSLs*, Appendix D and E does not indicate whether a PEF is appropriate for a utility worker scenario. However, Appendix E (USEPA 2002b, page 10) states that the majority of particulate emissions from construction are attributable to traffic on unpaved roads, with excavation and other activities contributing to a lesser amount. Because the utility/sewer worker's activities would consist primarily of excavating, not driving heavy equipment on unpaved roads, the default PEF for wind generated dust used for most other site receptors (including some other outdoor workers) was used.

Inhalation of Volatile Compounds

The following equation was utilized to derive EPC's of volatile compounds in outdoor air for inhalation exposure pathways:

$$C_{air} = \left(\frac{C_{soil}}{VF} \right)$$

where: C_{air}: Concentration of volatiles in air (mg/m^3), C_{soil}: Concentration in soil (UCL, mg/kg), and VF: Soil-to-air volatilization factor (m^3/kg)

The volatilization factor is used for defining the relationship between the concentration of volatile organic constituents in soil and the volatilized constituents in outdoor air. A VF is specific to each volatile compound and each exposure area. VFs for this assessment were calculated using Equation 4-8 from of *Soil Screening Guidance: Technical Background Document* (USEPA 2002b) and can be found in **Appendix E**.

4.1.5. Calculation of EPCs for Polychlorinated Biphenyls

Calculation of PCB concentrations for use in exposure point concentrations combined individual Aroclors into two groups. The concentrations of “Less chlorinated” PCBs (Aroclors 1016, 1221, 1232, and 1242) were combined for each sample, screened in RAGS Table 2 against the screening values for Aroclor 1016, and used to calculate the 95% UCL for the exposure point concentration. “Highly chlorinated” PCBs (Aroclors 1248, 1254, 1260, and 1268) were combined for each sample, then screened in RAGS Table 2 against the screening values for Aroclor 1254, and used to calculate the 95% UCL.

4.2. Quantitation of Exposure

The next step in the exposure assessment was to generate estimates of chronic daily intake (CDI) based on the magnitude, frequency, and duration of exposure for each identified complete exposure pathway. In accordance with *Risk Assessment Guidance for Superfund Vol. 1: Human Health Evaluation Manual* (USEPA 1989), exposure factors were applied to estimate the CDI from incidental ingestion, dermal contact, and inhalation with Site media for the receptor populations.

Chronic daily intake values were calculated for an RME and CT scenario. The RME scenario provides a conservative estimate of potential health risk related to exposure to constituents in Site media. The RME relies on estimated upper bound values for specific exposure parameters as a conservative and health protective measure. A more representative estimate of risk may be developed based on the average exposure values for a specific parameter. Estimates of health risks and hazards based on the less conservative exposure approximations are presented in the CT scenario.

4.2.1. Intake equations and parameter estimates

The intake equations for application in the assessment are presented below. The specific variables used in each calculation and their values are defined in Section 4.3, the RAGS Table 4 Series, and **Appendix G**.

Incidental ingestion of COPC in surface water

$$\mathrm{CDI_{sw}} = \frac{\mathrm{C_{sw} \times IR \times EF \times ED}}{\mathrm{BW \times AT}}$$

Dermal uptake of COPC in surface water

$$\mathrm{DAD_{sw}} = \frac{\mathrm{C_{sw,pw} \times SA \times PC \times ET \times EF \times ED \times 10^{-3}\ L/cm^3}}{\mathrm{BW \times AT}}$$

Incidental ingestion of COPC from soil and sediment

$$\mathrm{CDI_{soil,\,sediment}} = \frac{\mathrm{C_{soil} \times IR \times FI \times EF \times ED \times (1 \times 10^{-6}\ kg/mg)}}{\mathrm{BW \times AT}}$$

Dermal uptake of COPC from soil and sediment

$$DAD_{soil,\,sediment} = \frac{C_{soil} \times SA \times ABS \times AF \times EF \times ED \times (1 \times 10^{-6}\ kg/mg)}{BW \times AT}$$

Inhalation of airborne constituents in fugitive dust

$$CDI_{air} = \frac{C_{air} \times InR \times ET \times EF \times ED}{BW \times AT}$$

where:

ABS:	Dermal absorption factor	(unitless)
AF:	Soil to skin adherence factor	(mg/cm^2)
AT:	Averaging time	(days)
BW:	Body weight	(kg)
C_{air}:	COPC concentration in air	(mg/m^3)
C_{soil}:	COPC concentration in soil	(mg/kg)
C_{sed}:	Concentration of each constituent in sediment	(mg/kg)
C_{sw}:	Concentration of each constituent in surface water	(mg/L)
CDI:	Chronic daily intake	(mg/kg-day)
DAD:	Dermally absorbed dose	(mg/kg-day)
ED:	Exposure duration	(years)
EF:	Exposure frequency	(days/year)
ET:	Exposure time	(hours/day)
FI:	Fraction ingested from contaminated source	(unitless)
IR:	Ingestion rate for soil (mg/day) or water	(L/day)
InR:	Inhalation rate	(m^3/hour)
PC:	Permeability Coefficient	(cm/hour)
SA:	Skin surface area for dermal absorption	(cm^2)

4.3. Exposure Parameter Estimates

Values selected and assumptions made for the RME and CT scenarios are presented in the RAGS Table 4 Series and discussed below.

4.3.1. Age Dependent Adjustment for Chemicals with Mutagenic Mode of Action

PAHs

Those constituents listed in the USEPA's 2006 memorandum (USEPA 2006) as having a Mutagenic Mode of Action (MMOA) are subject to adjustment by Age Dependent Adjustment Factors (ADAFs) as described in *Supplemental Guidelines for Assessing Susceptibility from Early Life Exposure to Carcinogens - Supplemental Guidance* (USEPA 2005):

- Ages 0 to < 2 years: ADAF = 10
- Ages 2 to < 6 years: ADAF = 3
- Ages 6 to < 16 years: ADAF = 3
- Ages 16 to < 30 years: ADAF = 1

This ADAF evaluation required the modification of the RAGS Table 4 Series to include the specific age bins listed above (0 to 2 years, 2 to 6 years, 6 to 16 years, and 16 to 30 years). The 0 to 2 year and 2 to 6 year bins utilize child exposure parameters, while the 6 to 16 and 16 to 30 year bins utilize adult exposure parameters. The cancer risk for child receptors is the sum of the risks associated with the 0 to 2 and 2 to 6 year bins. The cancer risk for adult receptors is the sum of the risks for all four bins. This ADAF evaluation was derived specifically for this assessment by using the *Wastebeds 1 through 8 Bike Trail HHRA* (USEPA 2008b) as an example.

It should be noted that other PAHs considered toxicologically related to benzo(a)pyrene, based on the *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (USEPA 1993), are not included on the list of chemicals with a MMOA (USEPA 2006) but are subject to an ADAF as well.

Vinyl Chloride

Vinyl chloride is listed as an MMOA chemical in USEPA's 2006 memorandum (USEPA 2006), but this constituent is a special case with respect to age adjustment. The methodology used for assessing cancer risk associated with this compound was not completed by using ADAFs but followed the USEPA's (2001a) recommendation that cancer risk be calculated on a pro-rated basis for the lifetime segments (6 years child, 24 years adult) individually and then summed.

The examples in the USEPA (2001a) indicate that both pro-rated and non-pro-rated risks for vinyl chloride should be generated and used in the summation of risk for children. For the residential adult, lifetime exposure is estimated by calculating the pro-rated risks for vinyl chloride for the adult and adding the result to the sum of the prorated and non-prorated child risk estimates.

The formula for child cancer risk (oral) for vinyl chloride, pro-rated, is:

$$Child\ Exposure_{PR} = \frac{C_{gw} \times IR_{child} \times CF \times EF_{child} \times ED_{child} \times CSF}{BW_{child} \times AT}$$

Where:
Child Exposure_{PR} = Pro-rated child exposure (unitless)
C_{gw} = Concentration in ground water (mg/L)
IR_{child} = Child ingestion rate of water (L/day)
EF_{child} = Exposure frequency (days/year)
ED_{child} = Exposure duration (years)
CSF = Oral cancer slope factor ($(\text{mg/kg-day})^{-1}$)
BW_{child} = Body weight (kg)
AT = Averaging time (days)

The non-prorated segment for vinyl chloride for child exposure is:

$$\text{Child Exposure}_{\text{non-PR}} = \frac{C_{gw} \times IR \times CF \times CSF}{BW}$$

Where:
Child $\text{Exposure}_{\text{non-PR}}$ = Non pro-rated child exposure (unitless)
C_{gw} = Concentration in ground water (mg/L)
IR = Ingestion rate of water (L/day)
CSF = Oral cancer slope factor ($(\text{mg/kg-day})^{-1}$)

BW = Body weight (kg)

The formula for adult cancer risk (oral) for vinyl chloride, pro-rated, is:

$$\text{Adult Exposure}_{\text{PR}} = \frac{C_{gw} \times IR_{adult} \times CF \times EF_{adult} \times ED_{adult} \times CSF}{BW_{adult} \times AT}$$

Where:
Adult Exposure$_{PR}$ = Pro-rated adult exposure (unitless)
C_{gw} = Concentration in ground water (mg/L)
IR_{adult} = Ingestion rate of water (L/day)
EF_{adult} = Exposure frequency (days/year)
ED_{adult} = Exposure duration (years)
CSF = Oral cancer slope factor ((mg/kg-day)$^{-1}$)
BW_{adult} = Body weight (kg)
AT = Averaging time (days)

As outlined above, residential adult lifetime exposure to ground water carcinogenic risk (oral) for vinyl chloride equals:

$$\text{CDI}_{\text{VinylChloride}} = \text{Child Exposure}_{\text{PR}} + \text{Child Exposure}_{\text{non-PR}} + \text{Adult Exposure}_{\text{PR}}$$

Where:
CDI$_{\text{Vinyl Chloride}}$ = Chronic Daily intake of vinyl chloride (mg/kg/day)
Child Exposure$_{PR}$ = Pro-rated child exposure (mg/kg/day)
Child Exposure$_{\text{non-PR}}$ = Non pro-rated child exposure (mg/kg/day)
Adult Exposure$_{PR}$ = Pro-rated adult exposure (mg/kg/day)

Dermal calculations for vinyl chloride incorporate the same pro-rated/ non pro-rated principles, adjusting the equations as described in this section.

4.3.2. Dermal Adsorption Factor

The dermal absorption factor (ABS, unitless) represents the fraction of the soil constituent that may be absorbed through the skin over each exposure event. In general, metals are poorly absorbed through the skin whereas organic constituents may be absorbed more readily. Constituent-specific values were obtained from USEPA Risk Assessment Guidance (RAGS Part E, USEPA 2004c, Exhibit 3-4). Table 2 of that document presents the specific values for each constituent. The values used in this HHRA are supplied in **Appendix G**. If chemical-specific data for dermal absorption were not available, 100% dermal absorption was assumed.

4.3.3. Soil-to-Skin Adherence Factor

Soil to skin adherence factors (AF, mg/cm^2) represent the average mass of soil that adheres to the skin over each exposure event. The AF depends on the specific activity being conducted and is higher for body parts with greater exposure to the soils. For example, the AF is higher for a construction worker than for an industrial worker, with greater adherence to the hands as compared with less exposed parts such as the head. AFs are therefore derived as the body part weighted average estimates for each receptor, considering the specific activities in which each receptor group is likely to participate. The specific RME and CT AFs obtained from USEPA Risk Assessment Guidance (RAGS Part E, USEPA 2004c, Exhibit 3-5) and applied for each receptor group as summarized below.

- For a transient older child trespasser exposed to surface soil, the RME AF value is 0.07 mg/cm^2 and the CT value is 0.01 mg/cm^2. For a transient older child trespasser exposed to surface sediment, the RME and CT AF values are 2.7 mg/cm^2 and 0.2 mg/cm^2, respectively. For a transient older child trespasser exposed to seep sediment, the RME and CT AF values are 2.7 mg/cm^2 and 0.2 mg/cm^2, respectively.
- For an adult lunchtime trespasser exposed to surface soil, the RME AF value is 0.07 mg/cm^2 and the CT value is 0.01 mg/cm^2. For an adult lunchtime trespasser exposed to seep sediment, 0.07 mg/cm^2 was used as the RME and the CT AF values.
- For commercial/industrial workers exposed to surface soil, the RME and CT AF values are 0.3 mg/cm^2 and 0.1 mg/cm^2, respectively.
- For utility/sewer workers exposed to surface soil, the RME AF is 0.3 mg/cm^2, while the CT value is 0.2 mg/cm^2, the geometric mean for utility workers (RAGS Part E, USEPA 2004c, Exhibit 3-3).
- For trespassers/ATV recreators (both older child and young adult) exposed to surface soil, the RME AF is 0.7 mg/cm^2, while the CT value is 0.2 mg/cm^2. For trespassers/ATV recreators (both older child and young adult) exposed to seep sediment, the RME AF is 2.7 mg/cm^2, while the CT value is 0.2 mg/cm^2.
- In the scenario of the construction worker exposed to surface and subsurface soils, the RME value is 0.3 mg/cm^2 and the CT value is 0.1 mg/cm^2. The same values are used for exposure to seep sediment.
- In the scenario of the state fairgrounds attendee (both adult and older child) exposed to surface soil, the RME value is 0.07 mg/cm^2 and the CT value is 0.01 mg/cm^2. For the younger child state fairgrounds attendee, RME and CT values are 0.2 mg/cm^2 and 0.04 mg/cm^2, respectively. For the state fairgrounds maintenance worker, RME and CT values are 0.2 mg/cm^2 and 0.02 mg/cm^2, respectively.
- For ditch maintenance workers exposed to site ditch sediment and seep sediment, the RME and CT AF values are 0.9 mg/cm^2 and 0.2 mg/cm^2, respectively.
- For trespassers/fisherpersons exposed to surface soil, surface sediment or seep sediment, the RME and CT AF values are 0.3 mg/cm^2 and 0.15 mg/cm^2, respectively.

4.3.4. Averaging Time

The averaging time (AT, days) is the time period over which exposure is averaged. In accordance with USEPA guidance (USEPA 1989, Exhibits 6-11 through 6-16), the averaging time for exposure to potential carcinogenic compounds (AT-C) is 25,550 days. This accounts for exposure to a carcinogenic substance over a 70-year lifetime. For exposure to non-carcinogens, the averaging time (AT-NC) is calculated as the exposure duration (years) multiplied by 365 days per year (USEPA 1989, Exhibits 6-11 through 6-16). The averaging time for exposure to non-carcinogenic substances therefore varies for receptors depending on their exposure duration.

4.3.5. Body Weight

The body weight (BW, kg) estimates are receptor-specific for adults, older children, and younger children. For adults, a default body weight of 70 kg was applied (USEPA 1997a, Table 7-11). For children aged 6 to <18 years, a body weight of 43 kg was used based on values reported by USEAPA (Exposure Factors Handbook, USEPA, 1997a, Table 7-11). For older children (ages 12 to <18 years), a body weight of 56 kg was used based on values for 12 to 17 year old boys and girls reported by the USEPA (USEPA 1997a, Table 7.3) averaged over the age range. A body weight of 15 kg was used for younger children (less than 6 years old), the default given in USEPA risk assessment guidance (RAGS vol. 1, USEPA 1991, Section 6.0 Summary Table).

4.3.6. Exposure Duration

Exposure duration (in years) is an estimate of the time period over which a receptor is exposed. Exposure duration values are presented in the RAGS Table 4 Series and discussed below.

- For the transient trespasser RME scenario, an exposure duration of 12 years was applied for the older child (6 to <18 years) transient trespasser, and 25 years for the adult lunchtime trespasser (USEPA 1991, Attachment B). The corresponding CT values applied were 12 years and 9 years, respectively.
- For the trespasser/ATV recreator scenario, the exposure duration was assumed to be 6 years for the older child (12 to <18 years) and 12 years for the young adult (18 to <30 years), for both RME and CT.
- For the future commercial and industrial worker and the state fairgrounds maintenance worker scenario, EDs of 25 years (RME) and 9 years (CT) were applied (RAGS Part E, USEPA 2004c, Exhibit 3-5). The same EDs were applied for the utility/sewer worker (USEPA 1991, Attachment B).
- For the future construction worker scenario, an ED of 2 years was assumed for both RME and CT. This value is based on professional judgment, assuming that 2 years is a conservative estimate of the duration of a typical construction project.
- For the current/future state fairgrounds attendee scenario, EDs of 30 years, 12 years, and 6 years were assumed for an adult, older child (6 to <18 years), and younger child (0 to <6 years) receptors, respectively. The RME and CT values were identical.
- For the current/future ditch maintenance worker scenario, the RME and CT EDs were assumed to be 13 years and 5 years, respectively. Ditch maintenance workers visit the Site once every two years to clear away debris that has accumulated in the Site ditches. Since this accumulation occurs slowly, ditch maintenance activities occur infrequently.
- For the current/future trespasser/fisherperson scenario, an ED of 30 years was assumed for both RME and CT.
- For the future adult resident scenario, the applied RME ED value was 30 years and the corresponding CT value was 9 years (USEPA 1989, Exhibit 6-11). For the future child resident scenario (0 to <6 years), the applied ED value was 6 years for both RME and CT (USEPA 1989, Exhibit 6-11). These are USEPA recommended values for water contact in residential scenarios (RAGS Part E, USEPA 2004c, Exhibit 3-2).

4.3.7. Exposure Frequency and Exposure Time

Exposure frequency (in days/year) is a receptor-specific parameter that estimates how frequently the receptor exposure occurs. The following discussion is divided into two subsections: 1) receptors that are exposed to soil *and* sediment, and 2) receptors that are exposed to only soil *or* sediment.

Exposure Frequencies for Receptors Exposed to Soil and Sediment: Exposure frequencies were modified in this HHRA for receptors that are exposed to surface soils, seep sediments, and, in some cases, aquatic sediments (Site Ditches and Ponded Area) within the same Exposure Unit. Without this modification, it is likely that exposure scenarios involving these media would overestimate the risk obtained through the incidental ingestion and dermal exposure routes. Exposure frequencies were adjusted to reflect the aerial extent of each type of media. **Appendix H, Table 1** presents the percentage of each media type (seep, aquatic sediment, and soil) for each Exposure Unit where receptors are exposed to two or three of these media. These percentages were used to adjust the previously approved RME exposure frequencies (**Appendix H, Table 2**). Note that the soil exposure frequency was not adjusted (to be protective), and aquatic sediment exposure frequency was rounded up to one (as the actual number were less than one). The same methodology was used to adjust the previously approved CT exposure frequencies **(Appendix H, Table 2**). Below is a discussion of the RME and CT exposure frequencies for media other than sediment. Refer to **Appendix H** for the derivation of the sediment exposure frequencies for these receptors.

Transient Trespasser [older child (6 to 18 years)] and Trespasser/ATV Recreator [older child (12 to 18 years)] – The soil and surface water RME exposure frequency for the above-listed trespassers is assumed to be 94 days/year. This EF was developed assuming five days per week on Site for the 10 weeks that school is not in session and 2 days per week for the rest of the year when the average daily temperature is at least 50°F, so [(10 x 5)+(22 x 2)] or 94 days. The CT EF for these receptors was derived as one-half of the RME (47 days, see Specific Comment S7, May 4, 2007 NYSDEC comment letter). See **Appendix H** for the derivation of the sediment EFs for these receptors.

Trespasser/Fisherperson (adult) and Trespasser/ATV Recreator (adult) – The soil and surface water RME exposure frequency for the above-listed adult trespassers was set at 42 days. It is assumed that, due to occupational time limitations on weekdays, these adult trespassers will spend 2 days per week during the summer months and 1 day per week during the 22 weeks when the average daily temperature is at least 50°F, so [(10 x 2)+(22 x 2)] or 42 days. The CT EF for these receptors was set at 32 days per year using best professional judgment. See **Appendix H** for the derivation of the sediment EFs for these receptors.

Lunchtime Trespasser (adult) – The RME exposure frequency for the lunchtime trespasser exposed to soil and surface water is 95 days per year. It is assumed that this receptor will visit the Site on his or her lunch break five days per week when the maximum temperature hits 60°F, on days with less than 0.1 inch of precipitation. Based on Syracuse weather data, daily high of 60°F or greater occurs between April 25 and October 16, a span of 175 calendar days (25 weeks), or 125 days at 5 days per week. For the period of May 1 to October 30, precipitation of at least 0.1 inches occurs 24.3 percent of the time. Subtracting the wet days leave 95 days of annual exposure for the lunchtime trespasser. The CT soil scenario assumes two days per week instead of five [25 weeks x 2 days/week x (1-0.243)] = 38 days/year (see Specific Comment S8, May 4, 2007 NYSDEC comment letter). See **Appendix H** for the derivation of the sediment EFs for this receptor.

Construction Worker – An RME exposure frequency of 125 days per year was used in this assessment for the construction worker exposed to soil, surface water and ground water. This value is based on the assumption that half of the working days in the year are spent on the Site. The CT soil exposure frequency for this receptor is 63 days per year (125/2, based on best professional judgment). See **Appendix H** for the derivation of the sediment EFs for this receptor.

Utility/Sewer Worker – The RME exposure frequency for a utility/sewer worker exposed to soil, surface water and ground water is 20 days per year. This EF is based on best professional judgment. The CT soil exposure frequency is one day per year and is also based on best professional judgment. See **Appendix H** for the derivation of the sediment EFs for this receptor.

Exposure Frequencies for Receptors not Exposed to Soil and Sediment: The exposure frequencies did not require modification for receptors that were only exposed to soil or sediment. These exposure frequencies are discussed below.

- For the future commercial and industrial worker scenario, EFs of 250 days/year (RME) and 219 days/year (CT) were applied (USEPA 1991, Section 3.0; RAGS Part E, USEPA 2004c, Exhibit 3-5).
- For the current/future state fairgrounds attendee scenario [adult, older child (6 to <18 years), and younger child (0 to <6 years)], EFs of 14 days/year (RME) and 4 days/year (CT) were assumed.
- For the current/future state fairgrounds maintenance worker scenario, EFs of 25 days/year (RME) and 10 days/year (CT) were assumed.
- The CT and RME EF value for future adult and younger child residents is 350 days/year, which is consistent with the USEPA recommendation for residential water contact scenarios (RAGS Part E, USEPA 2004c, Exhibit 3-2).

Exposure time (in hours/day) is a receptor-specific parameter that applies to inhalation exposure and describes the length of time for which exposure occurs. Except where specifically listed, all exposure time values given below are based on best professional judgment.

- For the current/future transient older child trespasser (6 to <18 years), the ET is assumed to be 1 hour/day (RME) and 0.5 hour/day (CT).
- For the current/future adult lunchtime trespasser, the ET is assumed to be 0.5 hour/day for both RME and CT. These ET values (both RME and CT) are also used for the current/future state fairgrounds attendee [adult, older child (6 to <18 years), and younger child (0 to <6 years)].
- The ET for the future commercial/industrial worker, the future construction worker, the current/future utility/sewer worker, and the state fairgrounds maintenance worker, is 8 hours/day for both RME and CT in this assessment.
- For the current/future trespasser/ATV recreator [older child (12 to <18 years)], the ET is assumed to be 4 hours/day for both RME and CT. For the young adult (18 to <30 years), the ET is assumed to be 4 hours/day (RME) and 2 hours/day (CT).
- For the current/future trespasser/fisherperson, the ET is assumed to be 4 hours/day (RME) and 2 hours/day (CT).

- For the adult resident exposure to ground water during bathing/showering, the ETs applied are 0.58 hour/day and 0.25 hour/day for RME and CT, respectively. For exposure of the child (0 to <6 years) to ground water during bathing/showering, the ETs applied are 1 hour/day and 0.33 hour/day for RME and CT, respectively. ETs for both adult and child scenarios are from Schaum *et al*. (1994).

4.3.8. Ingestion Rate

Ingestion rate values for incidental ingestion of soils and ingestion of drinking water are presented below.

IRsoil: Incidental ingestion rate for soil (mg/day).

- **Transient Trespasser [older child (6 to 18 yrs) current/future]** – The RME and CT IR for surface soil for this receptor is assumed to be 50 mg/day. The IR for seep sediment for this receptor is 200 mg/day (RME) and 100 mg/day (CT). These values are consistent with USEPA recommendations (USEPA 1997a, Table 4.23).

- **Lunchtime Trespasser (adult, current/future)** – The RME and CT IR for surface soil and seep sediment for this receptor is assumed to be 50 mg/day. These values are consistent with USEPA recommendations (USEPA 1997a, Table 4.23).

