SUPPLEMENTAL SITE INVESTIGATION REPORT

FORMER GORHAM MANUFACTURING FACILITY 333 ADELAIDE AVENUE PROVIDENCE, RHODE ISLAND

Prepared for:

Textron, Inc.
40 Westminster Street
Providence, Rhode Island 02903

Prepared by:

MACTEC Engineering and Consulting, Inc.
107 Audubon Road
Wakefield, Massachusetts 01880

July 31, 2006

Volume I of IV

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Volume I of IV

MACTEC

engineering and constructing a better tomorrow

July 31, 2006

MACTEC PN: 3650050041

Mr. Joseph T. Martella II
Senior Engineer
State of Rhode Island
Office of Waste Management
Department of Environmental Management
235 Promenade Street
Providence, RI 02908-5767

RE: Submittal of Supplemental Site Investigation Report
Former Gorham Manufacturing Site
333 Adelaide Avenue
Providence, Rhode Island

Dear Mr. Martella:

On behalf of Textron, Inc., MACTEC Engineering and Consulting, Inc. (MACTEC) is pleased to submit a one hard copy and one electronic copy of the Supplemental Site Investigation Report (SIR) for the Former Gorham Manufacturing Site located at 333 Adelaide Avenue, Providence, Rhode Island. This SIR is being submitted in accordance with the March 2006 Consent Order, August 2005 Letter of Responsibility (LOR) and the April 2006 amended LOR issued by Rhode Island Department of Environmental Management (RIDEM). This SIR has also been prepared consistent with the provisions of Section 8 of the Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases.

These activities incorporated the following comments provided by RIDEM:

- RIDEM comments dated March 14, 2006 on the November 2005 Draft Work Plan;
- RIDEM amended LOR dated April 5, 2006;
- RIDEM comments made during a May 2, 2006 meeting with Textron and MACTEC; and,
- RIDEM comments following