- **Commercial/Industrial Worker (adult, future)** – The RME soil ingestion rate is 100 mg/day (USEPA 2002b, Exhibit 1-2) and the CT ingestion rate is 50 mg/day (USEPA 1991, Section 6.0 Summary Table).

- **Utility/Sewer Worker (current/future)** – The RME soil and seep sediment ingestion rate is 330 mg/day and the CT ingestion rate is 100 mg/day. These values are consistent with EPA guidance for the IRsoil for construction workers and non-residential outdoor workers, respectively (USEPA 2002b, Exhibit 1-2).

- **Trespasser/ATV Recreator [older child (12 to <18 yrs) and young adult (18 to <30 yrs) current/future]** – The soil and seep sediment RME ingestion rate is 200 mg/day and the CT ingestion rate is 100 mg/day (USEPA 1997a, Table 4.23).

- **State Fairgrounds Attendee (adult, current/future)** – The soil ingestion rate is 50 mg/day for both CT and RME scenarios (USEPA 1997a, Table 4.23).

- **State Fairgrounds Attendee [older child (6 to <18 years), current/future]** – The RME soil ingestion rate for this receptor is 100 mg/day (USEPA, 1991, Section 2.2). The CT soil ingestion rate is 50 mg/day (USEPA 1997a, Table 4.23).

- **State Fairgrounds Attendee [younger child (0 to <6 years), current/future] –** The RME and CT soil ingestion rates for this receptor are both 100 mg/day USEPA 1997a, Table 4.23).

- **State Fairgrounds Maintenance Worker (current/future)** – The RME soil ingestion rate for this receptor is 100 mg/day (USEPA 2002b, Exhibit 1-2) and the CT ingestion rate is 50 mg/day (USEPA 1997a, Table 4.23).

- **Ditch Maintenance Worker (current/future)** – The RME and CT sediment ingestion rates for this receptor are identical (330 mg/day). This is consistent with EPA guidance (USEPA 2002b, Exhibit 1-2) and the Onondaga Lake HHRA (NYSDEC 2002b).

- **Trespasser/Fisherperson (adult, current/future)** – The RME and CT surface soil ingestion rates for this receptor are the same (50 mg/day, USEPA 1997a, Table 4.23). The RME seep sediment ingestion rate for this receptor is assumed to be 100 mg/day (USEPA 2002b, Exhibit 1-2; NYSDEC 2002b). The CT value is 50 mg/day (USEPA 1997a, Table 4.23).

- **Construction Worker (future)** – The RME and CT soil and seep sediment ingestion rates for this receptor are both 330 mg/day (USEPA 2002b, Exhibit 1-2).

IRwater: Incidental ingestion rate for water (L/day).

- **Resident (adult, future) –** The RME water ingestion rate for this receptor is 2 L/day (USEPA 1991, Section 2.1). The CT water ingestion rate is 1.4 L (USEPA 1997a, Table 3-30 – average).

- **Resident [child (0 to 6 yrs), future] –** The RME water ingestion rate for this receptor is 1.1 L/day (USEPA 2002b, Table 4-12). The CT water ingestion rate is 0.74 L/day (USEPA 1997a, Table 3-30 – average of children age 1-10).

4.3.9. Inhalation Rate

The inhalation rate (InR, m^3/hour) depends on individual characteristics such as age, gender, weight, health, and activity level. The receptor-specific values are described below:

- **Transient Trespasser [older child (6 to 18 yrs) current/future]** – The RME and CT inhalation rates for this receptor and both 1.2 m^3/hour (USEPA 1997a, Table 5-23).

- **Lunchtime Trespasser (adult, current/future)** – The RME and CT inhalation rates for this receptor and both 1.0 m^3/hour (USEPA 1997a, Table 5-23).

- **Utility/Sewer Worker (current/future) –** The RME and CT inhalation rates for this receptor and both 1.5 m^3/hour. This value is consistent with USEPA recommendations for an outdoor worker during moderate activity (USEPA 1997a, Table 5-23).

- **Commercial/Industrial Worker (adult, future)** – The RME and CT inhalation rates for this receptor and both 1.6 m^3/hour. This value is consistent with USEPA recommendations for adults at moderate activity levels (USEPA 1997a, Table 5-23).

- **Trespasser/ATV Recreator [older child (12 to <18 yrs) and young adult (18 to <30 yrs) current/future]** – The RME and CT inhalation rates for these receptors are 1.5 m^3/hour. This value is consistent with USEPA recommendations for an outdoor worker during moderate activity (USEPA 1997a, Table 5-23).

- **State Fairgrounds Attendee [adult, older child (6 to <18 yrs), younger child (0 to 6 yrs), current/future]** – The RME and CT inhalation rates for these receptors are the same (1.0 m^3/hour). This value is based on USEPA recommendations for adults engaged in light activity levels (USEPA 1997a, Table 5-23).

- **State Fairgrounds Maintenance Worker (current/future)** – The RME and CT inhalation rates for this receptor is 1.2 m^3/hour (USEPA 1997a, Table 5-23).

- **Trespasser/Fisherperson (adult, current/future)** – The RME and CT inhalation rates for this receptor is 1.0 m^3/hour. This value is based on USEPA recommendations for adults engaged in light activity levels (USEPA 1997a, Table 5-23).

- **Construction Worker (future)** – The RME and CT inhalation rates for this receptor is 1.5 m^3/hour. This value is based on USEPA recommendations for an outdoor worker during moderate activity (USEPA 1997a, Table 5-23).

4.3.10. Permeability Coefficient

The permeability coefficient (K_p, cm/hour) represents the rate at which dissolved constituents in water migrate across the skin into the bloodstream. Chemical-specific dermal permeability coefficients from USEPA (*RAGS Part E*, USEPA 2004c, Exhibits B-3 and B-4) were applied. The values for each constituent are presented in **Appendix G.**

4.3.11. Skin Surface Area Estimates

Skin surface area (SA) for dermal absorption from water (cm^2) and soil (cm^2/day) represents the exposed surface area of the skin that may contact water or soil. The receptor and media specific values are summarized in **Appendix I**.

- For an older child (6 to <18 years) transient trespasser and state fairgrounds attendee, an SA value of 5400 cm^2 is applied and is consistent with NYSDEC guidance (NYSDEC 2002b). For a younger child state fairgrounds attendee, the SA value is 2800 cm^2 (NYSDEC 2002b, USEPA 2004c, Exhibit C-1). For an adult trespasser/fisherperson and adult state fairgrounds attendee, the value is 5700 cm^2 consistent with USEPA guidance (NYSDEC 2002b, USEPA 2004c, Exhibit C-1). The RME and CT SA values are identical.

- The SA value for a utility/sewer, ditch maintenance, commercial/industrial, or construction worker, and for adult lunchtime trespassers, is 3300 cm^2, based on USEPA guidance for construction and outdoor workers (USEPA 2002b, Exhibit 1-2). For the state fairgrounds maintenance worker, an SA value of 1930 cm^2 is applied. The RME and CT SA values are identical.

- For a trespasser/ATV recreator [both older child (12 to < 18 years) and young adult (18 to < 30 years)], the RME SA value is 3522 cm^2, while the CT value is 1125 cm^2 , based on exposure to hands, forearms, lower legs, and face (USEPA 2004c, Exhibit C-1).

- The younger child and adult resident scenarios assume that the entire body is exposed during showering or bathing. Consequently, the SA values for water exposure are 6600 cm^2 and 18,000 cm^2 for a child and adult, respectively, based on guidance from the USEPA for residential scenarios (USEPA 2004c, Exhibit 3-2). The RME and CT SA values are identical.

4.3.12. Event Frequency and Duration

The event frequency and duration together describe the amount of time that a receptor is in contact with water. For all relevant receptors, the event frequency (EV; events/day) in this HHRA is once per day. The receptor-dependent event durations (t_{event}; hours/event) are provided below.

- For an older child trespasser, the RME event duration is 1 hour/event and the CT event duration is 0.5 hour/event. For an adult lunchtime trespasser, the RME and CT event durations are both 0.5 hour/event.

- The event duration for a utility/sewer worker, construction worker and ditch maintenance worker is 8 hours/day, based on a standard 8-hour work day (USEPA 1991, Section 1.2 for commercial/industrial workers). The RME and CT values are identical.

- For both older child (12 to <18 years) and young adult (18 to <30 years) trespassers/ATV recreators, as well as for adult trespassers/fisherpersons, the RME event duration is 4 hours/event and the CT event duration is 2 hours/event.

- The event duration for residents is based on the amount of time spent showering or bathing. For a younger child (0 to <6 years) resident, the RME value is 1 hour/event and the CT value is 0.33 hour/event. For an adult resident, the RME and CT values are 0.58 and 0.25 hour/event, respectively. These values are consistent with USEPA guidance (USEPA 2004c, Exhibit 3-2).

4.3.13. Fraction Absorbed

FA: Fraction absorbed water (unitless). Chemical specific values for FA are based on USEPA guidance (USEPA 2004c, Exhibits B-3 and B-4) and summarized in **Appendix G.**

4.3.14. Lag Time per Event

τ_{event}: Lag time per event (hours/event). The chemical-dependent values for lag time are based on USEPA guidance (USEPA 2004c, Exhibits B-3 and B-4) and summarized in **Appendix G.**

4.3.15. Beta Constant

B: Dimensionless ratio of the K_p of a compound through the stratum corneum relative to its K_p across the viable epidermis (ve) (unitless). B values are chemical-specific and based on guidance from EPA (USEPA 2004c, Exhibits B-3 and B-4). **Appendix G** reports the B values for this study.

4.3.16. Time to Reach Steady State

t*: Time to reach steady state (hours). The chemical-dependent values for t* are based on USEPA guidance (USEPA 2004c, Exhibits B-3 and B-4) and summarized in **Appendix G.**

5. Toxicity Assessment

The purpose of the toxicity assessment is to evaluate available information regarding the potential for Site-related chemical residues of potential concern to cause adverse effects in exposed individuals. The potential toxicological effects resulting from a given dose of a chemical are classified according to two criteria, consisting of non-cancer effects (hazards) and cancer effects (risks). The toxicity assessment presented herein was completed according to USEPA guidance (USEPA 1989). In particular, toxicity values were obtained from a hierarchy of sources, described in Section 5.3. The hierarchy consists of Tier 1 - USEPA's Integrated Risk Information System (IRIS); Tier 2 - Provisional Peer-Reviewed Toxicity Values (PPRTV) used in USEPA's Superfund Program; and Tier 3 - other peer-reviewed toxicity values. Tier 3 toxicological values were not used in this assessment unless these values were specifically approved by the USEPA Superfund Technical Support Center (STSC).

5.1. Non-Cancer Effects

A non-cancer health effect occurs as a result of damage to cells in one or more human organs, which causes the organ(s) to function less efficiently (or not at all). Due to the body's ability to cope with small doses of most substances, a non-cancer health effect will not occur if intake of a chemical is below a certain threshold dose. This threshold dose is referred to as a "no observed adverse effect level" (NOAEL) for a substance. From a NOAEL, a reference dose (RfD) is calculated and compared with the calculated intake of a constituent. If the calculated intake in a given species is less than the RfD for a constituent, then no adverse non-cancer health effects are expected as a result of that exposure.

The specific non-carcinogenic toxic effects that may be elicited depend on the exposure concentration and the duration of exposure. If an individual is exposed to very high concentrations of a substance, severe organ dysfunction can occur in a short period of time. This is referred to as an acute toxic effect. If an individual is exposed to lower levels of a substance regularly for a long period of time, smaller amounts of repeated damage to an organ can accumulate and cause the organ to malfunction. These are termed sub-chronic and chronic toxic effects (depending on the exposure duration).

A brief discussion of the methods by which RfDs are derived is presented below. For some constituents, RfDs are derived directly from data on human exposures. This may include data relating to occupational exposures, normal dietary levels of certain constituents (*e.g.*, magnesium), therapeutic doses of certain constituents (*e.g.*, silver), and epidemiological data relating to populations with background exposures (*e.g.*, selenium) or accidental exposures (*e.g.*, mercury).

For most constituents, the USEPA derives RfDs based on laboratory studies in which experimental animals were exposed to different concentrations of a constituent, and a NOAEL is identified or estimated. If data from several animals' studies are available, USEPA seeks to identify the species that is most comparable to humans, based on knowledge of specific biological properties. However, if adequate comparative data is not available, USEPA selects the study on the most sensitive animal species as the critical study for the basis of the NOAEL. The NOAEL is then used to derive a RfD for potential adverse effects in human populations.

In most cases, there is considerable uncertainty regarding the extension of toxicological data from animal studies to humans (see Section 7 – Uncertainty Section). In other words, the actual RfD for humans or sensitive sub-populations of humans (*e.g.*, children and the elderly) would not be precisely known based on data from laboratory studies with animals. This uncertainty arises because there may be differences between the animal and human species regarding factors such as the metabolism of the constituent, the distribution and clearance rate of the constituent from the body, and the sensitivity of the specific organ systems to the constituent. Therefore, the USEPA derives RfDs that are designed to be protective of the public at large, including sensitive sub-populations.

To accomplish this, the USEPA applies a series of uncertainty factors to calculate a final, conservative RfD value. Depending on many parameters of the study/studies reviewed, the NOAEL may be divided by an uncertainty factor ranging from 0 to 10,000. This means that the reported no observed adverse effect level for the given test is then divided by several orders of magnitude. For human data an uncertainty factor of 10 is usually applied for the application of data from the public at large to sensitive sub-populations. For animal data the uncertainty factor of 100 (10 for sensitive sub-populations and 10 for animal to human extrapolation) is applied for deriving the human RfD.

5.2. Cancer Effects

To evaluate cancer risks, the USEPA has developed cancer slope factors (CSFs), which are expressed as risks per $(mg/kg\text{-}day)^{-1}$. The CSFs are derived using a low-dose extrapolation procedure, which assumes that there is no threshold for the induction of cancer (as opposed to non-cancer toxicity, where it is assumed that certain doses will not produce adverse health effects). COPCs operating with a mutagenic mode of action were evaluated following USEPA (2006) guidance on age dependent adjustment factors. Section 4.3.1 provides a more detailed discussion of the treatment of chemicals with an MMOA. The methodology used for assessing cancer risk associated with vinyl chloride followed the USEPA guidance (2001a) recommending that cancer risk be calculated on a pro-rated basis for the lifetime segments individually and then summed.

Weight of evidence – USEPA classifies substances according to their potential to induce cancer in humans. The USEPA reviews and evaluates available data regarding the potential carcinogenic effects of a constituent, and assigns a “carcinogenicity” classification according to a weight of evidence classification scheme (49 CFR 462394). A constituent may be classified into one of five groups with respect to the weight of evidence for human carcinogenicity. The categories are:

- Group A – Known Human Carcinogen. A constituent is classified in Group A if there is sufficient evidence from human observations (epidemiological studies) to support an association between exposure to a chemical agent and cancer in humans
- Group B1 – Probable Human Carcinogen. A constituent is classified as a B1 carcinogen if there is sufficient evidence for carcinogenicity based on animal studies and limited (suggestive but not conclusive) evidence based on human observations.
- Group B2 – Probable Human Carcinogen. A B2 carcinogen is a constituent for which there is sufficient evidence for carcinogenicity in animals and inadequate evidence for carcinogenicity in humans.
- Group C – Possible Human Carcinogen. A constituent is classified as a Group C carcinogen if there is limited evidence for carcinogenicity in animals and inadequate evidence for carcinogenicity in humans.

- Group D – A constituent is classified as a Group D agent if there is insufficient data available with which to evaluate the carcinogenicity of the constituent.

Slope Factors – For Group A, B, or C chemicals, USEPA derives chemical-specific cancer slope factors (CSFs). A CSF is a number which, when multiplied by the estimated chemical-specific CDI, provides an estimate of the "excess cancer risk" associated with that exposure. Theoretically, the excess cancer risk represents the lifetime probability (greater than background) that a carcinogenic event would occur in an individual as a result of a given exposure or pattern of exposures. It is important to note that for many chemicals, the excess cancer risk as calculated by USEPA's procedure is likely to result in a conservative and health protective overestimate of the potential cancer risk.

5.3. Derivation of Toxicity Values – Hierarchy

For each constituent that was retained as a COPC, a brief synopsis of the human toxicological effects, including chronic RfDs and CSFs was compiled from the following hierarchy of sources listed below:

- Tier 1 - EPA's Integrated Risk Information System (IRIS).

- Tier 2 - Provisional Peer-Reviewed Toxicity Values (PPRTV) used in USEPA's Superfund Program.

- Tier 3 - Other (peer-reviewed) toxicity values, including:

    - Minimal Risk Level produced by the Agency for Toxic Substances and Disease Registry (ATSDR),

    - California Environmental Protection Agency (CalEPA) values, and

    - EPA Health Effects Assessment Summary Table (HEAST) values (USEPA 1997b).

Third tier toxicological values were not used in this assessment unless these values were supplied by the USEPA Superfund Technical Support Center (STSC).

The non-cancer toxicity data applied in the risk characterizations of oral/dermal exposures evaluated in this report are presented in RAGS Table 5-1. Non-cancer toxicity data applied for the inhalation of outdoor air is presented in RAGS Table 5-2. The cancer toxicity data applied in the risk characterizations of oral/dermal exposures evaluated in this document are presented in RAGS Table 6.1. Cancer toxicity data applied for the inhalation of outdoor air is presented in RAGS Table 6.2. All values in RAGS Tables 5 and 6 were taken either from the IRIS or were supplied by the STSC.

The values provided by the STSC can be divided into two groups. The first group of toxicity values provided by the STSC is labeled as PPRTV on the subject RAGS Tables 5 and 6. The PPRTV label indicates that the value was presented in a Provisional Peer Reviewed Toxicity Information report supplied to Honeywell by the USEPA. The date associated with the PPRTV value is the date of the specific report for that constituent (*e.g.*, RfC for Aluminum, PPRTV report dated October 23, 2006).

The second group of toxicity values provided by the STSC is labeled according to their original source on the subject RAGS Tables 5 and 6 (ATSDR, HEAST, CalEPA, *etc.*). The use of these toxicity values was approved by the USEPA in electronic mail communications to Honeywell but there are no Provisional Peer Reviewed Toxicity Information reports associated with these toxicity values. For example, a March 27, 2008 email from R. Nunes (US EPA Region II) to T. Conklin and P. Sinha (O'Brien & Gere) contained a spreadsheet that endorsed values for several constituents from these sources (ATSDR, HEAST, CalEPA). This spreadsheet lists a CalEPA value for the arsenic RfC. The source of the RfC is listed as CalEPA (STSC) on the subject RAGS Table 5.2 to indicate that this value originated from the CalEPA website and was approved by the STSC as per the March 27, 2008 email. The dates listed on RAGS Table 5 and 6 for the toxicity values selected from these sources follows USEPA protocol (current dates for electronic sources [CalEPA] and date of publication for non-electronic sources).

5.4. Adjustment for Dermal Toxicity

Assessing toxicity associated with dermal exposure to constituents in soil and water requires special considerations. Dermal toxicity of a substance depends on factors including the analyte concentration in contact with the skin, the potential dose, the area of skin surface exposed, the exposure duration, the absorption of the analyte through the skin, the internal dose, and the amount of analyte that can be delivered to a target organ (*i.e.*, biologically effective dose) (USEPA 1997a).

In most instances, it was necessary to use oral toxicity data to estimate dermal toxicity. The dermal CDI represents the absorbed dose of the analyte. However, for many constituents, the oral toxicity data is based on the administered dose rather than the absorbed dose. Therefore, in order to assess dermal exposures, the oral toxicity data was adjusted to reflect the absorbed dose in accordance with USEPA guidance (USEPA 2004c) as follows:

$RfD_{dermal} = RfD_{oral} \times$ Gastrointestinal absorption efficiency (ABS_{GI})

$CSF_{dermal} = CSF_{oral}$ / Gastrointestinal absorption efficiency (ABS_{GI})

The gastrointestinal absorption efficiency data used for evaluating dermal exposures were obtained from Exhibit 4-1, USEPA (2004c). The RfD_{oral} and the CSF_{oral} were calculated using the above equations for constituents with an ABS_{GI} of less than 50 percent. Otherwise, no absorption adjustment was made (USEPA 2004c).

5.5. Chemical-specific Summaries and Toxicology of Selected COPCs.

Toxicological summary information is provided below for selected constituents identified as COPCs.

5.5.1. Benzene

Benzene potentially contributes to Site-wide carcinogenic risk to commercial/industrial workers exposed to ground water (as potable water) in the future scenario. Benzene also potentially contributes to the non-carcinogenic hazard for three receptor populations exposed to Site-wide ground water (as potable water) in the future exposure scenarios: commercial/industrial workers, child residents, and adult residents (Sections 6.1.9 and 6.1.10).

Benzene is a volatile constituent of crude oil, refined gasoline, and motor fuels. Benzene is also a byproduct of the production of coke. It is also used extensively in industry as a raw material or chemical intermediate for the production of other chemicals, such as styrene and phenols and the manufacture of plastics, resins, detergents, pharmaceuticals, pesticides, and dyes (ATSDR 2007).

The short-term effects of ingesting large amounts of benzene include vomiting, stomach irritation, convulsion, increased heart rate, and ultimately death. The oral and dermal reference dose for benzene is $4.0x10^{-3}$ mg/kg-day (IRIS accessed September 2008) and the inhalation reference concentration is $3.0x10^{-2}$ mg/m^3 (converted to $5.5x10^{-2}$ mg/kg-day) (IRIS accessed September 2008).

Benzene is classified as a Group A Carcinogen (Known Human Carcinogen). A chemical is classified as Group A if there is sufficient evidence from human observations (epidemiological studies) to support an association between exposure to a chemical agent and cancer in humans. Chronic exposure to benzene produces blood changes causing several forms of leukemia and harmful effects of the bone marrow resulting in anemia (Sittig 1981; ATSDR 2007). The inhalation unit risk (IUR) for benzene ranges from $2.2x10^{-3}$ to $7.8x10^{-3}$ (mg/m^3)$^{-1}$ (IRIS accessed September 2008). The upper end of this range [$7.8x10^{-3}$ (mg/m^3)$^{-1}$] was used as the IUR for this assessment and was converted to an inhalation cancer slope factor of $2.7x10^{-2}$ (mg/kg-day)$^{-1}$. An oral slope factor of $5.5x10^{-2}$ (mg/kg-day)$^{-1}$ was derived by the USEPA from IUR factor and is used in this assessment (IRIS accessed September 2008).

5.5.2. Manganese

Manganese contributes to Site-wide non-cancer hazards primarily through the inhalation pathway for the older child and young adult trespassers/ATV recreators in a current/future scenario and construction workers in a future scenario. Major uses of manganese include the manufacture of dry cell batteries, paints, varnishes, inks, dyes, reagents, pyrotechnics, and in metal alloys (HSDB 2010).

Manganese is an important micronutrient for the physiological function of animals and plants; however, high level exposures, especially via inhalation, can cause adverse toxicological effects. These effects include central nervous system and brain damage, lethargy, and tremors. The oral and dermal reference dose for manganese is $4.0x10^{-3}$ mg/kg-day (IRIS accessed September 2008) and the inhalation reference concentration is $5.0x10^{-5}$ mg/m^3 (converted to $1.43x10^{-5}$ mg/kg-day) (IRIS accessed September 2008).

There is no evidence for the carcinogenicity of manganese, and no cancer slope factor is available for manganese.

5.5.3. Nickel

Nickel contributes to Site-wide carcinogenic risk and non-cancer hazards primarily through the inhalation pathway for the older child trespassers/ATV recreators in a current/future scenario and construction workers in a future scenario. Nickel is mainly used in metallurgy for plating and creating various alloys such as stainless steel as well as in components of batteries, surgical prostheses, ceramics, and magnets (HSDB 2010).

Nickel is an extremely abundant naturally-occurring element that exists in all soil and is often present in water and air (ATSDR 2005). Human exposure to nickel may induce allergic reactions, rhinitis, sinusitis, perforation of nasal septum, pulmonary and respiratory system damage, and renal dysfunction. The oral and dermal reference dose for nickel is $4.0x10^{-3}$ mg/kg-day (IRIS accessed

September 2008) and the inhalation reference concentration is $9.0x10^{-5}$ mg/m^3 (converted to $2.57x10^{-5}$ mg/kg-day) (IRIS accessed September 2008).

Carcinogenicity has been documented following inhalation exposure to nickel dust (ATSDR 2005). Nickel and compounds containing nickel are considered possible human carcinogens and nickel dust and nickel subsulfide are classified as human carcinogens (ATSDR 2005). No oral or dermal cancer slope factor is available for nickel. The inhalation cancer slope factor utilized in this assessment is $9.10x10^{-1}$ (mg/kg-day)$^{-1}$ (CalEPA toxicity criteria database; value recommended by Superfund Technical Support Center).

5.5.4. Arsenic

Arsenic contributes to Site-wide carcinogenic risk predominately through the inhalation pathway for older child trespassers/ATV recreators in a current/future scenario. Arsenic is a naturally occurring element that is prevalent in the earth's crust which exists in organic but mainly inorganic forms (ATSDR 2007b). Arsenic has been historically used as an herbicide, wood preservative, pesticide, and is used in metal alloys and semiconductors (HSDB 2010).

Arsenic is highly toxic following both acute and chronic exposure. Acute exposure can result in gastritis, fever, insomnia, anorexia, disturbed heart function, and death (IRIS 2010). Chronic exposure often results in skin lesions, skin cancer, nervous system disruption, abnormal heart function, anemia, and leucopenia. The oral and dermal reference dose for arsenic is $3.0x10^{-4}$ mg/kg-day (IRIS accessed September 2008) and the inhalation reference concentration is $5.0x10^{-5}$ mg/m^3 (converted to $1.43x10^{-5}$ mg/kg-day) (IRIS accessed September 2008).

Arsenic is a known human carcinogen, although the mechanisms by which arsenic is carcinogenic remain unknown. Arsenic's carcinogenicity is primarily through the route of inhalation; dermal exposure and exposure through ingestion exhibit a different pathology (although not precluding cancer formation). The oral and dermal cancer slope factor for arsenic is $1.50x10^{0}$ (mg/kg-day)$^{-1}$ (IRIS accessed September 2008). The inhalation cancer slope factor utilized in this assessment is $1.51x10^{+1}$ (mg/kg-day)$^{-1}$ (IRIS accessed September 2008).

5.5.5. Polychlorinated Biphenyls

PCBs potentially contribute to the non-carcinogenic hazard future commercial/industrial worker through the incidental ingestion of surface soil.

PCBs are mixtures of up to 209 different compounds (congeners) that include a biphenyl and between one to ten chlorine atoms. "Aroclors" were commercial products marketed in the U.S. with differing amounts of the individual congeners. PCBs have been used as a dielectric fluid in electrical equipment such as transformers and capacitors due to their heat resistance and insulating properties. PCBs were also used in the ballasts of fluorescent lights and in hydraulic oils. They can be released to the environment during fires involving electrical equipment containing these compounds. PCBs are strongly adsorbed on solid surfaces, including glass and metal surfaces in laboratory apparatus, and onto soils, sediment, and particulates in the environment.

1. Non-Cancer Toxicity – The non-cancer effects of PCB include dermatological effects, sore throat, skin rash, gastrointestinal disturbance, eye irritation, and headache, as well as higher serum triglyceride and/or cholesterol levels and high blood pressure at higher blood concentrations of PCBs.

For non-cancer toxicity, the Aroclors have been divided into two groups:

The “Less Chlorinated” Aroclors consist of Aroclors 1016, 1221, 1232, and 1242. This group was characterized in the HHRA by using the oral reference concentration for Aroclor 1016 ($7.0x10^{-5}$ mg/kg-day, IRIS accessed September 2008). The dermal reference dose for the “less chlorinated” group was $7.0x10^{-5}$ mg/kg/day (IRIS accessed September 2008).

The “Highly Chlorinated” Aroclors consist of Aroclors 1248, 1245, 1260, and 1268. This group was characterized in the HHRA by using the oral reference concentration for Aroclor 1254 ($2.0x10^{-5}$ mg/kg-day, IRIS accessed September 2008). The dermal reference dose for the “highly chlorinated” group was also $2.0x10^{-5}$ mg/kg/day (IRIS accessed September 2008).

2. Cancer Toxicity – Both groups of PCBs (“less chlorinated” and “highly chlorinated”) are classified as Probable Human Carcinogens (B2) in IRIS (accessed September 2008). A B2 carcinogen is an agent for which there is sufficient evidence for carcinogenicity in animals and inadequate evidence for carcinogenicity in humans. For cancer toxicity, all detected Aroclors were summed as “total PCBs”; this total PCB value was then used to determine the exposure point concentration for cancer toxicity.

The IRIS database has a tiered set of CSFs; this HHRA utilizes the High Risk and Persistence Tier. The criteria used for this tier include food chain exposure, sediment or soil ingestion, dust or aerosol inhalation, any early-life exposure, and the presence of dioxin-like, tumor producing, or persistent congeners. Based on this approach, the CSFs applied for all PCB congeners for oral, dermal, and inhalation exposures were $2.0x10^{0}$ $(mg/kg\text{-}day)^{-1}$, $2.0x10^{0}$ $(mg/kg\text{-}day)^{-1}$, and $2.0x10^{0}$ $(mg/kg\text{-}day)^{-1}$, respectively.

5.5.6. Polycyclic Aromatic Hydrocarbons

Only three of the thirteen major Polycyclic Aromatic Hydrocarbons (PAHs) are discussed in this section: benzo(a)pyrene, benzo(a)anthracene, and phenanthrene. Phenanthrene potentially contributes to Site-wide non-carcinogenic hazard for the child recreator exposed to surface sediment under the future scenario. Benzo(a)anthracene potentially contributes to Site-wide carcinogenic risk for the older child trespasser (current/future) and the child recreator (future) exposed to surface sediment, as well as to the future child resident exposed to ground water (modeled as potable water). Benzo(a)pyrene potentially contributes to the Site-wide carcinogenic risk for several scenarios and media (Section 6).

PAHs contain two or more aromatic rings. They are ubiquitous in nature and are both naturally occurring and anthropogenic. PAHs are a component of fossil fuels and are produced from the incomplete combustion of organic compounds. PAHs are found in coal, creosote oils and pitches formed from the distillation of coal tars (ASTDR 1990).

1. Non-Cancer Toxicity – The oral reference doses for phenanthrene as well as other non-carcinogenic PAHs are presented in **Table 5.1** below. For non-carcinogenic PAHs without published reference doses the RfD for pyrene is used. This approach is consistent with the recommendations of the NCEA for PAH surrogates in the Onondaga Lake HHRA.

Table 5.1. *Surrogates for Oral Reference Doses for Non-Carcinogenic PAHs.*

Non-carcinogenic PAH	Published Oral RfD*	Proposed Surrogate	Oral and Dermal RfD for use in the HHRA
Pyrene	3.0×10^{-2}	NA	$3.0x10^{-2}$ mg/kg/day
Benzo[g,h,i]perylene	NA	Pyrene	$3.0x10^{-2}$ mg/kg/day
Phenanthrene	NA	Pyrene	$3.0x10^{-2}$ mg/kg/day

2. Cancer Toxicity – There are several PAHs that are classified as a Probable Human Carcinogen (B2) in IRIS (accessed September 2008). A B2 carcinogen is an agent for which there is sufficient evidence for carcinogenicity in animals, and inadequate evidence for carcinogenicity in humans.

The USEPA IRIS database (accessed September 2008) has a published CSF for benzo(a)pyrene of $7.3x10^{0}$ (mg/Kg-day)$^{-1}$. Using this value and the relative potency approach provided by USEPA in the *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (USEPA 1993), the oral CSFs were calculated for the PAHs in **Table 5.2** below.

Table 5.2. *Surrogates for Oral and Dermal CSF for Carcinogenic PAHs.*

Carcinogenic PAH	Published Oral CSF*	Relative Potency	Oral and Dermal CSF used in the HHRA
Benzo[a]pyrene	$7.3x10^{0}$ (mg/kg-day)$^{-1}$	1.0	$7.3x10^{0}$ (mg/kg-day)$^{-1}$
Benzo[a]anthracene	NA	0.1	$7.3x10^{-1}$ (mg/kg-day)$^{-1}$
Benzo[b]fluoranthene	NA	0.1	$7.3x10^{-1}$ (mg/kg-day)$^{-1}$
Benzo[k]fluoranthene	NA	0.01	$7.3x10^{-2}$ (mg/kg-day)$^{-1}$
Chrysene	NA	0.001	$7.3x10^{-3}$ (mg/kg-day)$^{-1}$
Dibenzo[a,h] anthracene	NA	1.0	$7.3x10^{0}$ (mg/kg-day)$^{-1}$
Indeno[1,2,3-cd]pyrene	NA	0.1	$7.3x10^{-1}$ (mg/kg-day)$^{-1}$
NA = not available Source: USEPA Integrated Risk Information System (IRIS)			

The oral slope factors for all PAHs were not adjusted for the dermal route of exposure, according to guidance provided in USEPA RAGS, Part E (USEPA 2004c). The STSC suggested that the Inhalation Unit Risk factor [$1.1x10^{0}$ (mg/m^{3})$^{-1}$] and the Inhalation Slope factor [$3.9x10^{0}$ (mg/kg-day)$^{-1}$] from the CalEPA be used in this assessment for benzo(a)pyrene; however, the relative potency factor approach was not used to adjust the Inhalation Unit Risk values for the other PAHs.

6. Risk Characterization

Risk characterization is the final step of the risk assessment. It is defined as the combination of the exposure assessment and toxicity assessment to produce an estimate of risk and a characterization of uncertainties in the estimated risk. This section presents the results of the risk assessment for the Site.

6.1. Reasonable Maximum Exposure

Reasonable maximum exposure risks and hazards for Site receptors are presented in RAGS Part D Series Tables 7, 9, and 10. The RAGS Table 7 Series presents the derivation of risks and hazards for Site receptors by exposure medium. The RAGS Table 9 Series summarizes risks and hazards for a given Site receptor across all relevant media. The RAGS Table 10 Series summarizes risks and hazards for a given Site receptor across all relevant media for only those constituents that result in unacceptable risks and/or hazards. The risk characterization discussion below focuses on overall risks and hazards to Site receptors across all relevant media, and identification of constituents that significantly contribute to those risks and hazards (RAGS Part D Table 9 Series).

6.1.1. Current/Future – Older Child Transient Trespasser (Cancer and Non-cancer)

For the older child transient trespasser (RAGS Table 10.1 RME; Exposure Unit 1), the estimated total cancer risk is 2×10^{-5}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 7×10^{-1} is below the acceptable threshold of 1.

6.1.2. Current/Future – Adult Lunchtime Trespasser (Cancer and Non-cancer)

For the adult lunchtime trespasser (RAGS Table 10.2 RME; Exposure Unit 1), the estimated total cancer risk is 9×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 3×10^{-1} is below the acceptable threshold of 1.

6.1.3. Current/Future – Utility/Sewer Worker (Cancer and Non-cancer)

For the utility/sewer worker (RAGS Table 10.3 RME; Exposure Units 2 and 7), the estimated total cancer risk is 7×10^{-5}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 1×10^{0} is at the threshold of 1. The primary contribution to the total hazard index is from exposure to shallow ground water (9×10^{-1}) and surface and subsurface soil ($2\text{x}10^{-1}$). Benzene (shallow ground water) and highly chlorinated PCBs (Surface and subsurface soil) contribute significantly to this hazard index.

6.1.4. Future – Commercial/Industrial Worker (Cancer and Non-cancer)

For the commercial/industrial worker (RAGS Table 10.4 RME; Exposure Unit 2), the estimated total cancer risk is 5×10^{-5}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 1×10^{0} is at the threshold of 1. The primary contribution to the total hazard index is from exposure to surface soil through the ingestion (7×10^{-1}) and dermal routes (7×10^{-1}). Highly chlorinated PCBs contribute to this hazard index ($1\text{x}10^{0}$).

The vapor intrusion pathway was evaluated qualitatively in the HHRA for the commercial/industrial worker. The RAGS Table 2 Series screening for the indoor air exposure was conducted in one of two ways. First, risks posed by constituent concentrations in indoor air vapor intrusion were evaluated by comparing Site-wide shallow ground water to USEPA OSWER (2002a) ground water to indoor air criteria (RAGS Table 2.26). The maximum concentration of five constituents exceeded screening levels. The ratios of the five retained constituents to the selected screening value are: bis(2-ethylhexyl)phthalate (1016), naphthalene (39), benzene (2800), toluene (6), and vinyl chloride (1).

The secondary qualitative line-of-evidence used to assess potential risk to the commercial/industrial worker from the indoor air pathway was to screen the available soil vapor data was using the framework presented in USEPA (2004a). Soil vapor data are available for the NY State Fair Parking Area and the Upland Old Field Successional Area. Soil vapor collected from the NY State Fair Parking Area contained four carcinogens (benzene, carbon tetrachloride, chloroform, and tetrachloroethene) exceeded the 10^{-6} risk standard and five constituents that lacked RBCs and PRGs (RAGS Table 2.9). Soil vapor data collected from the Upland Old Field Successional Area had five carcinogens (benzene, carbon tetrachloride, chloroform, tetrachloroethene, and trichloroethene) exceeded the 10^{-6} risk threshold (RAGS Table 2.17). Four constituents lacked RBCs and PRGs and are discussed in the uncertainty section.

6.1.5. Current/Future – Older Child Trespasser/ATV Recreator (Cancer and Non-cancer)
For the older child trespasser/ATV recreator (RAGS Table 10.5 RME; Exposure Unit 3), the estimated total cancer risk is 3×10^{-5}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 7×10^{0} exceeds the acceptable threshold of 1. When segregated by primary target organ, the total hazard index for nasal/respiratory effects is 4×10^{0} and the total hazard index for nervous system effects is 3×10^{0}. The primary contribution to the total hazard index is from inhalation exposure to fugitive dust (5×10^{0}) and exposure to surface soil through the dermal and ingestion routes (1×10^{0}). Exposure to manganese (3×10^{0}) and nickel (2×10^{0}) contribute significantly (hazard quotient > 1) to the total hazard index.

6.1.6. Current/Future – Young Adult Trespasser/ATV Recreator (Cancer and Non-cancer)
For the young adult trespasser/ATV recreator (RAGS Table 10.6 RME; Exposure Unit 3), the estimated total cancer risk is 2×10^{-5}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 2×10^{0} exceeds the acceptable threshold of 1. When segregated by primary target organ, the total hazard index for nasal/respiratory effects is 7×10^{-1} and the total hazard index for nervous system effects is 1×10^{0}. The primary contribution to the total hazard index is from inhalation exposure to fugitive dust (2×10^{0}). Exposure to manganese (1×10^{0}) and nickel (7×10^{-1}) contribute significantly (hazard quotient > 1) to the total hazard index.

6.1.7. Future – Construction Worker (Cancer and Non-cancer)
For the construction worker (RAGS Table 10.7 RME; Exposure Units 3 and 7), the estimated total cancer risk is 4×10^{-5}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 1×10^{1} exceeds the acceptable threshold of 1. When segregated by primary target organ, the total hazard index for lymphocyte effects is 5×10^{0} and the total hazard index for nervous system effects is also 3×10^{0}. The primary contribution to the total hazard index is from inhalation exposure to fugitive dust (5×10^{0}) and from dermal exposure to Site ground water (6×10^{0}). Exposure to benzene (ground water; 5×10^{0}) and manganese (outdoor air; 3×10^{0}) contribute significantly (hazard quotient > 1) to the total hazard index.

6.1.8. Current/Future – Adult State Fairgrounds Attendee (Cancer and Non-cancer)

For the adult state fairgrounds attendee (RAGS Table 10.8 RME; Exposure Unit 4), the estimated total cancer risk is 4×10^{-7}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 1×10^{-2} is below the acceptable threshold of 1.

6.1.9. Current/Future – Older Child State Fairgrounds Attendee (Cancer and Non-cancer)

For the older child state fairgrounds attendee (RAGS Table 10.9 RME; Exposure Unit 4), the estimated total cancer risk is 1×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 4×10^{-2} is below the acceptable threshold of 1.

6.1.10. Current/Future – Younger Child State Fairgrounds Attendee (Cancer and Non-cancer)

For the younger child state fairgrounds attendee (RAGS Table 10.10 RME; Exposure Unit 4), the estimated total cancer risk is 5×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 1×10^{-1} is below the acceptable threshold of 1.

6.1.11. Current/Future – State Fairgrounds Maintenance Worker (Cancer and Non-cancer)

For the state fairgrounds maintenance worker (RAGS Table 10.11 RME; Exposure Unit 4), the estimated total cancer risk is 1×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 5×10^{-2} is below the acceptable threshold of 1.

6.1.12. Current/Future – Ditch Maintenance Worker (Cancer and Non-cancer)

For the ditch maintenance worker (RAGS Table 10.12 RME; Exposure Unit 5), the estimated total cancer risk is 9×10^{-7}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 5×10^{-2} is below the acceptable threshold of 1.

6.1.13. Current/Future – Adult Trespasser/Fisherperson (Cancer and Non-cancer)

For the adult trespasser/fisherperson (RAGS Table 10.13 RME; Exposure Unit 6), the estimated total cancer risk is 2×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 2×10^{-1} is below the acceptable threshold of 1.

6.1.14. Future – Adult Resident (Cancer and Non-cancer)

For the adult resident (RAGS Table 10.14 RME; Exposure Unit 7), the estimated total cancer risk is 1×10^{-2} which exceeds the acceptable range of 1×10^{-4} to 1×10^{-6}. The three exposure routes evaluated for this receptor (ingestion, inhalation and dermal) contributed equally to excess cancer risk. Risk from the ground water ingestion exposure route (5×10^{-3}) resulted from exposure to benzene (4×10^{-3}), arsenic (7×10^{-4}), and n-nitroso-di-n-propylamine (1×10^{-4}). Estimated risk from the inhalation of constituents in Site-wide ground water during showering or bathing (6×10^{-3}) resulted largely from exposure to benzene (6×10^{-3}). Estimated risk from the dermal exposure to Site-wide ground water during showering or bathing (2×10^{-3}) was dominated by exposure to dibenzo(a,h)anthracene (7×10^{-4}), benzene (6×10^{-4}), benzo(a)anthracene (1×10^{-4}), and benzo(a)pyrene (1×10^{-4}).

For the adult resident, the estimated hazard index of 2×10^{2} exceeds the acceptable threshold of 1. When segregated by primary target organ, total hazard indices for the kidney, nervous system, lymphocyte, and other effects exceed 1. The primary contribution to the total hazard index is from exposure to ground water as potable water and shower vapor (9×10^{1} and 6×10^{1}, respectively), with benzene contributing most significantly to both hazards (4×10^{1} and 6×10^{1}, respectively).

6.1.15. Future - Child Resident (Cancer and Non-cancer)

For the child resident (RAGS Table 10.15 RME; Exposure Unit 7), the estimated total cancer risk is 1×10^{-2} which exceeds the acceptable range of 1×10^{-4} to 1×10^{-6}. As with the adult resident, all three exposure routes contributed approximately equally to the excess cancer risk. Risk from the ground water ingestion exposure route (3×10^{-3}) resulted from exposure to benzene (2×10^{-3}) and arsenic (3×10^{-4}). Estimated risk from the inhalation of constituents in Site-wide ground water during showering or bathing (9×10^{-3}) resulted primarily from exposure to benzene (9×10^{-3}). Estimated risk from the dermal exposure to Site-wide ground water during (2×10^{-3}) was dominated by exposure to benzene (3×10^{-4}), benzo(a)anthracene (4×10^{-4}), benzo(a)pyrene (2×10^{-4}), dibenzo(a,h)anthracene (6×10^{-4}), and arsenic (3×10^{-4}).

For the child resident, the estimated hazard index of 7×10^{2} exceeds the acceptable threshold of 1. When segregated by primary target organ, total hazard indices for the liver, kidney, nervous system, lymphocyte, ocular effects, and other effects exceed 1. The primary contribution to the total hazard index is from exposure to ground water as potable water and shower vapor (2×10^{2} and 5×10^{2}, respectively), with benzene contributing most significantly to both hazards (1×10^{2} and 4×10^{2}, respectively).

6.2. Central Tendency

CT risks and hazards for Site receptors are presented in RAGS Series Tables 7, 9, and 10. The RAGS Table 7 series presents the derivation of risks and hazards for Site receptors by exposure medium. The RAGS Table 9 series summarizes the estimated risks and hazards for a given receptor across all relevant media. The RAGS Table 10 series summarizes the estimated risks and hazards for a given receptor across all relevant media for only those constituents that result in significant risks and/or hazards. In the risk characterization discussion below, the focus is on overall risks and hazards to receptors across all relevant media, and identification of constituents that significantly contribute to those risks and hazards (RAGS Table 9 Series).

6.2.1. Current/Future – Older Child Transient Trespasser (Cancer and Non-cancer)

For the older child transient trespasser (RAGS Table 10.1 CT; Exposure Unit 1), the estimated total cancer risk is 1×10^{-5}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 6×10^{-1} is below the acceptable threshold of 1.

6.2.2. Current/Future – Adult Lunchtime Trespasser (Cancer and Non-cancer)

For the adult lunchtime trespasser (RAGS Table 10.2 CT; Exposure Unit 1), the estimated total cancer risk is 1×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 8×10^{-2} is below the acceptable threshold of 1.

6.2.3. Current/Future - Utility/Sewer Worker (Cancer and Non-cancer)

For the utility/sewer worker (RAGS Table 10.3 CT; Exposure Units 2 and 7), the estimated total cancer risk is 1×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index is 6×10^{-2}, which is below the acceptable threshold of 1.

6.2.4. Future - Commercial/Industrial Worker (Cancer and Non-cancer)

For the commercial/industrial worker (RAGS Table 10.4 CT; Exposure Unit 2), the estimated total cancer risk is 6×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index is 5×10^{-1}, which is below the acceptable threshold of 1.

The vapor intrusion pathway was evaluated qualitatively in the HHRA for the commercial/industrial worker. As there is no difference between the RME and CT exposures for this qualitative evaluation, the results of these evaluations are not presented again here. See Section 6.1.4. for a presentation of these results.

6.2.5. Current/Future – Older Child Trespasser/ATV Recreator (Cancer and Non-cancer)

For the older child trespasser/ATV recreator (RAGS Table 10.5 CT; Exposure Unit 3), the estimated total cancer risk is 9×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 3×10^{0} exceeds the acceptable threshold of 1. When segregated by primary target organ, the total hazard index for nasal/respiratory effects is 2×10^{0} and the total hazard index for nervous system effects is 2×10^{0}. The primary contribution to the total hazard index is from inhalation exposure to fugitive dust (3×10^{0}). Exposure to manganese (1×10^{0}) and nickel (9×10^{-1}) contribute significantly (hazard quotient > 1) to the total hazard index.

6.2.6. Current/Future – Young Adult Trespasser/ATV Recreator (Cancer and Non-cancer)

For the young adult trespasser/ATV recreator (RAGS Table 10.6 CT; Exposure Unit 3), the estimated total cancer risk is 6×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index is 8×10^{-1}, which is below the acceptable threshold of 1.

6.2.7. Future - Construction Worker (Cancer and Non-cancer)

For the construction worker (RAGS Table 10.7 CT; Exposure Units 3 and 7), the estimated total cancer risk is 6×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 3×10^{0} exceeds the acceptable threshold of 1. When segregated by primary target organ, the total hazard index for nervous system effects is 2×10^{0}. The primary contribution to the total hazard index is from inhalation exposure to fugitive dust (2×10^{0}) and dermal exposure to Site ground water (5×10^{-1}). Exposure to benzene (ground water; 4×10^{-1}) and manganese (outdoor air; 1×10^{0}) contribute significantly (hazard quotient > 1) to the total hazard index.

6.2.8. Current/Future – Adult State Fairgrounds Attendee (Cancer and Non-cancer)

For the adult state fairgrounds attendee (RAGS Table 10.8 CT; Exposure Unit 4), the estimated total cancer risk is 8×10^{-8}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 4×10^{-3} is below the acceptable threshold of 1.

6.2.9. Current/Future – Older Child State Fairgrounds Attendee (Cancer and Non-cancer)

For the older child state fairgrounds attendee (RAGS Table 10.9 CT; Exposure Unit 4), the estimated total cancer risk is 1×10^{-7}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 6×10^{-3} is below the acceptable threshold of 1.

6.2.10. Current/Future – Younger Child State Fairgrounds Attendee (Cancer and Non-cancer)
For the younger child state fairgrounds attendee (RAGS Table 10.10 CT; Exposure Unit 4), the estimated total cancer risk is 6×10^{-7}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 3×10^{-2} is below the acceptable threshold of 1.

6.2.11. Current/Future - State Fairgrounds Maintenance Worker (Cancer and Non-cancer)
For the state fairgrounds maintenance worker (RAGS Table 10.11 CT; Exposure Unit 4), the estimated total cancer risk is 6×10^{-8}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 9×10^{-3} is below the acceptable threshold of 1.

6.2.12. Current/Future - Ditch Maintenance Worker (Cancer and Non-cancer)
For the ditch maintenance worker (RAGS Table 10.12 CT; Exposure Unit 5), the estimated total cancer risk is 1×10^{-7}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 3×10^{-2} is below the acceptable threshold of 1.

6.2.13. Current/Future – Adult Trespasser/Fisherperson (Cancer and Non-cancer)
For the adult trespasser/fisherperson (RAGS Table 10.13 CT; Exposure Unit 6), the estimated total cancer risk is 1×10^{-6}, which is within the acceptable range of 1×10^{-4} to 1×10^{-6}. The estimated hazard index of 8×10^{-2} is below the acceptable threshold of 1.

6.2.14. Future – Adult Resident (Cancer and Non-cancer)
For the adult resident (RAGS Table 10.14 CT; Exposure Unit 7), the estimated total cancer risk is 2×10^{-3} which exceeds the acceptable range of 1×10^{-4} to 1×10^{-6}. The primary exposure route that contributed to this risk was the ground water ingestion (1×10^{-3}). This risk resulted from exposure to benzene (9×10^{-4}) and arsenic (1×10^{-4}).

For the adult resident, the estimated hazard index of 8×10^{1} exceeds the acceptable threshold of 1. When segregated by primary target organ, total hazard indices for the kidney, nervous system, lymphocyte, and other effects exceed 1. The primary contribution to the total hazard index is from exposure to ground water as potable water (6×10^{1}) and shower vapor (1×10^{1}), with benzene contributing most significantly to both hazards (3×10^{1} and 1×10^{1}, respectively).

6.2.15. Future - Child Resident (Cancer and Non-cancer)
For the child resident (RAGS Table 10.15 CT; Exposure Unit 7), the estimated total cancer risk is 4×10^{-3} which exceeds the acceptable range of 1×10^{-4} to 1×10^{-6}. The three exposure routes evaluated for this receptor (ingestion, inhalation and dermal) contributed equally to excess cancer risk. Risk from the ground water ingestion exposure route (2×10^{-3}) primarily resulted from exposure to benzene (1×10^{-3}) and arsenic (2×10^{-4}). Estimated risk from the inhalation of constituents in Site-wide ground water during showering or bathing (1×10^{-3}) resulted largely from exposure to benzene (9×10^{-4}). Estimated risk from the dermal exposure to Site-wide ground water during showering or bathing (1×10^{-3}) was dominated by exposure to benzene (2×10^{-4}), benzo(a)anthracene (4×10^{-4}), benzo(a)pyrene (2×10^{-4}), and dibenzo(a,h)anthracene (6×10^{-4}).

For the child resident, the estimated hazard index of 2×10^{2} exceeds the acceptable threshold of 1. When segregated by primary target organ, total hazard indices for the kidney, nervous system, lymphocyte, and other effects exceed 1. The primary contribution to the total hazard index is from exposure to ground water as potable water and shower vapor (2×10^{2} and 5×10^{1}, respectively), with benzene contributing most significantly to both hazards (8×10^{1} and 5×10^{1}, respectively).

7. Uncertainty Assessment

Estimation of risks to human health that may result from exposure to constituents in the environment is a complex process. Each assumption used in estimating cancer risks and non-cancer hazards, whether it is the toxicity value for a particular chemical or the value of a parameter in an exposure equation, has a degree of variability and uncertainty associated with it. In each step of the risk assessment process, beginning with the data collection and analysis and continuing through the toxicity assessment, exposure assessment, and risk characterization, conservative assumptions are made that are intended to be protective of human health and to ensure that risks and hazards are not underestimated.

The risk and hazard values generated in this HHRA are not precise, deterministic estimates, but conditional estimates controlled by conservative upper-bound assumptions regarding exposure and toxicity. The calculated risk values provide an upper bound of the potential health risk value, as opposed to a precise, realistic estimate of actual health risks.

Derivation of the risk estimate requires multiplying conservative assumptions, and therefore the numeric effect of the conservatism of the assumptions is multiplied in the process. This is done by convention, consistent with USEPA protocols, with the objective of minimizing the likelihood of underestimating the actual Site risks and hazards. However, this introduces uncertainty into the estimates.

Additional uncertainties can be associated with the major assumptions and scientific judgments made during the evaluation. Assumptions and judgments based on scientific data are necessary in order to define the conceptual boundary of the Site and to facilitate quantitation of receptor pathway scenarios.

The main sources of uncertainty, relative to the assumptions, results, and conclusions of the HHRA are:

- Uncertainty in Site characterization and data quality
- Uncertainty in the selection of the COPCs
- Uncertainty in the Exposure Assessment
- Uncertainty in the Toxicity Assessment
- Uncertainty in the calculation of quantitative risk estimates.

Uncertainties related to these sources and the approaches taken to provide conservative and health protective estimates of Site risks are discussed below.

7.1. Site Characterization and Data Quality

Site characterization may contain a level of uncertainty for a variety of reasons, including:

- Whether a sufficient number of samples have been taken to characterize a given area, and whether potential areas of high contamination have been sampled
    - For example, in the Ditch A – South exposure area, only two ditch sediment samples are available and the maximum detections for all constituents were from one sample location

(SED-02). The number of samples per each exposure area is further summarized below; only those samples utilized in the HHRA are included.

- Fifteen surface soil samples were collected and analyzed for the majority of constituents in the Biosolids Area; however, an additional five samples were collected and analyzed for chromium in this area (*i.e.*, twenty samples were collected and analyzed for chromium in the Biosolids Area).

Table 7.1. *Summary of Utilized Samples.*

Exposure Area	Exposure Medium*	Number of Samples
Biosolids Area	Subsurface Soil	2
	Surface Soil	20
	Ground Water (All depths)	6
Ditch A - South	Surface Sediment	2
	Surface Water	2
Lakeshore Area	Seep Sediment	15
	Subsurface Soil	59
	Surface Soil	34
	Shallow Ground Water (Start depth ≤ 10 ft bgs)	42
	Ground Water (All depths)	125
	Seep Water	7
New York State Fair Parking Areas	Subsurface Soil	13
	Surface Soil	39
	Soil Vapor	6
	Shallow Ground Water (Start depth ≤ 10 ft bgs)	7
	Ground Water (All depths)	91
Ponded Area	Surface Sediment	6
	Surface Water	6
Site Ditch Areas	Seep Sediment	7
	Surface Sediment	6
	Seep Water	7
	Surface Water	9
Upland Old Field Successional Area	Seep Sediment	11
	Subsurface Soil	22
	Surface Soil	60
	Soil Vapor	4
	Shallow Ground Water (Start depth ≤ 10 ft bgs)	12
	Ground Water (All depths)	135
	Seep Water	8

- Whether the data are still relevant – due to either the age of the sample, or changes in site conditions since the samples were collected

  - Analytical data has been collected over significant spatial and temporal scales by multiple investigators. In general, data collected over multiple collection events for the same location have been given equal weight in the HHRA. However, there are cases where more recent sampling events may be preferable to older events. For example, the ditch sediment samples (SED-02, SED-03, SED-04, SED-05, and SED-06) and the Ponded Area sediment samples (SED-01, SED-07, and SED-08) were collected in 2004. Given the dynamic nature of aquatic sediment, it is possible that there has been additional sediment deposition in the six years since these samples were taken. It is unknown whether this potential deposition would increase or decrease the exposure point concentration for constituents in these exposure areas. Therefore, it is also unknown how this source of uncertainty would impact risk estimates in this HHRA.

- Whether the data include results for all contaminants reasonably expected to be present, based both on Site history and samples analyzed for a full suite of contaminants

  - Data utilized for this evaluation are the result of the data collection efforts targeted to support the characterization of the Site through the RI/FS process and investigations performed prior to the onset of Site PSA/RI/FS. Section 1.3 describes the Site investigation history and the development of the Site data set.
  - The Site-wide ground water dataset (all depths) includes four metals (molybdenum, tin, titanium and boron) that were reported erroneously by the laboratory as these parameters were not requested at the time of sampling. Because this mistake only occurred for one well and one sampling event, only one sample point is available for these four compounds. Nevertheless, these metals were included in the HHRA and the concentration of molybdenum (1.8 mg/L) resulted in a hazard quotient that exceeded the regulatory standard of 1 for the adult ($1x10^1$) and child ($3x10^1$) resident hypothetical drinking water scenario (ingestion exposure route). These hazard estimates likely are not reflective of the true hazard from exposure to ground water constituents.

- The way in which unusual samples/data were addressed.

Data quality can impact the reliability of results and conclusions of human health risk assessments. Most of the available data utilized in this risk assessment were validated and the following actions were taken with respect to assigned validation qualifiers:

R - The data were determined to be unusable for qualitative and quantitative purposes. Rejected data were not utilized in the risk assessment.

J - The analyte was positively identified; the associated numerical value was the approximate concentration of the analyte in the sample. The analytical data were not adjusted to compensate for potential high or low bias in the analytical result, due to uncertainty regarding the magnitude of the bias.

B – For inorganic constituents, the reported value was obtained from an instrument reading that was less than the sample quantitation limit (SQL). The “B” qualifier is a laboratory-applied qualifier, and for metals is functionally equivalent for to a laboratory-applied “J” qualifier. The analytical data with “B” qualifiers were provided by the NYSDEC and were utilized at its request in the Remedial Investigation Report, Baseline Ecological Risk Assessment, and this Human Health Risk Assessment.

7.1.1. Chemical Speciation

Several constituents (*e.g.*, mercury and chromium) potentially exist in more than one form at the Site. The quality of the data concerning speciation of these constituents can affect the uncertainty surrounding the results and conclusions presented in the HHRA.

7.1.1.1. Mercury

From a human health perspective, it is the amount of methylmercury, rather than total mercury that is of most interest, since methylmercury is much more readily absorbed into the human bloodstream. In this HHRA it was assumed that 100% of the "total mercury" in all media was in the methylated form as methylmercury. The maximum total mercury concentration for each exposure area/media combination was screened against RBCs and PRGs values for methylmercury and methylmercury TRVs were used to calculate risk. This assumption provides the best upper bound value and would provide the most conservative estimation of risk. Specifically, based on the IRIS RfDs for methyl mercury and mercury, methyl mercury is three times as toxic as inorganic mercury; so risks associated with mercury in soil or sediment may be overestimated by as much as a factor of three. Further, based on limited soil and sediment data as presented in the Onondaga Lake and Geddes Brook/Ninemile Creek HHRA Reports (NYSDEC; 2002a and 2003b, respectively), only a small fraction of mercury in these media is in the organic form. However, in the final analysis, as the highest HI associated with mercury (soil or sediment) for any receptor was 2×10^{-2} (RAGS Table 9.4 RME), the effect of this assumption (probable overestimate) does not significantly impact the overall hazards.

7.1.1.2. Chromium

As noted in Section 3.2, historically collected total chromium (Cr Total) soil data was converted to hexavalent chromium (Cr^{+6}) by using one of two Site-specific Cr^{+6}/Cr Total ratios. This protocol was used to convert all historical total chromium data in soil to hexavalent chromium. Total chromium and hexavalent chromium results were then screened against their specific RBCs or PRGs and the chemical-specific TRV were used to calculate risk. Hexavalent chromium data was unavailable for some media (*e.g.*, shallow ground water, Lakeshore Area seep water, ditch sediment), and there was no appropriate Cr^{+6}/Cr Total ratios ratio to generate Cr^{+6} data. Therefore, as a conservative measure, chromium results from these media were assumed to be hexavalent chromium for both the screening process and in the calculation of risks and hazards.

There are two additional issues that impact the calculation of the Site-wide ratio of Cr^{+6}/Cr Total and may increase the uncertainty of this HHRA. First, there is an anomalous subsurface result from the State Fair Parking Lot (WB 18-SB-134) that has a Cr^{+6}/Cr Total ratio of 0.57 (50%). Second, hexavalent chromium has a high number of non-detects in the Site-wide data set. Hexavalent chromium was detected in only 16 of 57 total samples (28%), 13 of 38 (34%) in surface soil samples and 3 of 13 (23%) subsurface soil samples. Chromium, whether hexavalent or otherwise, was not a risk driver in any scenario (see Section 6). Therefore, the above-outlined sources of uncertainty did not materially affect the quantitative HHRA.

A recent study by the National Toxicology Program (http://ntp.niehs.nih.gov/ntp/htdocs/ST_rpts/TOX72.pdf) identified hexavalent chromium as an oral carcinogen as well as an inhalation carcinogen. Based on the data from this study, IRIS is currently developing an oral slope factor for hexavalent chromium, as well as making a determination as to whether mutagenic mode of action is responsible for carcinogenesis. The states of California and New Jersey are also developing their own oral slope factors. At this time, Region 2 has been given support by the Office of Solid Waste and Emergency Response that the New Jersey oral slope factor of 0.5 $(mg/kg/day)^{-1}$ is appropriate for use in Superfund risk assessments in the absence of a Tier I or II toxicity source. However, since this risk assessment was initiated prior to the release of the New Jersey assessment, no hexavalent chromium oral slope factor has been utilized in this HHRA.

7.1.1.3. Polychlorinated Biphenyls

As presented in Section 3.2, PCBs were evaluated as "groups" of Aroclors, rather than by individual Aroclors. PCBs were grouped together based on their relative level of chlorination. "Less chlorinated" PCBs (Aroclors 1016, 1221, 1232, and 1242) were combined for analysis and evaluated against the screening and toxicity values for Aroclor 1016. "Highly chlorinated" PCBs (Aroclors 1248, 1254, 1260, and 1268) were combined for analysis and evaluated against the screening values and toxicity values for Aroclor 1254. For screening purposes, "Total PCBs" represented all Aroclors sampled, which were compared to screening values of Aroclor 1254.

7.2. Selection of COPCs

Uncertainty in the selection of COPCs may result from the selection of analytical parameters used to evaluate environmental media and the screening of analytes for inclusion in the quantitative evaluation of risk.

7.2.1. Selection of Analytical Parameters

Consistent with guidance for investigations conducted under CERCLA, the selection of analytical parameters were based on Site history and historical operations. Although there is detailed knowledge of historical operations at the Site, full knowledge of constituents that may have been included in the Solvay waste is unlikely. Most sampling programs, however, utilized broad-spectrum analyses (*e.g.*, Target Compound List or Target Analyte List) to evaluate environmental media. Therefore, the uncertainty in the selection of the appropriate analytical parameters is low.

7.2.2. COPC Screening Process

In this document, a conservative screening process consistent with USEPA guidance (USEPA 1989) was applied. In that process, the maximum concentrations of the detected constituents in surface soil, combined surface and subsurface soil, surface water, surface sediment, shallow ground water, and all ground water were compared to conservative screening values for the protection of human health.

The screening values utilized were the lowest of the USEPA Region PRGs (USEPA 2004b) or the USEPA Region 3 RBCs (USEPA 2007a). RBC and PRGs for tap water were applied to screen surface water and ground water 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. Constituents detected in media that did not have established RBC or PRGs were carried forward for further evaluation in the risk assessment. In addition, all detected Group A carcinogens (*e.g.*, arsenic, benzene, chromium) were retained as COPCs even if their maximum detected concentration did not exceed their respective screening criteria. As noted above, in media other than soil, unspeciated chromium was evaluated as hexavalent chromium.

Because of the conservative approach taken in the screening process, uncertainty related to the development of the COPCs list is relatively low and the likelihood that a constituent that may pose an unacceptable risk to human health has not been evaluated is extremely low.

In addition to the COPC selection process described above, naturally occurring inorganic compounds were eliminated from the COPC list if they were essential nutrients. Based on this consideration, calcium, magnesium, potassium, and sodium were not carried forward as COPCs for the risk assessment. Wet chemistry analytes and geochemical parameters were not included in the risk assessment (*e.g.*, chloride, nitrogen, and total organic carbon). Their constituents are not expected to pose an unacceptable hazard at concentrations measured at the Site.

Other considerations leading to potential uncertainty in the screening process include screening analytical results for several constituents against benchmarks for surrogate compounds. These include:

- All chlordane constituents were summed and screened against the chlordane RBC and technical chlordane PRG criteria.
- "Less chlorinated" PCBs (Aroclor 1016, 1221, 1232, and 1242) were combined for analysis and evaluated against the screening and toxicity values for Aroclor 1242.
- "Highly chlorinated" PCBs (Aroclor 1248, 1254, 1260, and 1268) were combined for analysis, evaluated against the screening values and toxicity values for Aroclor 1254.

The two non-standard metals, boron and molybdenum, were retained as COPCs based on the analysis of one sample. The non-cancer hazard quotients of these metals for various receptors are summarized below (Table 7.2).

Table 7.2. *Summary of Future Exposure Scenario Non-cancer Hazards (Boron and Molybdenum).*

COPC	Exposure Route	RME-COPC	CT-COPC
Future Resident Adult			
Boron	Ingestion	6E-01	4E-01
	Dermal	3E-03	1E-03
Molybdenum	Ingestion	1E+01	7E+00
	Dermal	5E-02	2E-02
Future Resident Child			
Boron	Ingestion	2E+00	1E+00
	Dermal	9E-03	3E-03
Molybdenum	Ingestion	3E+01	2E+01
	Dermal	2E-01	5E-02

The dermal exposure route does not contribute to unacceptable hazard quotients for either metal. For the ingestion exposure route, the RME hazard quotient for boron is below the threshold of 1 for the Future Resident Adult and slightly above the threshold (HQ = 2) for the Future Resident Child. For molybdenum, RME and CT hazard quotients under the ingestion exposure route exceed the threshold of 1 for both the Future Resident Adult and the Future Resident Child. However, as noted above, these hazard quotients were derived on the basis of one sample. Moreover, future residential exposures are not anticipated given the intended future use of the Site. Risks due to molybdenum will be noted in the RI, and considered in the FS, especially if anticipated future use of the Site were to include residential use.

7.2.3. Screening for the Indoor Air Pathway

The vapor intrusion pathway was evaluated qualitatively in the HHRA for the commercial/industrial worker (RAGS Tables 2.9, 2.17, and 2.26). There were several compounds that did not have appropriate toxicity information in each of these screening tables. For example, on RAGS Table 2.26, fourteen of the nineteen constituents were retained in the assessment because there was no toxicity information. As this pathway was not evaluated quantitatively in this assessment (no risk or hazard was calculated), the lack of appropriate standards for these constituents is likely to underestimate the risk from indoor air for this potential future exposure scenario.

7.3. Uncertainty in the Exposure Assessment

The selected receptors and exposure scenarios presented in this HHRA are based on current and historical observations of activities at the Site and likely potential future uses of the Site. The specific exposure assumptions for a given scenario tend to represent conservative estimates that were approved and agreed upon by the USEPA and NYSDEC.

The primary areas of uncertainty affecting the Exposure Assessment for these involve the assumptions affecting exposure pathways, the estimation of exposure point concentrations, and the parameters used to estimate chemical doses. The uncertainties associated with these various sources are discussed below.

7.3.1. Central Tendency and Reasonable Maximum Exposure Scenarios

This risk assessment contains many layers of conservative assumptions. For example, in the RME scenario, the values selected for exposure point concentrations in each equation used to calculate risks to the RME individual are upper-bound estimates. If the risk assessment was able to capture the uncertainty and variability associated with each parameter, it is likely that the actual risk to the RME individual would be less than the risks estimated in this assessment.

In this HHRA, both CT and RME scenarios were evaluated. As a result, some uncertainty in the evaluation of potential exposures was eliminated. Where published CT or RME parameters were not available, best professional judgment was used, thereby potentially increasing the uncertainty. In some cases, the USEPA recommended RME default values for exposure parameters were used conservatively for CT estimates that added increased uncertainty. The default or selected exposure parameters used in this assessment likely resulted in a moderate overestimation of risk, even in the cases of the reasonably maximally exposed individual.

7.3.2. Drinking Water Exposure Scenario

In accordance with the NYSDEC's request, the hypothetical drinking water scenario was evaluated in the risk assessment. However, Site-related groundwater is not used as a drinking or industrial water supply and is highly unlikely to be used as a drinking or industrial supply in the future, since the area is supplied by municipal water from OCWA. Furthermore, the yield of the overburden groundwater unit is inadequate for water supply wells and the high salinity of the deep aquifer (3,000 mg/l chloride) precludes its use as drinking water.

7.3.3. Inhalation of Volatile Organic Compounds from Surface Water

Several receptors in this HHRA were exposed to surface water. The concentration of VOCs and SVOCs in some Site surface water bodies was elevated relative to the selected standard (*e.g.*, naphthalene in ditch surface water). However, as there is no default approach to model the volatilization of constituents from surface water, risk or hazards from this pathway were not evaluated in this assessment. This limitation likely resulted in an underestimation of risk for receptors exposed to surface water.

7.3.4. Calculation of Exposure Point Concentration

Uncertainties associated with the development of EPCs are typically related to the quality and quantity of the data available and the protocols used to generate the EPC.

The methodology used to develop the EPCs used in this risk assessment is discussed in detail in Section 4. Statistical and procedural methods were applied to the data in order to develop an estimate of the EPC for COPCs selected for each Exposure Unit on a medium-specific basis. The general approach used the following criteria:

- Where a given data set contained less than three sample points or only one unique detected sample, the maximum value for each analyte in that data set was used as the EPC. These data sets are summarized below.

Table 7.3. *Summary of Constituents with an EPC Based on a Maximum Detected Concentration.*

Exposure Point	Exposure Medium	COPC
Exposure Unit 1	Surface Soil	VOCs: 2-Hexanone; Benzene
	Seep Sediment	Pesticides: Delta-BHC
		SVOCs: Benzo(a)pyrene
		VOCs: Benzene
	Seep and Surface Water	Metals: Arsenic; Cobalt
		SVOCs: Acenaphthylene; N-nitroso-di-N-propylamine
		VOCs: Tetrachloroethene
Exposure Unit 2	Surface Soil	VOCs: Benzene
	Surface and Subsurface Soil	VOCs: 2-Hexanone
	Seep Sediment	Pesticides: Delta-BHC
		SVOCs: Benzo(a)pyrene
		VOCs: Benzene
	Seep Water	Metals: Antimony; Arsenic; Chromium; Cobalt
		SVOCs: Acenaphthylene; N-nitroso-di-N-propylamine
		VOCs: Benzene
Exposure Unit 3	Surface and Subsurface Soil	VOCs: 2-Hexanone
	Seep Sediment	Pesticides: Delta-BHC
		SVOCs: Benzo(a)pyrene
	Seep Water	Metals: Cobalt
		Pesticides: Heptachlor Epoxide
		SVOCs: 4-Nitrophenol; Acenaphthylene; N-nitroso-di-N-propylamine
		VOCs: 1,2,4-Trimethylbenzene; 1,3,5-Trimethylbenzene
Exposure Unit 4	Surface Soil	VOCs: Benzene
Exposure Unit 5	Sediment	SVOCs: Acenaphthylene
		VOCs: 2-Hexanone; Benzene
	Seep and Surface Water	Pesticides: Delta-BHC; Dieldrin
		SVOCs: Dibenzofuran
		VOCs: 1,2,4-Trimethylbenzene; 1,3,5-Trimethylbenzene
Exposure Unit 6	Surface Sediment	Metals: Arsenic; Barium; Chromium; Iron; Manganese; Thallium; Vanadium
		SVOCs: Benzo(a)pyrene; Benzo(b)fluoranthene
		VOCs: Benzene; Carbon Disulfide
	Seep and Surface Water	Pesticides: Heptachlor Epoxide
		SVOCs: 4-Nitrophenol
		VOCs: 1,2,4-Trimethylbenzene; 1,3,5-Trimethylbenzene

Table 7.3. *Summary of Constituents with an EPC Based on a Maximum Detected Concentration.*		
Exposure Point	**Exposure Medium**	**COPC**
Exposure Unit 7	Shallow Ground Water	Pesticides: 4,4'-DDT; Heptachlor Epoxide
	Potable Water (all depths)	Metals: Boron; Molybdenum
		PCBs: Highly Chlorinated and Total PCBs
		SVOCs: 2,4,6-Trichlorophenol; Benz(a)anthracene; Benzo(a)pyrene; Dibenz(a,h)anthracene; Indeno(1,2,3-CD)pyrene; N-nitroso-di-N-propylamine
		VOCs: Trichloroethene

- For data sets with four or more data points, and at least two unique detected samples, statistical methods were applied.

In the latter case, the ProUCL Version 4.0 statistical software package (USEPA 2007b) was used to examine the data distribution and develop an upper confidence level on the arithmetic mean (UCL). ProUCL was run using Regression on Order Statistics (ROS), which is a method for accounting for non-detect samples in the data set. ROS infers values for non-detect samples based on the distribution of detected data, and thus reduces the sensitivity to different reporting limits. ProUCL recommends the most appropriate UCL to use given the distribution type. The UCL recommended by ProUCL was subsequently applied as the EPC.

As noted in Section 4.1.1, in some cases the 95% UCL is less than the reported average concentration. In instances where the detection frequency is low and non-detect samples largely outnumber detected samples, the 95% UCL recommended by ProUCL Version 4.0 can be smaller than the mean detected concentration, since it reflects the large number of non-detect samples. In these cases, the maximum detected concentration is used as the EPC, citing "Insufficient Data" as the rationale.

7.3.5. Derivation of 95% UCLs – Regression on Order Statistics versus ½ Detection Limit Substitution

ProUCL Version 4.0 includes Regression on Order Statistics (ROS) for constituents; EPA Region 2 recommended also developing EPCs using the approach of substituting non-detects with ½ of the detection limit (DL) per RAGS, Part A. ProUCL Version 4.0 was used to compare EPCs calculated using ROS statistics to EPCs calculated by substituting ½ of the detection limit. This comparison was conducted for five datasets and focused on the following risk drivers:

- Benzo(a)pyrene in Exposure Unit 1 surface soils
- Arsenic in Exposure Unit 3 surface water
- Benzene in Exposure Unit 7 groundwater
- Benzo(a)pyrene in Exposure Unit 4 surface soil
- Arsenic in Exposure Unit 7 groundwater

For several compounds that contribute to total risk, we calculated upper confidence limits on the mean after substituting non-detects with ½ of the detection limit. We compared the resulting EPC with those determined by ProUCL using ROS method after excluding non-detect samples with high detection limits per RAGS, Part A.

Results of the two methods are summarized in **Table 7.4** below. For four of the five cases shown below, the ½ DL substitution yields a slightly higher exposure point concentrations than the ROS method. It should be noted; however, the ½ DL substitution method alters the distribution of the data, which causes ProUCL to choose a different statistical test than was chosen in the ROS case.

Table 7.4. *Comparison of EPC Calculation Methods.*

Exposure Unit	Medium	Constituent	Detection Frequency	ROS EPC	ROS Statistic	½ DL EPC	½ DL Statistic	Ratio of ½ DL EPC to ROS EPC
1	Surface Soil	Benzo(a) pyrene	58/85	2.345	95% KM (Chebyshev) UCL	2.884	Use 97.5% Chebyshev (Mean, Sd) UCL	1.2
3	Surface Water	Arsenic(mg/L)	3/15	0.431	99% KM (Chebyshev) UCL	0.37	Use 99% Chebyshev (Mean, Sd) UCL	0.9
7	Ground Water	Benzene (µg/L)	237/302	6684	97.5% KM (Chebyshev) UCL	8418	Use 99% Chebyshev (Mean, Sd) UCL	1.3
4	Surface Soil	Benzo(a) pyrene (mg/kg)	16/28	0.937	95% KM (BCA) UCL	2.499	Use 99% Chebyshev (Mean, Sd) UCL	2.7
7	Ground Water	Arsenic (ug/L)	83/284	0.0386	95% KM (BCA) UCL	0.0636	Use 97.5% Chebyshev (Mean, Sd) UCL	1.6

Based on these example cases, the EPC derived from the ½ DL substitution method is similar to the ROS EPCs, regardless of detection frequency.

7.3.6. Particulate Emissions and Volatilization Estimates

The inhalation of air particulates and volatile compounds generated from Site soils was evaluated in this HHRA. Because the USEPA Region 9 PRG (USEPA 2004b) criteria utilized in the screening process are protective of multi-pathway exposure to soil, uncertainty surrounding the potential effects related to those constituents what were not retained part the RAGS 2 Tables Series is greatly reduced.

The calculation of the Particulate Emission Factor (PEF) and the Volatilization Factor (VF) are discussed in Section 4.1.4. Of those soil constituents that were retained, volatile organic compounds were evaluated using the soil-to-air volatilization factor (see **Appendix E**). Other types of constituents (metals, PCBs, pesticides, and SVOCs) were evaluated as particulate emissions (see **Appendix F**). Because the calculation of estimated air concentrations may be affected by a variety of factors including temperature, wind speed, vegetative cover, *etc*., the concentrations used in this HHRA do not represent precise estimates. For example, the PEF for the ATV trespasser is based, in part, on the assumption that four vehicles will average 15 mph, for 4 hours/day, for 94 days/year. This equates to 5640 miles per year on a single ATV. This value is more than three times higher than the recommended national annual average ATV usage rate of 1570 miles/yr (USEPA 2002) and is likely to overestimate the potential for Site constituents to cause risk and hazard to ATV receptors.

7.3.7. Uncertainties in the Soil/Sediment Dermal Exposure Pathway Assumptions

Soil/Sediment-to-Skin Adherence Factors (AF) and Dermal Absorption Factors (ABS) recommended by the NYSDEC were applied in the exposure assessment. In addition, route-to-route extrapolation factors were applied in the estimation of absorbed dose for each receptor. Uncertainties associated with each of these items are discussed below.

7.3.7.1. Soil/Sediment-to-Skin Adherence Factors

The soil/sediment-to-skin AF represents the average mass of soil that adheres to the skin over each exposure event. The AF depends on the specific activity being conducted and is typically higher for body parts with greater exposure to the soils or sediments. The specific RME and CT AFs used in this HHRA were obtained from USEPA Risk Assessment Guidance (RAGS Part E, USEPA 2004c, Exhibit 3-3) and the rationale for the various AFs used in this document are discussed in Section 4.3.3. Although this guidance provides recommended AFs for various activities and receptor categories, there is a wide range of AFs that can be found in other guidance documents and published literature. As such, the actual AFs for any given activity for a receptor at the Site cannot be determined precisely. The AFs chosen in this document, however, tend to represent conservative values that will likely overestimate the amount of soil or sediment that adheres to the skin of a receptor. Consequently, risks and hazards associated with dermal exposure for soil will likely be overestimated.

7.3.7.2. Dermal Absorption Factors

The dermal absorption factor (ABS) represents the fraction of the soil constituent that may be absorbed through the skin over each exposure event. In general, metals are poorly absorbed through the skin whereas organic constituents may be absorbed more easily. As discussed in Section 4.3.2, constituent-specific values were obtained from USEPA Risk Assessment Guidance (RAGS Part E, USEPA 2004c, Exhibit 3-4). If chemical specific information for dermal absorption was not available, 100% dermal absorption was assumed. In the latter case, it is highly likely that dermal exposure to COPCs is overestimated.

7.3.7.3. Route-to-Route Extrapolation

Most toxicity values are based on studies related to either exposure via inhalation or, usually, ingestion rather than on dermal studies. Consequently, an extrapolation from one of these exposure routes to the absorbed dermal dose must be used to determine the appropriate reference dose for dermal exposure. In this HHRA, oral absorption efficiencies used in the route-to-route extrapolations were from obtained from Exhibit 4-1 of USEPA (2004c) RAGS Part E. The process for selection of the oral absorption efficiencies is as follows:

- For oral absorption efficiency for dermal greater than 50%, no adjustments were made for the dermal route.
- For constituents with a range of oral absorption efficiencies for dermal in Exhibit 4-1, the highest value was reported
- For constituents not listed in Exhibit 4-1, an absorption efficiency of 1 (100%) was assumed.

Inherent in this process is the introduction of uncertainty surrounding the absorbed RfD for dermal and absorbed cancer slope factor for dermal presented in RAGS Tables 5.1 and 6.1 (**Attachment A**); however, the impact of the uncertainty is difficult to estimate.

7.3.7.4. Skin Surface Area Available for Dermal Contact

Skin surface area for dermal contact and absorption (SA) from water and soil were derived from a variety of sources and, in some cases, were made using on best professional judgment based on Site-specific knowledge. In most cases, the RME and CT values for SA were identical, however, in one case, the SA for the older child and young adult trespasser/ATV recreator was reduced from an RME value of 3522 cm^2 to a CT value of 1125 cm^2/day. This CT value was based on the site specific knowledge that only the face and hands are exposed because ATV recreators typically wear helmets, shirts with long sleeves, and full-length pants for much of the year. For other scenarios evaluated, the chosen values were generally equal to or greater than those recommended in USEPA RAGS Part E (2004c).

7.3.8. Uncertainties Associated with the Ingestion Pathway

Uncertainties associated with the ingestion pathway for soil, sediment, and surface water are evaluated below.

7.3.8.1. Incidental Soil and Sediment Ingestion Rates

Ingestion rates for soil and sediment used in this HHRA represent the amount of these media that are ingested as a result of activities associated with each receptor. Typically, receptors with greater contact with soil or sediment (*e.g.*, construction worker) have a greater rate of incidental ingestion compared to those whose activities result in less contact with soil or sediment (*e.g.*, an office or factory worker).

A soil incidental ingestion rate of 330 mg/day (RME) was applied for the construction, utility worker, and drainage ditch maintenance worker; however, this value may overestimate potential soil exposures for these receptors. Other assessments have indicated that default incidental ingestion rates in the range of 100 to 200 mg/day are appropriate for high soil contact activities. Draft NYSDEC guidance for the evaluation of petroleum release sites (NYSDEC 1997) apply a default construction worker soil incidental ingestion rate of 82 mg/day, whereas the USEPA default rates for evaluation of agricultural scenarios is 100 mg/day (reviewed in USEPA 1997). Sheppard (1995) (in USEPA 1997, Table 4-15) estimated an incidental ingestion rate of 20 mg/hr for gardening activities. Based on this estimate, the total soil ingested over five to eight hours would be 100 to 160 mg/day. The CT evaluation (using 100 mg/day for the utility worker; and 330 mg/day for the construction and drainage ditch maintenance workers) provides an indication of the impact that the uncertainty surrounding this value has on the estimated risks and hazards for these receptors.

Similarly, the incidental soil ingestion rate applied to the commercial/industrial worker RME scenario (100 mg/day) likely leads to an overestimation of increased cancer risk and hazard. It is not likely that an indoor worker will ingest a similar amount of soil as an agricultural worker.

An incidental soil ingestion rate of 200 mg/day for the older child and young adult trespasser/ATV recreator was applied in the RME scenario following the USEPA and NYSDEC's recommendation. This value is conservative relative to the mean soil ingestion rate for children (100 mg/day; *Exposure Factors Handbook*, USEPA 1997, Table 4.23). The value of 200 mg/day is used because the ATV rider is not a typical exposure scenario and may generate considerable dust.

7.3.8.2. Water Ingestion Rates

Incidental ingestion of surface water was not evaluated in this HHRA because such ingestion by the chosen receptors is considered *de minimis*. This assumption may lead to an underestimate of risks and hazards, however, it is not expected to have an appreciable impact on the results.

Although Site-wide ground water is not considered potable water, a hypothetical drinking water scenario was evaluated in the risk assessment. For this scenario, water intake was assumed to be 2 L/day for adult residents and 1 L/day for younger child residents, consistent with USEPA guidance (RAGS Part A, USEPA 1989, Exhibit 6-11). The adult water ingestion rate is based on lognormal distribution with an arithmetic mean of 1.26 L/day and a standard deviation of 0.66 L/day.

7.3.9. Uncertainties in the Exposure Frequencies

Uncertainties related to exposure frequencies can lead to intake values that can either underestimate or overestimate risk and hazard. Although the exposure frequencies used in evaluating human exposure in this risk assessment are generally conservative (see ATV trespasser discussion below), it is possible that some receptors could be exposed at a greater frequency than that evaluated here. For instance, the transient trespasser was evaluated based on an exposure frequency of 94 days/year. It is possible that a homeless trespasser may be on-site more than 94 days/year, particularly due to time spent on-site during the warmer months of the year. As such, the risk and hazard estimates in this HHRA may underestimate this exposure.

With respect to the younger adult trespasser/ATV recreator, the EF of 42 days/year was selected. This EF was developed assuming 2 days per week on Site for the 10 summer weeks and 1 day per week for the rest of the year when the average daily temperature is at least 50°F. An alternative EF for this receptor could be based on the assumption that, due to occupational limitations, trespassing would be limited to 1 day/weekend for the 32 weeks when the average daily temperature is at least 50°F (32 days/year). This would equate to 1920 miles/yr (32 days/yr x 4 hr/day x 15 mile/hour), which is 22% higher than the recommended national annual average ATV usage rate of 1570 miles/yr set by the USEPA (2002).

Similarly, it could be argued that the EF for the older child trespasser/ATV recreator should be the same as the young adult as all trespassing is expected to occur on the weekends because ATVs must be transported to the Site by adult drivers, whose time is limited on the weekdays. The ATVs must be transported because the Site is not directly adjacent to residential areas, so older child ATV trespassers cannot ride their ATVs onto the Site directly. The exposure frequencies used for the trespassing/ATV recreator likely resulted in an overestimation of risk and/or hazard.

7.4. Uncertainties in Toxicity Values

Toxicity information for many chemicals is often limited. Consequently, there are varying degrees of uncertainty associated with toxicity values (*i.e.*, cancer slope factors, reference doses). For example, uncertainties can arise from the following sources:

- *Extrapolation from Animal Studies to Humans* – Toxicity results are often derived from studies in animals, and there are substantial uncertainties in the inter-species extrapolation of animal results to humans due to differences in toxicokinetics and toxicodynamics. In general, the USEPA deals with this uncertainty by application of an uncertainty factor of 10. That is, in cases where humans are either equally sensitive or less sensitive than animals, the toxicity factors will substantially overestimate risk.

- *Extrapolation from High Dose to Low Dose* – Most animal studies are performed using relatively high exposure levels, and there is often uncertainty in the best way to extrapolate the dose-response curve to the lower exposure levels typically experienced by humans at a Superfund site. In general, the USEPA deals with this issue by assuming a conservative dose response model, and by using a conservative estimate of the LOAEL and NOAEL.

- *Extrapolation from Continuous Exposure to Intermittent Exposure* – Most animal studies are performed using a relatively constant exposure design, while most human exposures occur intermittently (especially for recreational visitors). Current risk assessment methods assume that risk is proportional to average dose rather than dose rate, and this could result in either an overestimate or an underestimate of true risk.

- *Lack of Adequate Test Results* – In some cases, only a few studies are available to characterize the toxicity of a chemical, and uncertainties exist not only in the dose response curve, but also in the nature and severity of the adverse effects which the chemical may cause. The USEPA typically deals with this uncertainty by applying an uncertainty factor of 10 to 100 to account for limitations in the database. Thus, in cases where available data do identify the most sensitive endpoint of toxicity, risk estimates will substantially overestimate true hazard.

- *Potentially Sensitive Human Subpopulations* – In general, it is assumed that some humans may be more sensitive than others to the adverse effects of a chemical, but data are usually not available to determine if this is true. The USEPA typically deals with this uncertainty by applying an uncertainty factor of 10. Thus, most people are expected to have a risk 10 times lower than calculated, and even if some people are sensitive, the calculated risks may still be larger than actual.

  In general, uncertainty in toxicity factors is one of the largest sources of uncertainty in the development of estimates of risks and hazards at a site. Because of the conservative methods that are used in dealing with the uncertainties, it is much more likely that the uncertainty will result in an overestimation rather than an underestimation of risk. Uncertainty in toxicity factors also arises from lack of knowledge on the potential interactive effects of different chemicals. Most RfD and slope factor values are derived from studies of the adverse effects of pure chemicals. However, human exposure scenarios usually involve multiple chemicals, raising the possibility that synergistic or antagonistic interactions might occur. However, data are not adequate to permit any quantitative adjustment in toxicity values or risk calculations based on inter-chemical interactions. This uncertainty may result in overestimates or underestimates of risk.

- *Lack of Quantitative Toxicity Values for Detected Chemicals* – For constituents of potential concern without quantitative toxicity values, risks/hazards could not be estimated, resulting in the potential under-estimation of risks and hazards. A summary of these COPCs is provided in the table below.

Table 7.5. *Summary of Detected Chemicals with Lack of Quantitative Toxicity Values.*			
COPC	**Scenario / Receptor ***	**Exposure Unit**	**Exposure Medium**
Metals			
Cobalt	All Potential Receptors	1, 3	Seep Surface Water
	Current / Future Lunchtime Trespasser Adult Current / Future Utility / Sewer Worker Adult	2	Seep Surface Water
	Future Resident Adult Future Resident Child	7	Potable Water
Lead	All Potential Receptors	1	Surface Soil
	Current / Future Lunchtime Trespasser Adult Future Commercial / Industrial Worker Adult	2	Surface Soil
	Current / Future Trespasser / ATV Recreator Older Child Current / Future Trespasser / ATV Recreator Young Adult	3	Surface Soil
	All Potential Receptors	1, 3, 6	Seep Surface Water
	Current / Future Lunchtime Trespasser Adult Current / Future Utility / Sewer Worker Adult	2	Seep Surface Water
Lead cont.	All Potential Receptors	1, 2, 3	Outdoor Air
	Current / Future Utility / Sewer Worker Adult	2	Surface & Subsurface Soil
	Future Construction Worker Adult	3	Surface & Subsurface Soil
	Current / Future Utility / Sewer Worker Adult	7	Shallow Ground Water
	Future Construction Worker Adult	7	Ground Water
	All Potential Receptors	5	Surface Water
	Future Resident Adult Future Resident Child	7	Potable Water
SVOCs			
Acenaphthylene	All Potential Receptors	1, 4, 6	Surface Soil
	Current / Future Lunchtime Trespasser Adult Future Commercial / Industrial Worker Adult	2	Surface Soil
	Current / Future Trespasser / ATV Recreator Older Child Current / Future Trespasser / ATV Recreator Young Adult	3	Surface Soil
	All Potential Receptors	1, 3	Seep Surface Water
	Current / Future Lunchtime Trespasser Adult Current / Future Utility / Sewer Worker Adult	2	Seep Surface Water
	All Potential Receptors	1, 2, 3, 4, 6	Outdoor Air
	Current / Future Utility / Sewer Worker Adult	2	Surface & Subsurface Soil
	Future Construction Worker Adult	3	Surface & Subsurface Soil
	All Potential Receptors	5	Ditch Sediment
VOCs			
1,3,5-Trimethylbenzene	All Potential Receptors	3, 6	Seep Surface Water
	All Potential Receptors	5	Surface Water
* *All Potential Receptors* indicates that quantitative toxicity values are lacking for all potential receptors associated with the identified Exposure Unit(s) (see Tables 2.1 and 2.2 for receptors and their associated Exposure Units).			

- *TCE Cancer Slope Factor* – An inhalation cancer slope factor for trichloroethene (TCE) of 0.4 mg/kg-day (USEPA 2001b) was utilized in the risk assessment. This is a conservative draft provisional toxicity value adopted by the USEPA. For reference, the prior inhalation cancer slope factor for TCE from other sources (USEPA 1995; CalEPA) range from $7.0x10^{-3}$ to $4.0x10^{-1}$ $(mg/kg\text{-}d)^{-1}$. Therefore, cancer risks from inhalation of TCE may be overestimated.

- *Hierarchy of Toxicity Values* – The potential toxicological effects resulting from a given dose of a chemical are classified according to two criteria, consisting of non-cancer effects (hazards) and cancer effects (risks). The toxicity assessment presented herein was completed according to USEPA guidance (USEPA 1989). In particular, toxicity values were obtained from a hierarchy of sources, described in Section 5.3. The hierarchy consists of Tier 1 - USEPA's Integrated Risk Information System (IRIS); Tier 2 - Provisional Peer-Reviewed Toxicity Values (PPRTV) used in USEPA's Superfund Program; and Tier 3 - other peer-reviewed toxicity values. Tier 3 toxicological values were not used in this assessment unless these values were supplied by the USEPA Superfund Technical Support Center (STSC).

- *Factors for Assessing PAHs* – Benzo(a)pyrene, benzo(a)anthracene, and phenanthrene potentially contribute to Site-wide non-carcinogenic hazard and carcinogenic risk for various receptor and media scenarios.

    - The oral reference doses for phenanthrene as well as other non-carcinogenic PAHs are presented in **Table 5.1** of Section 5.5.6. For non-carcinogenic PAHs without published reference doses, the RfD for pyrene is used. This approach is consistent with the recommendations of the NCEA for PAH surrogates in the Onondaga Lake HHRA.
    - There are several PAHs that are classified as a Probable Human Carcinogen (B2) in IRIS (accessed September 2008). A B2 carcinogen is an agent for which there is sufficient evidence for carcinogenicity in animals, and inadequate evidence for carcinogenicity in humans.
    - The USEPA IRIS database (accessed September 2008) has a published CSF for benzo(a)pyrene of $7.3x10^{0}$ $(mg/Kg\text{-}day)^{-1}$. Using this value and the relative potency approach provided by USEPA in the *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (USEPA 1993), the oral CSFs were calculated for the PAHs in **Table 5.2** of Section 5.5.6.
    - The oral slope factors for all PAHs were not adjusted for the dermal route of exposure, according to guidance provided in USEPA RAGS, Part E (USEPA 2004c). The STSC suggested that the Inhalation Unit Risk factor [$1.1x10^{0}$ $(mg/m^3)^{-1}$] and the Inhalation Slope factor [$3.9x10^{0}$ $(mg/kg\text{-}day)^{-1}$] from the CalEPA be used in this assessment for benzo(a)pyrene; however, the relative potency factor approach was not used to adjust the Inhalation Unit Risk values for the other PAHs.

7.5. Spatial Hot Spots

As with many affected sites, the spatial distribution of constituents in environmental media can be significantly heterogeneous with localized areas of elevated concentrations. To evaluate whether a particular area is a spatial hot spot, the table below presents the percentage of constituents screened in as COPC for each exposure area and the mean of all exposure areas for a given exposure medium and chemical type. For this analysis, an exposure area can be considered a hot spot if the COPC percentage of constituents are more than one standard deviation greater than the mean of all exposure areas for a particular exposure medium. Percentages that exceed these criteria are shown in bold in **Table 7.2** below. However, it should be noted that spatial hot spots do not necessarily indicate the presence of unacceptable risk or hazard (*e.g*., pesticides). A discussion of risk-based hot spots is presented below in Section 7.6.

Hotspots include Ditch A – South surface sediment for metals and VOCs, the Upland Old Field Successional Area seep sediment for pesticides, and Site Ditches surface sediment and seep sediment for SVOCs. In seep water, the Lakeshore Area is considered a pesticide hotspot based on the criteria discussed above. Lakeshore Area and NYS Fair Parking Area shallow ground water exceed the criteria described above and are labeled as hotspots for pesticides and metals, respectively. Pesticides within surface soil within the Biosolids area, and PCBs and SVOCs within subsurface soil in the Lakeshore Area are hotspots. In surface water, Site Ditches and Ponded Area are hotspots for pesticides, and VOCs and SVOCs, respectively.

Table 7.6. *Spatial Distribution Summary.*

Exposure Area	Exposure Medium	Percentage of Constituents Screened in as COPC by Exposure Area				
		Metals	**PCBs**	**Pesticides**	**SVOC**	**VOC**
Ditch A South	Sediment	**63.6%**	0.0%	0.0%	18.2%	**18.2%**
Lakeshore Area	Seep Sediment	52.9%	11.8%	0.0%	17.6%	17.6%
Upland Old Field Successional Area	Seep Sediment	50.0%	16.7%	**5.6%**	16.7%	11.1%
Ponded Area	Surface Sediment	53.8%	15.4%	0.0%	23.1%	7.7%
Site Ditches	Surface & Seep Sediment	43.8%	0.0%	0.0%	**50.0%**	6.3%
Exposure medium mean		52.8%	8.8%	1.1%	25.1%	12.2%
Exposure medium mean + standard deviation		60.1%	17.0%	3.6%	39.2%	17.7%
Lakeshore Area	Seep Water	40.0%	0.0%	**5.0%**	30.0%	25.0%
Site Ditches	Seep Water	47.1%	0.0%	0.0%	23.5%	29.4%
Upland Old Field Successional Area	Seep Water	52.4%	0.0%	0.0%	33.3%	14.3%
Exposure medium mean		46.5%	-	1.7%	29.0%	22.9%
Exposure medium mean + standard deviation		52.7%	-	4.6%	33.9%	30.7%
Lakeshore Area	Shallow Ground Water	43.6%	0.0%	**7.7%**	23.1%	25.6%
NYS Fair Parking Area	Shallow Ground Water	**73.3%**	0.0%	0.0%	13.3%	13.3%
Upland Old Field Successional Area	Shallow Ground Water	56.3%	0.0%	0.0%	18.8%	25.0%
Exposure medium mean		57.7%	-	2.6%	18.4%	21.3%
Exposure medium mean + standard deviation		72.7%	-	7.0%	23.3%	28.3%
Biosolids Area	Surface Soil	53.3%	6.7%	**6.7%**	33.3%	0.0%
Lakeshore Area	Surface Soil	52.4%	9.5%	4.8%	28.6%	4.8%
NYS Fair Parking Area	Surface Soil	50.0%	0.0%	4.5%	40.9%	4.5%
Upland Old Field Successional Area	Surface Soil	45.8%	8.3%	4.2%	41.7%	0.0%
Exposure medium mean		50.4%	6.1%	5.0%	36.1%	2.3%
Exposure medium mean + standard deviation		53.7%	10.4%	6.2%	42.4%	5.0%
Biosolids Area	Subsurface Soil	51.6%	6.5%	6.5%	35.5%	0.0%
Lakeshore Area	Subsurface Soil	44.0%	**8.0%**	4.0%	**36.0%**	8.0%
NYS Fair Parking Area	Subsurface Soil	51.9%	7.4%	3.7%	33.3%	3.7%
Upland Old Field Successional Area	Subsurface Soil	46.7%	6.7%	6.7%	33.3%	6.7%
Exposure medium mean		48.5%	7.1%	5.2%	34.5%	4.6%

Table 7.6. *Spatial Distribution Summary.*

Exposure Area	Exposure Medium	Percentage of Constituents Screened in as COPC by Exposure Area				
		Metals	PCBs	Pesticides	SVOC	VOC
Exposure medium mean + standard deviation		52.4%	7.8%	6.8%	35.9%	8.1%
Ditch A South	Surface Water	70.0%	0.0%	0.0%	10.0%	20.0%
Ponded Area	Surface Water	22.2%	0.0%	0.0%	**44.4%**	**33.3%**
Site Ditches	Surface Water	62.5%	0.0%	**12.5%**	12.5%	12.5%
Exposure medium mean		51.6%		4.2%	22.3%	21.9%
Exposure medium mean + standard deviation		77.3%		11.4%	41.5%	32.5%

Bold indicates that area medium is a spatial hotspot.

Additionally, per the USEPA (2008b) HHRA conducted for a recreational bike trail at the site, the EPC for hexavalent chromium was calculated using both the data collected in May 2008 as well as data from the RI. Each sample collected in May 2008 was analyzed for total and hexavalent chromium. Statistical analysis done by Lockheed Martin for EPA (September 2008) suggested that concentrations of chromium VI in the Biosolids Area were different from the rest of the Site. Based on the ratio of hexavalent to total chromium from these samples, ratios were developed that could be applied to the historical chromium data collected during the RI. A separate ratio was developed for the Biosolids Area. The ratio was calculated using ordinary least square regression of hexavalent chromium concentrations against co-located total chromium concentrations. It was determined that 11 percent of the chromium in the Biosolids Area was hexavalent. For the rest of the Site, only 1 percent of the total chromium was determined to be hexavalent. These percentages were applied to the RI data in order to derive concentrations of hexavalent and trivalent chromium which were then used in the screening process and, in the case of hexavalent chromium, the development of an EPC.

7.6. Risk-Based Hot Spots

7.6.1. Site-Wide Cancer Risk

As shown in **Table 7.7**, the only receptors with cancer risk that exceed the regulatory threshold 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 ground water. 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.

Table 7.7. *Summary of Risk Drivers for Site-Wide RME Cancer Risk.*

Timeframe	Receptor	Primary Exposure Medium	Primary Constituents
Current/Future	Older Child Transient Trespasser	N/Ap	N/Ap
Current/Future	Lunchtime Trespasser	N/Ap	N/Ap
Current/Future	Utility/Sewer Worker	N/Ap	N/Ap
Future	Commercial/ Industrial Worker	N/Ap	N/Ap
Current/Future	Older Child Trespasser/ ATV Recreator	N/Ap	N/Ap
Current/Future	Young Adult Trespasser/ ATV Recreator	N/Ap	N/Ap
Future	Construction Worker	N/Ap	N/Ap

Table 7.7. *Summary of Risk Drivers for Site-Wide RME Cancer Risk.*

Timeframe	Receptor	Primary Exposure Medium	Primary Constituents
Current/Future	Adult State Fair Attendee	N/Ap	N/Ap
Current/Future	Older Child State Fair Attendee	N/Ap	N/Ap
Current/Future	Younger Child State Fair Attendee	N/Ap	N/Ap
Current/Future	State Fair Maintenance Worker	N/Ap	N/Ap
Current/Future	Ditch Maintenance Worker	N/Ap	N/Ap
Current/Future	Fisherperson/ Trespasser	N/Ap	N/Ap
Future	Adult Resident	Ground Water	Benzene, PAHs, Arsenic
Future	Child Resident	Ground Water	Benzene, PAHs, Arsenic

Notes:
N/Ap – Not applicable (acceptable risk).
Primary Exposure Medium – Exposure medium responsible for majority of receptor risk or hazard.
Primary Constituents – Constituents responsible for majority of receptor risk or hazard.

7.6.2. Site-Wide Non-Cancer Hazards

Although total Site-wide non-cancer hazards for a number of Site receptors are below the regulatory threshold of 1 (**Table 7.8** below), Site-wide hazards for the remaining receptors are driven by:

- Benzene in shallow ground water (0-10 ft bgs) and Site-wide ground water (all depths)
- Manganese, nickel, and “highly chlorinated” PCBs in Site soil

Because these constituents are responsible for the majority of Site non-cancer hazards, they represent non-cancer hazard drivers. Addressing these constituents would reduce Site non-cancer hazards considerably. However, prior to addressing metals, the hazards as a result of exposure to these metals should be considered relative to the hazards resulting from exposure to background concentrations. For instance, the hazard for the older child ATV recreator based on an EPC of 657 mg/kg for manganese in EU 3 (NY State Fair Parking Area, Upland Old Field Successional Area, and Biosolids Area) is 2.7. However, the hazard for this same receptor exposed to the 50th percentile background concentration for manganese in the eastern United States (~450 mg/kg, USEPA 2007d) is 1.8. Consequently, the non-cancer hazard posed to the older child ATV recreator from exposure to Site-related manganese is relatively consistent with the non-cancer hazard resulting from exposure to typical background concentrations of manganese.

Another factor that puts the manganese hazard quotient in perspective is dust particle size. As noted in the USEPA (2007d) *Framework for Metals Risk Assessment*, particle size of the inhaled compound is important when considering dosimetry and bioavailability. Larger, coarser particles are often the result of mechanical disruption (*e.g.*, construction activities) which the PEF equation models. These larger particles are less likely to stay suspended in the air for long periods of time and get deep in to the respiratory tract. Most likely, the manganese disturbed by ATV riding would be in the form of larger particles. However, because it is Solvay waste, rather than typical soil across the Wastebeds 1-8 Site, it is cannot be known with certainty if this is the case.

Table 7.8. *Summary of Risk Drivers for Site-Wide RME Non-Cancer Risk.*

Timeframe	Receptor	Primary Exposure Medium	Primary Constituents
Current/Future	Older Child Transient Trespasser	N/Ap	N/Ap
Current/Future	Lunchtime Trespasser	N/Ap	N/Ap
Current/Future	Utility/Sewer Worker	Shallow Ground Water	Benzene
Future	Commercial/ Industrial Worker	Surface Soil	Highly Chlorinated PCBs
Current/Future	Older Child Trespasser/ ATV Recreator	Outdoor Air	Manganese, Nickel
Current/Future	Young Adult Trespasser/ ATV Recreator	Outdoor Air	Manganese, Nickel
Future	Construction Worker	Shallow Ground Water and Outdoor Air	Manganese, Nickel, Benzene
Current/Future	Adult State Fair Attendee	N/Ap	N/Ap
Current/Future	Older Child State Fair Attendee	N/Ap	N/Ap
Current/Future	Younger Child State Fair Attendee	N/Ap	N/Ap
Current/Future	State Fair Maintenance Worker	N/Ap	N/Ap
Current/Future	Ditch Maintenance Worker	N/Ap	N/Ap
Current/Future	Fisherperson Trespasser	N/Ap	N/Ap
Future	Adult Resident	Ground Water	Benzene
Future	Child Resident	Ground Water	Benzene

Notes:
N/Ap – Not applicable (acceptable hazard).
Primary Exposure Medium – Exposure medium responsible for majority of receptor risk or hazard.
Primary Constituents – Constituents responsible for majority of receptor risk or hazard.

In addition to constituents that drive risk, there are Site areas that contain localized elevated constituent concentrations (hot spots). Specifically, the biosolids area contains elevated concentrations of PCBs and other compounds relative to the rest of the Site.

For nickel, a hot spot occurs in the area southeast of and adjacent to the Crucible Landfill, represented by the following sample locations: WB18-SS-19, WB18-SS-19A, WB18-SS-19B, WB18-SS-19C, and WB18-SS-19D. These concentrations are an order of magnitude higher than those in the rest of the Upland Old Field Successional Area.

Table 7.9. *Elevated Constituent Concentrations in the Southeast Vicinity of Crucible Landfill.*

	Southeast Vicinity of Crucible Landfill		Remainder of Upland Old Field Successional Area	
Constituent	Maximum Conc. (ppm)	Avg. Conc. (ppm)	Maximum Conc. (ppm)	Avg. Conc. (ppm)
Nickel	203	102.5	16	1.1

It is possible that the nickel hot spot is related to debris incidentally deposited from waste delivered to the Crucible Landfill.

7.7. Central Tendency Risks and Hazards

There are three receptors and exposure scenarios that indicate marginally unacceptable RME non-cancer hazards but acceptable CT hazards. These receptors are the current/future utility worker, future commercial/industrial worker, and the current/future young adult trespasser/ATV recreator. The RME hazards for these receptors are $1.3x10^0$, $1.4x10^0$, and $2x10^0$, respectively. These values are all very close to the acceptable hazard index of 1 and drop to within the acceptable range in the central tendency scenario. In contrast, receptors whose RME hazard greatly exceeds the acceptable range also have CT risks above the acceptable range. For example, the total hazard index for the future child resident is $7x10^2$ for the RME scenario and only drops to $2x10^2$ for the CT scenario. **Table 7.10** provides an overview of the risks and hazards for both the RME and CT scenarios.

Table 7.10. *Summary of Risks and Hazards for RME and CT Scenarios.*

		Acceptable Risk or Hazard			
Timeframe	**Receptor**	**RME Cancer**	**CT Cancer**	**RME Non-Cancer**	**CT Non-Cancer**
Current/Future	Older Child Transient Trespasser	yes	yes	yes	yes
Current/Future	Lunchtime Trespasser	yes	yes	yes	yes
Current/Future	Utility Worker	yes	yes	no	yes
Future	Commercial/ Industrial Worker	yes	yes	no	yes
Current/Future	Older Child Trespasser ATV Recreator	yes	yes	no	no
Current/Future	Young Adult Trespasser ATV Recreator	yes	yes	no	yes
Future	Construction Worker	yes	yes	no	no
Current/Future	Adult State Fair Attendee	yes	yes	yes	yes
Current/Future	Older Child State Fair Attendee	yes	yes	yes	yes
Current/Future	Younger Child State Fair Attendee	yes	yes	yes	yes
Current/Future	State Fair Maintenance Worker	yes	yes	yes	yes
Current/Future	Drainage Ditch Worker	yes	yes	yes	yes
Current/Future	Fisherperson Trespasser	yes	yes	yes	yes
Future	Adult Resident	no	no	no	no
Future	Child Resident	no	no	no	no

The following paragraphs provide a discussion of factors affecting cancer risks and hazards deemed unacceptable under the RME scenario but acceptable under the CT scenario.

7.7.1. Current/Future Utility Worker

The RME non-cancer total hazard index for this receptor is $1.3x10^0$. This index drops to $6x10^{-1}$ in the CT scenario. Although most exposure parameters remained constant between the RME and CT scenarios, some did vary significantly resulting in different risk estimates. Ingestion rates of soil differed between the two scenarios with 330 mg/day used for the RME and 100 mg/day used for the CT. The sediment to skin adherence factor was 0.3 for RME and 0.2 for CT. Exposure frequency and duration also differed between the RME and CT scenarios with 20 days/year over 25 years for the RME and 1 day/year over 9 years for the CT for exposure frequency and duration, respectively.

7.7.2. Future Commercial/Industrial Worker

The RME non-cancer total hazard index for this receptor is $1.4x10^0$. This index drops to $5x10^{-1}$ in the CT scenario. Differences in exposure parameters occurred primarily in the ingestion and dermal pathways. The RME soil ingestion rate was 100 mg/day whereas the CT was 50 mg/day. The RME soil to skin adherence factor was 0.3 mg/cm^3 and the CT was 0.1 mg/cm^3. The exposure frequency and duration also differed between the RME (250 days per year for 25 years) and CT scenarios (219 days per year for 9 years).

7.7.3. Young Adult Trespasser/ATV Recreator

The RME non-cancer total hazard index for this receptor is $2x10^0$. This index drops to $8x10^{-1}$ in the CT scenario. This is a result of differences in exposure parameters related to soil ingestion, dermal contact, and exposure frequency. The ingestion rate of soils for the RME scenario was 200 mg/day, whereas it was 100 mg/day the CT scenario. Two exposure parameters changed for the dermal pathway. The soil-to-skin adherence factor (0.7 mg/cm^3 for the RME versus 0.2 mg/cm^3 for the CT) and the skin surface area (3522 cm^2/day for the RME versus 1125 cm^2/day for the CT). Finally, the exposure frequency differed between these two scenarios (42 days/year for the RME versus 32 days/year for the CT).

7.8. Future Exposure Scenarios

Although the HHRA accounts for potential future exposure scenarios, there may be some potential future exposure scenarios that are not complete, but may become relevant. The HHRA also includes future child and adult residents even though residential use is not anticipated because the Site is zoned as industrial and has been deeded for "park purposes or other public use."

7.9. Uncertainty Due to Combination of Conservative Assumptions and Estimates

A consequence of adding risk estimates across chemicals and across pathways is that any conservatism that is contained in individual estimates tends to be compounded, and the final risk estimate may be especially conservative. Thus risk estimates based on the combination of risks across chemicals and pathways are biased higher than risk estimates for individual chemicals and pathways. This is particularly the case for risk estimates based on the RME scenario.

Overall, the RME scenario is meant to estimate a conservative exposure case that is well above the average but that is still within the range of possible exposures. So, when RME risks are summed across multiple exposure pathways, this is equivalent to assuming that the same individual is simultaneously exposed at the high end of the exposure distribution for each pathway. That said, the RME scenario is also meant to balance out uncertainties in the HHRA that otherwise tend in the direction of less conservatism.

7.10. Summary of Uncertainties

Because of the uncertainties summarized above, none of the exposure and risk calculations presented above should be interpreted as precise measures of the true risk. Rather, all values should be interpreted as uncertain estimates. Because many (but not all) of the approaches for dealing with uncertainty are intended to be conservative (*i.e.*, are more likely to overestimate than underestimate), the risk values above should generally be thought of as high-end estimates of the true risk, and actual risks are probably somewhat lower than the calculated values.

8. Conclusions

This HHRA considered exposure pathways for a variety of human receptors under both current conditions and future scenarios. The following receptors were considered:

- Current/future older child transient trespasser
- Current/future adult lunchtime trespasser
- Current/future utility/sewer worker
- Current/future older child and young adult trespasser/ATV recreator
- Current/future adult, older child, and younger child state fairgrounds attendee
- Current/future state fairgrounds maintenance worker
- Current/future ditch maintenance worker
- Current/future trespasser/fisherperson
- Future construction worker
- Future commercial/industrial worker
- Current/future child and adult resident

Within each exposure unit, the HHRA identified potential exposure pathways for receptors and constituents. A complete exposure pathway exists if there is a constituent source; a mechanism for release, retention, or transport of the contaminant; human contact with the medium; and an exposure route at the contact point.

Constituents of potential concern were identified for each exposure area. For each medium, the maximum detected concentration of the constituent was compared to a conservative screening value for the protection of human health. In general, constituents that exceed the screening value or did not have screening values available were retained as COPCs for further evaluation, while those below the screening value were excluded.

Cancer risks and non-cancer hazards were quantified for the reasonable maximum exposure and central tendency scenarios. The range for acceptable cancer risk is 10^{-6} to 10^{-4}, whereas non-cancer hazards are considered acceptable if they are below 1. This study presents the total risk and hazard for each receptor summed over all media, pathways, and constituents, and identifies the exposure media and constituents that contribute most significantly to the total risks and hazards.

The HHRA indicated that cancer risks and non-cancer hazards were within acceptable limits for the older child transient trespasser, lunchtime trespasser, adult state fairgrounds attendee, older child state fairgrounds attendee, younger child state fairgrounds attendee, state fairgrounds maintenance worker, drainage ditch worker, and trespasser/fisherperson (**Table 8.1**). Non-cancer hazards exceeded the acceptable threshold for the utility workers, commercial/industrial workers, older child trespasser/ATV recreator, young adult trespasser/ATV recreator, and construction workers under the RME scenarios. The only receptors with cancer risk that exceeded the threshold were potential future adult and child residents under the RME and CT scenarios. The table below summarizes the risks and hazards for each receptor. Risks and hazards are presented for each exposure medium and summed across all media.

Table 8.1 Site Risk and Hazards Summary.

			Cancer Risk		Non-Cancer Hazards	
Timeframe	**Receptor**	**Exposure Medium**	**RME**	**CT**	**RME**	**CT**
Current/ Future	Older Child Transient Trespasser	Surface Soil	2 E-05	6 E-06	4 E-01	4 E-01
		Outdoor Air	5 E-09	1 E-09	9 E-04	2 E-04
		Surface Sediment	1 E-07	9 E-09	3 E-03	3 E-04
		Seep Sediment	1 E-06	6 E-08	1 E-01	4 E-03
		Seep Surface Water	5 E-06	5 E-06	2 E-01	2 E-01
		All Media	2 E-05	1 E-05	7 E-01	6 E-01
Current/ Future	Lunchtime Trespasser	Surface Soil	7 E-06	7 E-07	2 E-01	6 E-02
		Outdoor Air	3 E-09	4 E-10	2 E-04	1 E-04
		Seep Sediment	8 E-08	9 E-09	3 E-03	9 E-04
		Seep Surface Water	2 E-06	3 E-07	5 E-02	2 E-02
		All Media	9 E-06	1 E-06	3 E-01	8 E-02
Current/ Future	Utility/ Sewer Worker	Surface/Subsurface Soil	7 E-06	5 E-08	2 E-01	4 E-03
		Outdoor Air	2 E-08	3 E-10	1 E-03	5 E-05
		Seep Sediment	2 E-07	2 E-08	5 E-03	2 E-03
		Seep Surface Water	6 E-06	1 E-07	9 E-02	4 E-03
		Shallow Ground Water	6 E-05	1 E-06	9 E-01	5 E-02
		All Media	7 E-05	1 E-06	1 E+00	6 E-02
Future	Commercial/ Industrial Worker	Surface Soil	5 E-05	6 E-06	1 E+00	5 E-01
		Outdoor Air	2 E-07	6 E-08	2 E-02	1 E-02
		All Media	5 E-05	6 E-06	1 E+00	5 E-01
Current/ Future	Older Child Trespasser/ ATV Recreator	Surface Soil	9 E-06	1 E-06	1 E+00	2 E-01
		Outdoor Air	1 E-05	7 E-06	5 E+00	3 E+00
		Seep Sediment	3 E-07	3 E-08	4 E-02	3 E-03
		Seep Surface Water	4 E-06	6 E-07	2 E-01	4 E-02
		All Media	3 E-05	9 E-06	7 E+00	3 E+00
Current/ Future	Young Adult Trespasser/ ATV Recreator	Surface Soil	7 E-06	2 E-06	4 E-01	1 E-01
		Outdoor Air	9 E-06	4 E-06	2 E+00	7 E-01
		Seep Sediment	2 E-07	3 E-08	1 E-02	1 E-03
		Seep Surface Water	3 E-06	4 E-07	9 E-02	1 E-02
		All Media	2 E-05	6 E-06	2 E+00	8 E-01
Future	Construction Worker	Surface/Subsurface Soil	3 E-06	3 E-07	1 E+00	1 E-01
		Outdoor Air	4 E-06	2 E-06	5 E+00	2 E+00
		Seep Sediment	6 E-08	3 E-08	2 E-02	8 E-03
		Seep Surface Water	3 E-06	1 E-06	5 E-01	2 E-01
		Shallow Ground Water	3 E-05	2 E-06	6 E+00	5 E-01
		All Media	4 E-05	6 E-06	1 E+01	3 E+00
Current/ Future	Adult State Fair Attendee	Surface Soil	4 E-07	8 E-08	1 E-02	4 E-03
		Outdoor Air	1 E-09	4 E-10	2 E-04	5 E-05
		All Media	4 E-07	8 E-08	1 E-02	4 E-03
Current/ Future	Older Child State Fair Attendee	Surface Soil	1 E-06	1 E-07	4 E-02	6 E-03
		Outdoor Air	9 E-10	3 E-10	3 E-04	8 E-05
		All Media	1 E-06	1 E-07	4 E-02	6 E-03

Table 8.1 Site Risk and Hazards Summary.

			Cancer Risk		Non-Cancer Hazards	
Timeframe	**Receptor**	**Exposure Medium**	**RME**	**CT**	**RME**	**CT**
Current/ Future	Younger Child State Fair Attendee	Surface Soil	5 E-06	6 E-07	1 E-01	3 E-02
		Outdoor Air	1 E-09	4 E-10	8 E-04	2 E-04
		All Media	5 E-06	6 E-07	1 E-01	3 E-02
Current/ Future	State Fair Maintenance Worker	Surface Soil	1 E-06	6 E-08	5 E-02	9 E-03
		Outdoor Air	4 E-08	4 E-10	6 E-03	1 E-04
		All Media	1 E-06	6 E-08	5 E-02	9 E-03
Current/ Future	Drainage Ditch Worker	Ditch and Seep Sediment	7 E-07	1 E-07	2 E-02	8 E-03
		Ditch and seep water	2 E-07	3 E-08	3 E-02	2 E-02
		All Media	9 E-07	1 E-07	5 E-02	3 E-02
Current/ Future	Fisherperson/ Trespasser	Surface Soil	1 E-06	6 E-07	1 E-02	7 E-03
		Outdoor Air	8 E-08	3 E-08	2 E-03	8 E-04
		Surface Sediment	2 E-08	8 E-09	5 E-05	2 E-05
		Seep Sediment	5 E-07	2 E-07	7 E-03	3 E-03
		Seep Surface Water	5 E-07	2 E-07	2 E-01	7 E-02
		All Media	2 E-06	1 E-06	2 E-01	8 E-02
Future	Adult Resident	Potable Water	1 E-02	2 E-03	2 E+02	8 E+01
		All Media	1 E-02	2 E-03	2 E+02	8 E+01
Future	Child Resident	Potable Water	1 E-02	4 E-03	7 E+02	2 E+02
		All Media	1 E-02	4 E-03	7 E+02	2 E+02

* Highlighted cells indicate values that exceed the range for acceptable cancer risk (10^{-6} to 10^{-4}) or acceptable non-cancer hazards (below 1).

The greatest cancer risk posed to current receptors is 7 x 10^{-5} for the utility/sewer worker. However, this value is within the acceptable range of 1×10^{-4} to 1×10^{-6}. Dermal exposure to benzene in shallow ground water drove this risk.

The greatest non-cancer hazard to a current receptor is $7\text{x}10^{0}$for the older child trespasser/ATV recreator. The hazard was driven by inhalation exposure to nickel and manganese in particulate matter in outdoor air.

The greatest cancer risk posed to a potential future receptor is for the future child resident (1×10^{-2}). All three ground water exposure routes contributed approximately equally to the excess cancer risk [ingestion (3×10^{-3}), inhalation (9×10^{-3}), and dermal (2×10^{-3})]. Benzene and arsenic in Site-wide ground water were primarily responsible for this excess cancer risk.

The greatest non-cancer hazard posed to a potential future receptor is also for the future child resident (7 x 10^{2}). This hazard is also driven primarily by exposure to benzene in ground water as a drinking water source and shower vapor. As noted previously, the use of ground water at the Site for potable applications is considered hypothetical and is extremely unlikely for several reasons: 1) the area is supplied by municipal water from the Village of Solvay; 2) the yield of the overburden ground water unit is inadequate for water supply wells; and 3) the high salinity of the deep aquifer (3,000 mg/l chloride) precludes its use as drinking water.

Although risks and hazards from vapor intrusion were not quantitatively evaluated in this HHRA, based on the vapor intrusion screening discussion in Section 6.1.4 and the high vapor pressure of many of the compounds detected, a vapor intrusion evaluation will need to be conducted prior to the construction of occupied buildings at the site. Based on the vapor intrusion evaluation, preventative measures may be included in the design and construction of buildings at the Site to mitigate the risk of exposure to on-Site soil gas. Such measures may include the use of a vapor barrier or the installation of a venting system, such as at the groundwater treatment plant.

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TABLES

TABLE 1
HISTORICAL DATA SOURCES
HONEYWELL WASTEBEDS 1 THROUGH 8 - GEDDES, NEW YORK

Report/Investigation Title	Sampled Area/Date	Chemical Analyses Performed on Collected Samples	Data Used in Human Health Risk Assessment
Revised Landfill Closure Plan Volumes 1 & 2 (C&S, 1986)	Crucible Landfill monitoring wells/ 1982 to 1985	Phenols, metals, cyanide, chloride, sulfate, TOC, TDS, and alkalinity	---
Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area (BBL, 1989)	Site-related surface water and ground water monitroing wells/1988 & 1989	Water quality parameters	---
Onondaga Lake Project. Waste Beds Investigation Report (TAMS, 1995)	Site-wide (ground water, waste material, surface water/seeps, and outfall and seep sediments)/1995	VOCs, SVOCs, and metals	---
Supplemental Wastebeds 1 through 8 Seeps, Sediment, and Water Sampling (NYSDEC, 2003)	Ponded Area, Lakeshore Area, and Site Ditches/2003	VOCs, SVOCs, and metals	One seep surface water and sediment sample (Lakeshore Area), one surface water and sediment sample (Ponded Area), and two surface water samples (Site Ditches)
Geddes Brook/Ninemile Creek Remedial Investigation: Remedial Investigation (RI) and sediment Interim Remedial Measure (IRM) [NYSDEC, 2003b]	Ninemile Creek surface water, sediment, and biota; Upland Old Field Successional Area floodplain soil/2001	VOCs, SVOCs, pesticides, PCBs, metals, PCDD/Fs	---
Ninemile Creek Supplemental Sampling Program (O'Brien & Gere, 2002)	Upland Old Field Successional Area floodplain soil/2002	SVOCs (PAHs and hexchlorobenzene), mercury, PCD/Fs, and TOC	---
Onondaga Lake Remedial Investigation/ Feasibility Study (RI/FS) [NYSDEC, 2002]	Onondaga Lake sediments/1992 & 2000	VOCs, SVOCs, pesticides, PCBs, metals, PCDD/Fs	---
Data Summary**.** Wastebeds 1 through 8. **Preliminary Site Assessment**. (O'Brien & Gere, 2005)	Biosolids Area, Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide	Surface soil samples.
	Lakeshore Area, NYS Fair Parking Areas, and Upland Old Field Successional Area/2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide	Soil boring samples.
	Biosolids Area, Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide; one sample collected for TCLP analyses	Test pit subsurface soil samples.
	Lakeshore Area, NYS Fair Parking Areas, and Upland Old Field Successional Area/2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, alkalinity, hardness, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3)	Ground water screening samples.
	Lakeshore Area, NYS Fair Parking Areas, and Upland Old Field Successional Area/2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, alkalinity, hardness, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3)	Ground water samples.
	Ponded Area, Site Dtiches, and Ditch A - South/ 2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, high resolution mercury, and cyanide	Surface water samples.
	Ponded Area, Site Dtiches, and Ditch A - South/ 2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, and TOC	Sediment samples.

TABLE 1
HISTORICAL DATA SOURCES
HONEYWELL WASTEBEDS 1 THROUGH 8 - GEDDES, NEW YORK

Report/Investigation Title	Sampled Area/Date	Chemical Analyses Performed on Collected Samples	Data Used in Human Health Risk Assessment
Data Summary. Wastebeds 1 through 8. **Preliminary Site Assessment**. (O'Brien & Gere, 2005) cont'd.	Lakeshore Area, Site Ditches, and Upland Old Field Successional Area/2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, high resolution mercury, and cyanide	Seep surface water samples.
	Lakeshore Area, Site Ditches, and Upland Old Field Successional Area/2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, and TOC	Seep sediment samples.
Remedial Invesitgation Report. Wastebeds 1 through 8. **Bike Trial Soil and Tissue Sampling**. (O'Brien & Gere, 2007)	Upland Old Field Successional Area/ 2004	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide	Surface soil samples.
Remedial Invesitgation Report. Wastebeds 1 through 8. **Focused Remedial Investigation**. (O'Brien & Gere, 2007)	Biosolids Area, Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2005 & 2006	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide	Soil boring samples.
	Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2005 & 2006	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, alkalinity, hardness, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3)	Ground water screening samples.
	Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2006	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, alkalinity, hardness, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3)	Ground water samples.
Remedial Invesitgation Report. Wastebeds 1 through 8. **Remedial Investigation**. (O'Brien & Gere, 2007)	Biosolids Area, NYS Fair Parking Areas, and Upland Old Field Successional Area/2007	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide	Surface soil samples.
	Biosolids Area, Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2007	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, and cyanide	Soil boring samples.
	Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2007	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, alkalinity, hardness, and major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3)	Ground water screening samples.
	Biosolids Area, Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2007	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, alkalinity, hardness, major cations (Ca, Mg, Na) and anions (Cl, SO_4, CO_3, HCO_3), and total Kjeldahl nitrogen	Ground water samples.
	Ponded Area/2007	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, high resolution mercury, and cyanide	Surface water samples.
	Ponded Area/2007	VOCs, SVOCs, pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, and TOC	Sediment samples.
	Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Outside an expsoure area/2007	VOCs	Soil vapor samples

TABLE 1
HISTORICAL DATA SOURCES
HONEYWELL WASTEBEDS 1 THROUGH 8 - GEDDES, NEW YORK

Report/Investigation Title	Sampled Area/Date	Chemical Analyses Performed on Collected Samples	Data Used in Human Health Risk Assessment
Chromium Speciation Evaluation. Wastebeds 1 through 8. **Remedial Investigation**. (O'Brien & Gere, 2007)	Biosolids Area, Lakeshore Area, NYS Fair Parking Areas, Upland Old Field Successional Area, and Site Ditches/2008	Total chromium and hexavalent chromium	Surface soil samples.
	Biosolids Area, Lakeshore Area, NYS Fair Parking Areas, and Upland Old Field Successional Area/2008	Total chromium and hexavalent chromium	Soil boring samples.
Revised Remedial Invesitgation Report. Wastebeds 1 through 8. **Supplemental Remedial Investigation**. (O'Brien & Gere, In process)	Lakeshore Area/2009	VOCs, SVOCs (including PXE and PTE), metals, mercury, cyanide, hexavalent chromium, and TOC	Surface soil samples.
	Lakeshore Area and Upland Old Field Successional Area/2009	VOCs, SVOCs (including PXE and PTE), metals, mercury, cyanide, and TOC	Soil boring samples.
	Upland Old Field Successional Area/ 2009	VOCs, SVOCs (including PXE and PTE), pesticides, PCBs (including Aroclor 1268), metals, mercury, cyanide, total Kjeldahl nitrogen, hardness, alkalinity, TDS, and major cations and anions (Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO^3)	Ground water samples.

Notes:
VOC = Volatile Organic Compound
SVOC = Semivolatile Organic Compound
PCB = Polychlorinated Biphenyl
TOC = Total Organic Carbon
TDS = Total Dissolved Solids
NYSDEC = New York State Department of Environmental Conservation
PCDD/F = Polychlorinated Dibenzo-p-Dioxin/Polychlorinated Dibenzofuran
TCLP = Toxicity Characteristic Leaching Potential
PXE = 1-phenyl-1-[2,4-dimethylphenyl]-ethane
PTE = 1-phenyl-1-[4-methylphenyl]-ethane
PAHs = Polycyclic Aromatic Hydrocarbons
--- = Investigation data not used in HHRA

Source:

Blasland, Bouck & Lee (BBL). 1989. *Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area, Solvay, New York*. Blasland, Bouck & Lee, Syracuse, New York.
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O'Brien & Gere. 2007. *Remedial Investigation Report, Wastebeds 1 though 8 Site, Geddes, New York.* O'Brien & Gere Engineers, Inc., East Syracuse, New York.
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FIGURES

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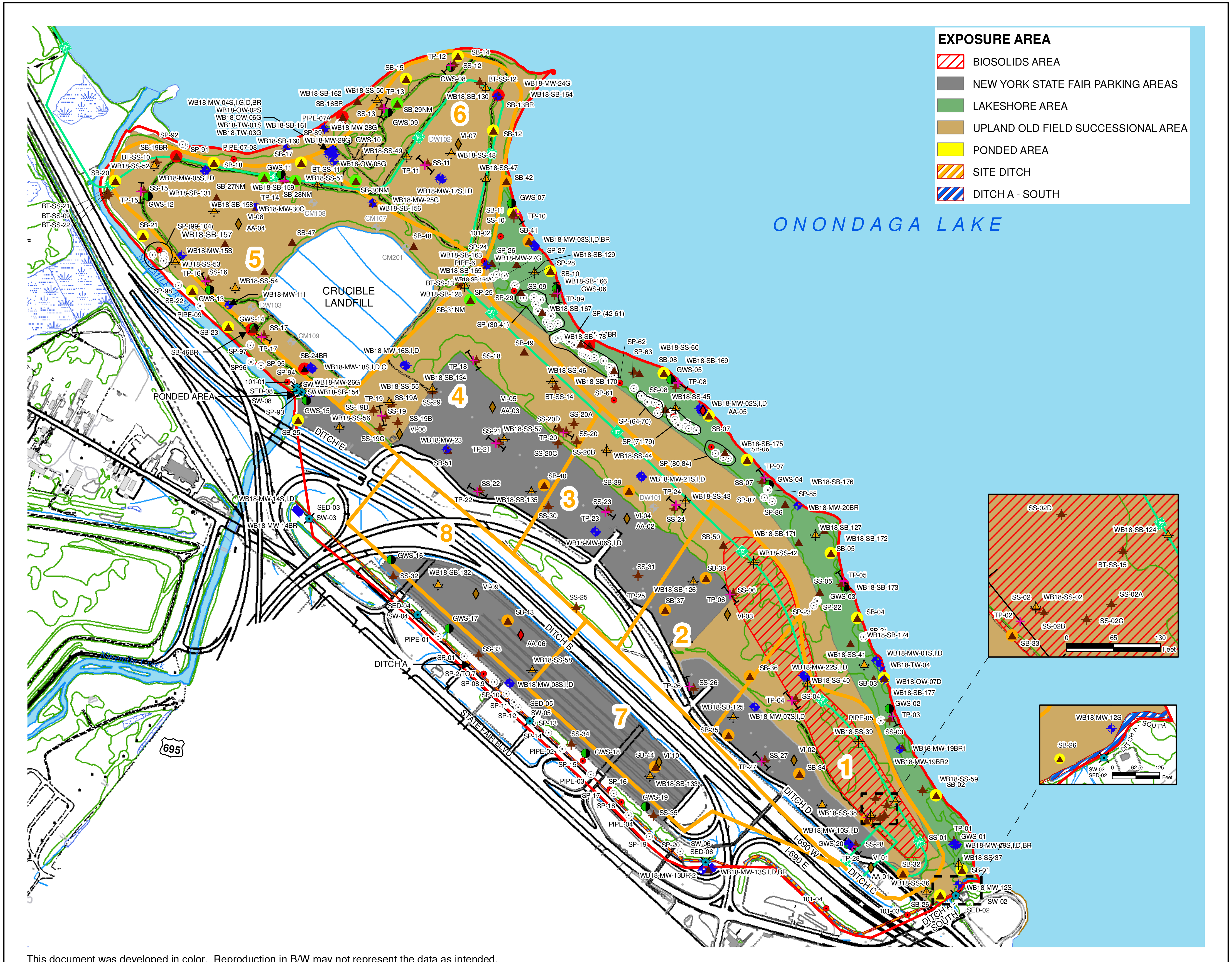

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FIGURE 1

N

LEGEND

LOCATION TYPE

- AMBIENT AIR
- MONITORING WELL
- GROUND WATER SCREENING
- SOIL BORING
- SURFACE SOIL
- SURFACE WATER/SEDIMENT
- TEST PIT SAMPLE
- VAPOR INTRUSION
- SEEP WATER/SEDIMENT (sampled)
- SEEP WATER/SEDIMENT (not sampled)
- SOIL SAMPLE (Cr SPECIATION)
- CRUCIBLE WELL (not sampled)
- BORING TO TOP OF BEDROCK/TILL
- BORING TO SILT AND CLAY
- BORING (SOURCE CHARACTERIZATION)
- BORING (NMC GRAVEL/ SAND DELINEATION)
- BIKE TRAIL
- TEST PIT
- APPROXIMATE WASTEBED BOUNDARY
- SITE BOUNDARY

HONEYWELL
WASTEBEDS 1-8 SITE
HUMAN HEALTH RISK ASSESSMENT
GEDDES, NEW YORK

EXPOSURE AREAS & SAMPLING LOCATIONS

0 350 700 1,400
Feet

AUGUST 2010
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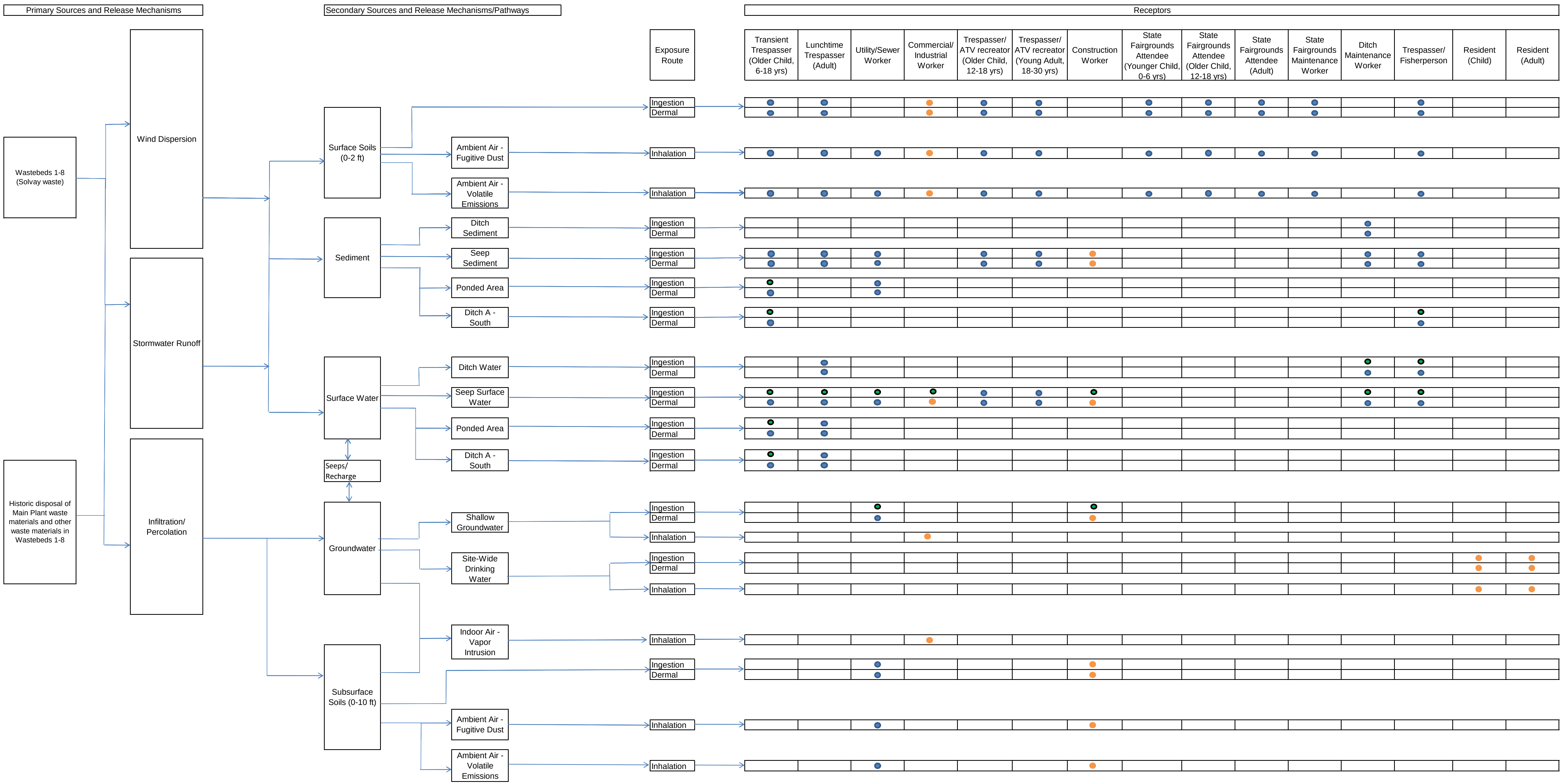
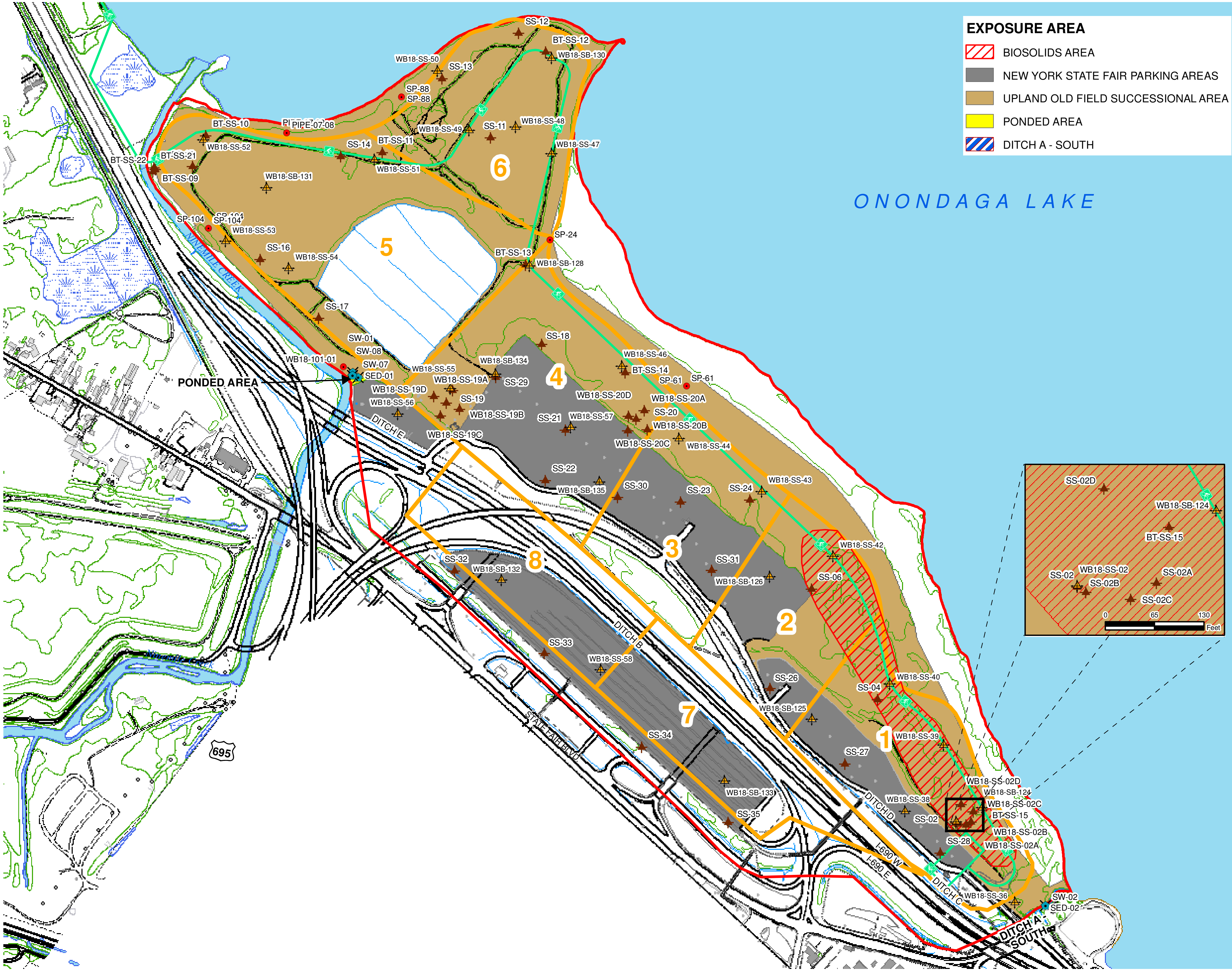
FIGURE 1B
CONCEPTUAL SITE MODEL
SITE WIDE
HONEYWELL WASTEBEDS 1-8 SITE - GEDDES AND SYRACUSE, NEW YORK



Notes:
- Receptor pathway present in future scenarios.
- Receptor pathway present in current/future scenarios.
- Potentially complete pathway but not evaluated in the HHRA because exposure is expected to be de minimis.

FIGURE 2



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LEGEND

LOCATION TYPE

- SURFACE SOIL
- SURFACE WATER/SEDIMENT
- SEEP WATER/SEDIMENT (sampled)
- SOIL SAMPLE (Cr SPECIATION)
- BIKE TRAIL
- SITE BOUNDARY
- APPROXIMATE WASTEBED BOUNDARY

HONEYWELL
WASTEBEDS 1 - 8
HUMAN HEALTH RISK ASSESSMENT
GEDDES, NEW YORK

EXPOSURE UNIT 1 - SAMPLING LOCATIONS

0 350 700 1,400
Feet

AUGUST 2010
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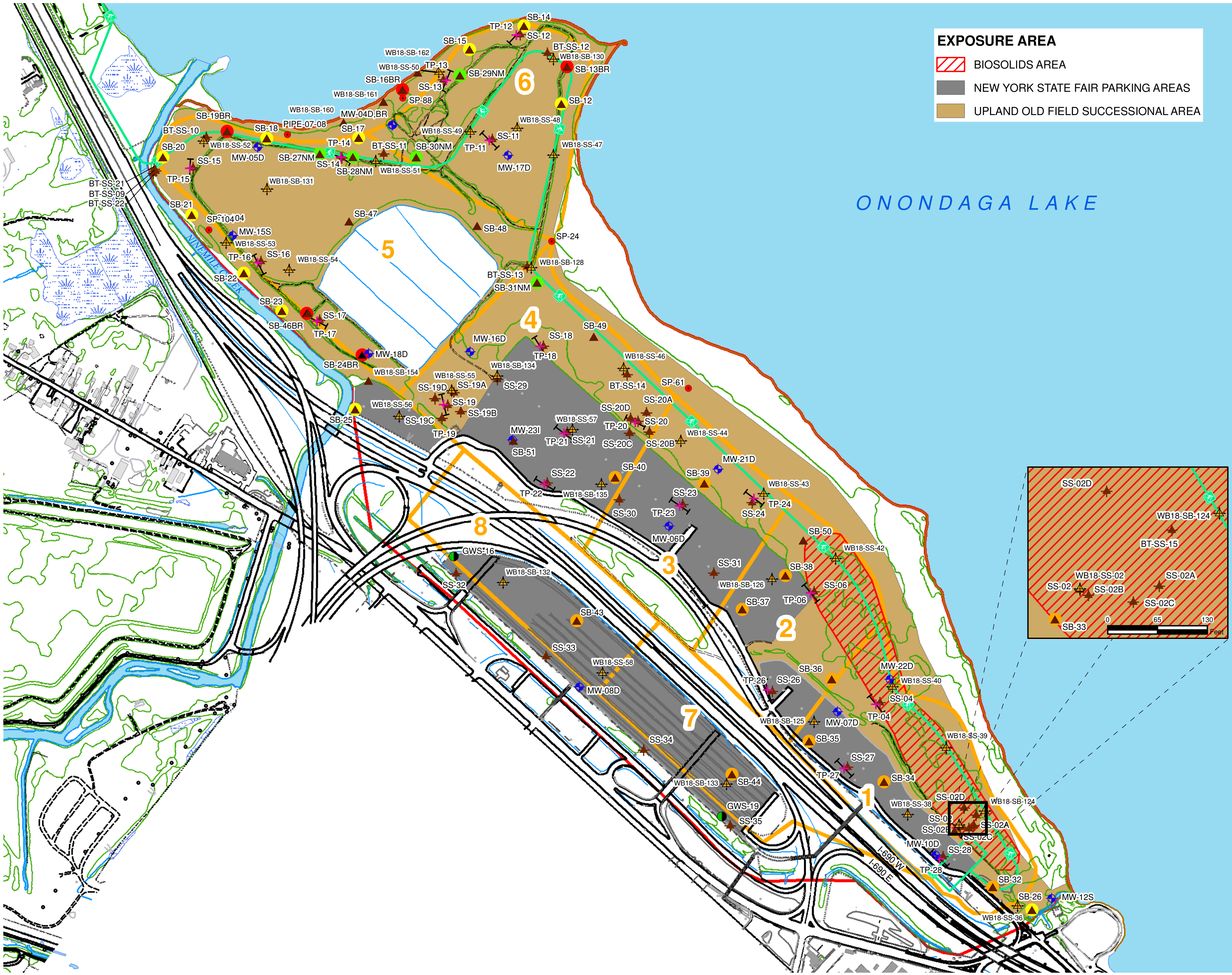
FIGURE 3



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LEGEND

LOCATION TYPE

- GROUND WATER SCREENING
- MONITORING WELL
- SOIL BORING
- SURFACE SOIL
- SEEP WATER/SEDIMENT (sampled)
- TEST PIT SAMPLE
- SOIL SAMPLE (Cr SPECIATION)
- BORING TO TOP OF BEDROCK/TILL
- BORING TO SILT AND CLAY
- BORING (SOURCE CHARACTERIZATION)
- BORING (NMC GRAVEL/ SAND DELINEATION)
- TEST PIT
- BIKE TRAIL
- SITE BOUNDARY
- APPROXIMATE WASTEBED BOUNDARY

HONEYWELL
WASTEBEDS 1 - 8
HUMAN HEALTH RISK ASSESSMENT
GEDDES, NEW YORK

EXPOSURE UNIT 2 - SAMPLING LOCATIONS

0 350 700 1,400
Feet

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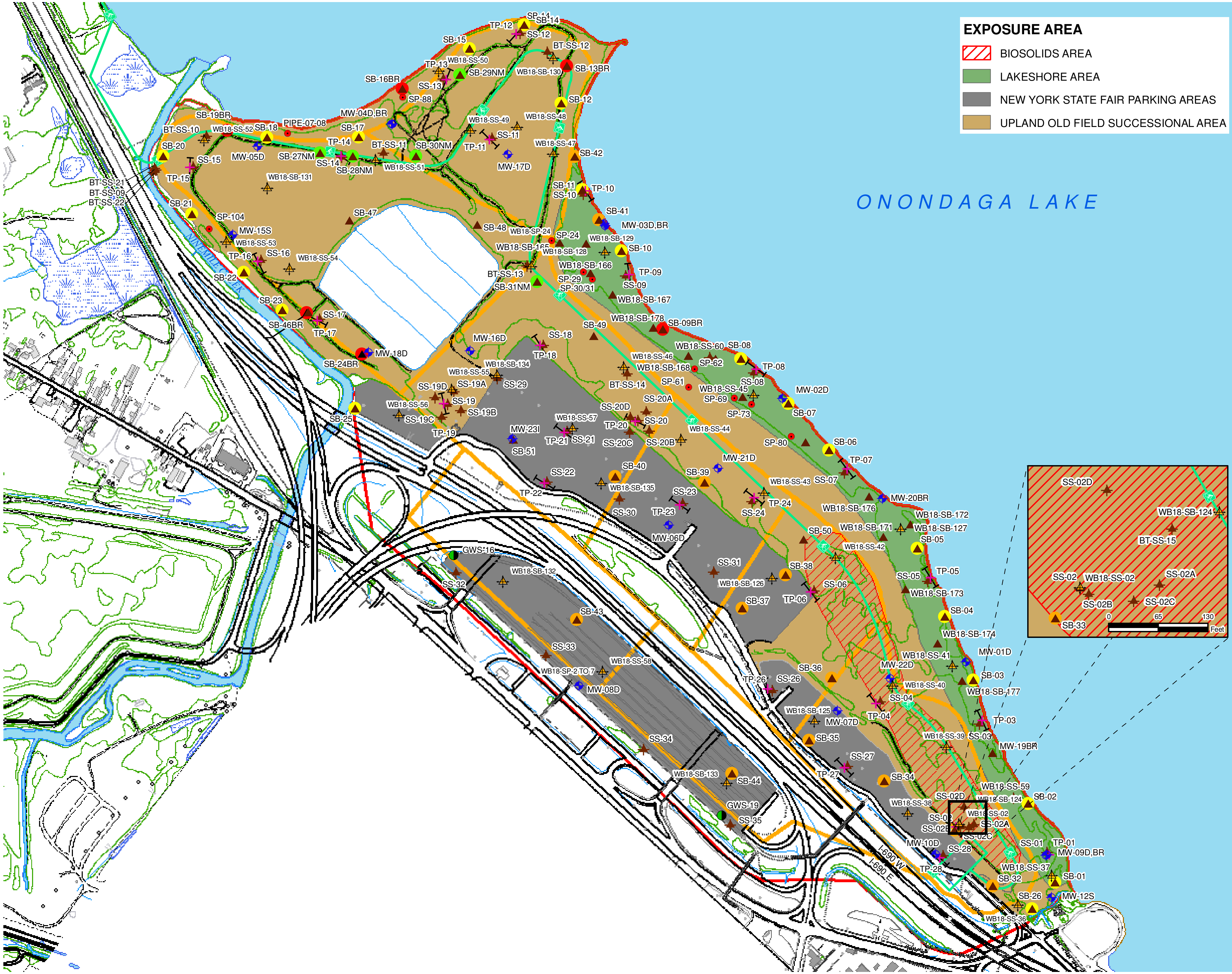
FIGURE 4



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N

LEGEND

LOCATION TYPE

- MONITORING WELL
- SOIL BORING
- SURFACE SOIL
- TEST PIT SAMPLE
- SOIL SAMPLE (Cr SPECIATION)
- BORING TO TOP OF BEDROCK/TILL
- BORING TO SILT AND CLAY
- BORING (SOURCE CHARACTERIZATION)
- BORING (NMC GRAVEL/ SAND DELINEATION)
- TEST PIT
- BIKE TRAIL
- SITE BOUNDARY
- APPROXIMATE WASTEBED BOUNDARY

HONEYWELL
WASTEBEDS 1 - 8
HUMAN HEALTH RISK ASSESSMENT
GEDDES, NEW YORK

EXPOSURE UNIT 3 - SAMPLING LOCATIONS

0 350 700 1,400
Feet

JANUARY 2010
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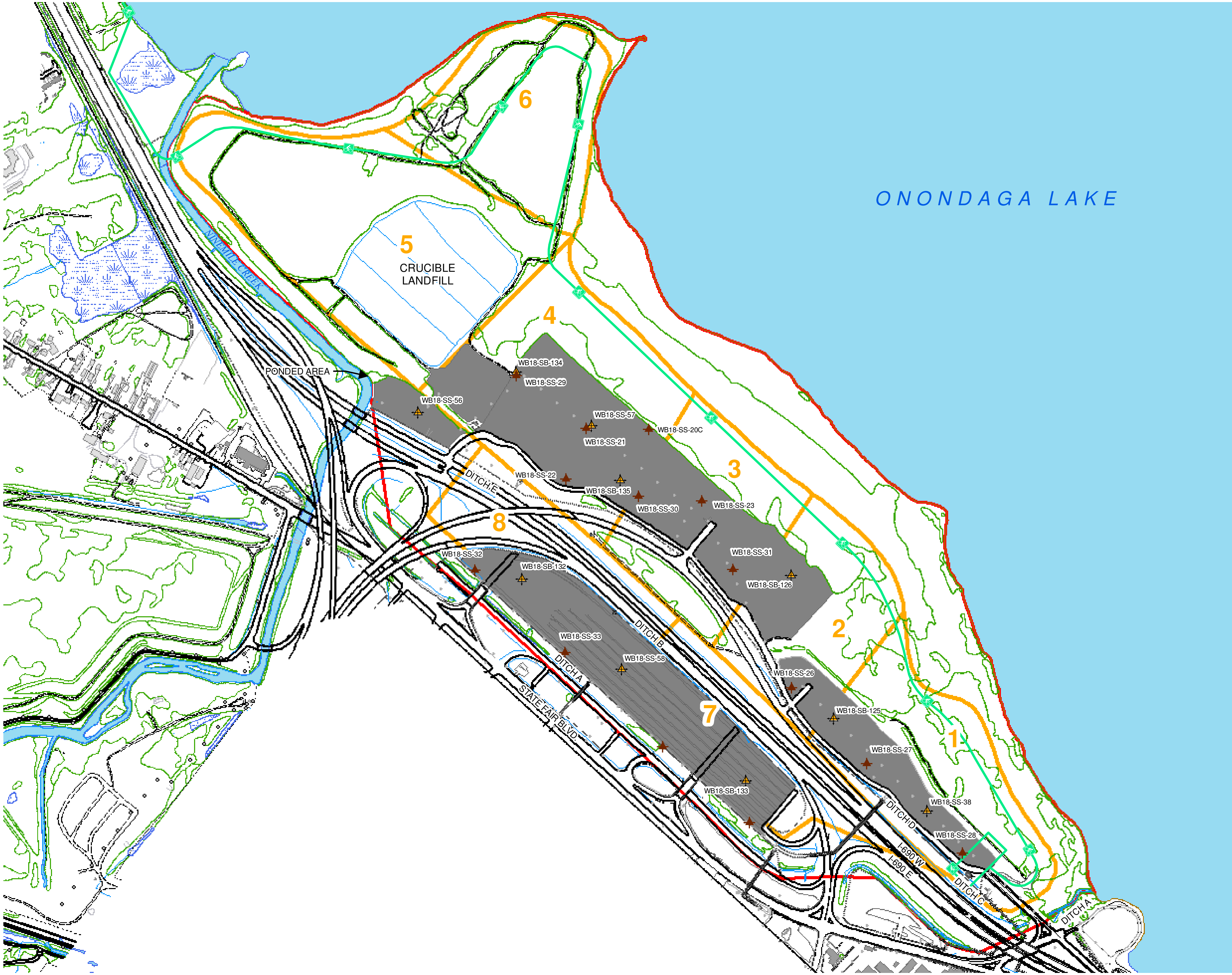

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FIGURE 5

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LEGEND

- SURFACE SOIL
- SOIL SAMPLE (Cr SPECIATION)
- BIKE TRAIL
- SITE BOUNDARY
- APPROXIMATE WASTEBED BOUNDARY

EXPOSURE AREA

- NEW YORK STATE FAIR PARKING AREAS

HONEYWELL
WASTEBEDS 1 - 8
HUMAN HEALTH RISK ASSESSMENT
GEDDES, NEW YORK

EXPOSURE UNIT 4 - SAMPLING LOCATIONS

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Feet

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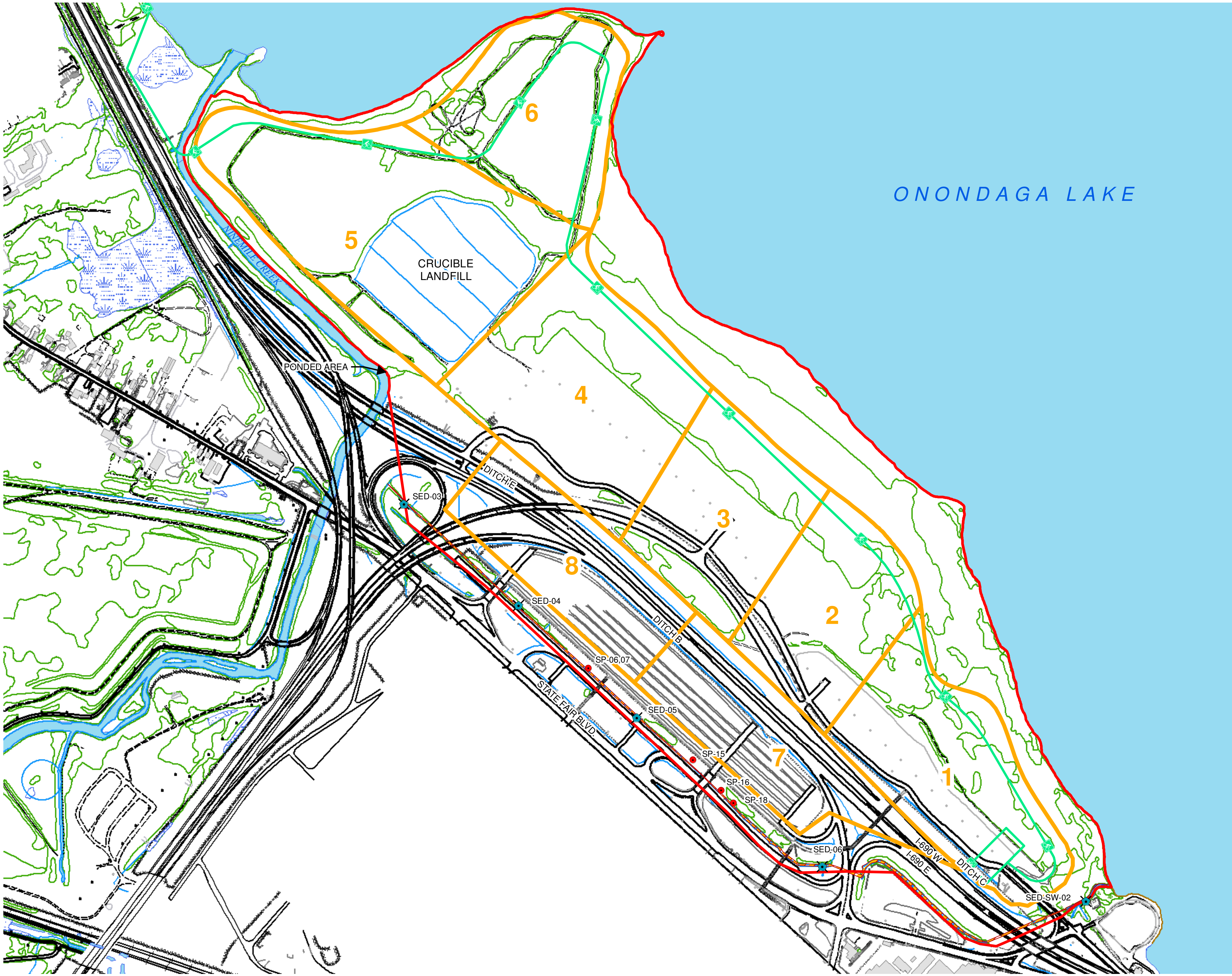

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FIGURE 6

N

LEGEND

LOCATION TYPE

- SURFACE WATER/SEDIMENT
- SEEP WATER/SEDIMENT (sampled)
- BIKE TRAIL
- SITE BOUNDARY
- APPROXIMATE WASTEBED BOUNDARY

EXPOSURE AREA

- SITE DITCH
- DITCH A - SOUTH

HONEYWELL
WASTEBEDS 1 - 8
HUMAN HEALTH RISK ASSESSMENT
GEDDES, NEW YORK

EXPOSURE UNIT 5 - SAMPLING LOCATIONS

0 400 800 1,600
Feet

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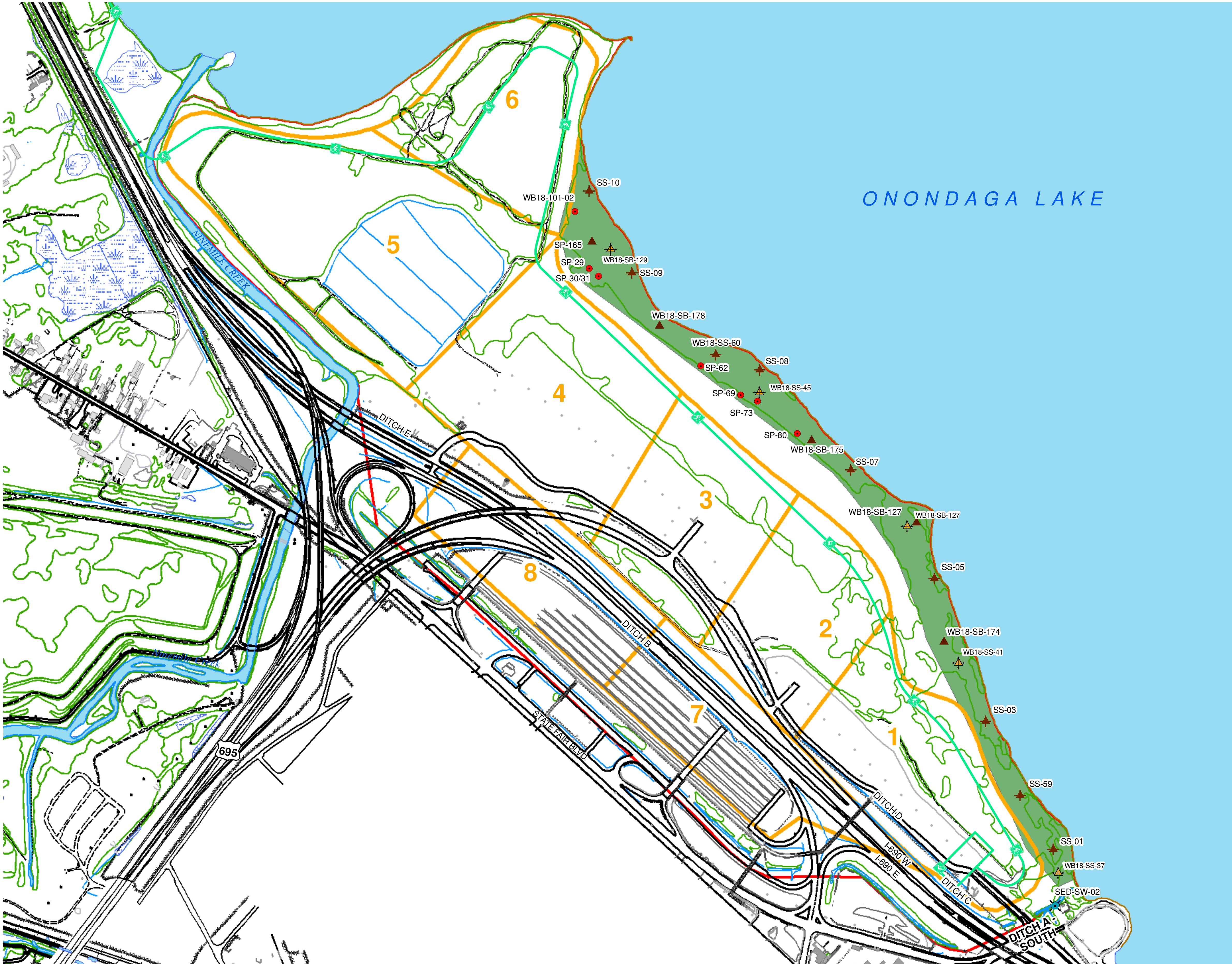
FIGURE 7



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N

LEGEND

LOCATION TYPE

- AMBIENT AIR
- MONITORING WELL
- SOIL BORING
- SURFACE SOIL
- SEEP/WATER/SEDIMENT (sampled)
- VAPOR INTRUSION
- SOIL SAMPLE (Cr SPECIATION)

EXPOSURE AREA

- LAKESHORE AREA
- DITCH A - SOUTH

HONEYWELL
WASTEBEDS 1 - 8
HUMAN HEALTH RISK ASSESSMENT
GEDDES, NEW YORK

EXPOSURE UNIT 6 - SAMPLING LOCATIONS

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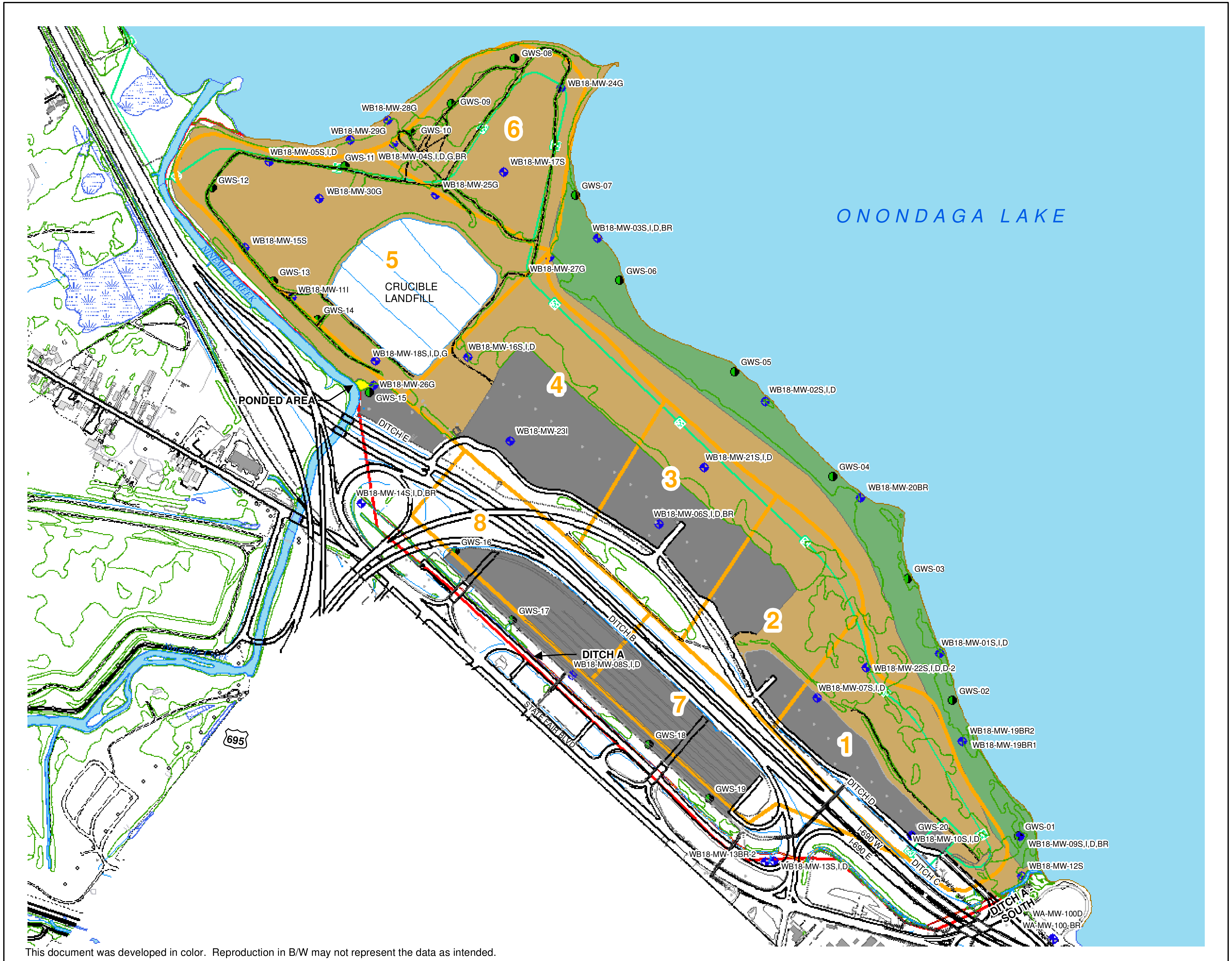
FIGURE 8



LEGEND

LOCATION TYPE

- MONITORING WELL
- GROUND WATER SCREENING
- BIKE TRAIL
- SITE BOUNDARY
- APPROXIMATE WASTEBED BOUNDARY

EXPOSURE AREAS

- NEW YORK STATE FAIR PARKING AREAS
- LAKESHORE AREA
- UPLAND OLD FIELD SUCCESSIONAL AREA
- PONDED AREA
- SITE DITCH

HONEYWELL
WASTEBEDS 1 - 8
HUMAN HEALTH RISK ASSESSMENT
GEDDES, NEW YORK

EXPOSURE UNIT 7 - SAMPLING LOCATIONS

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Feet

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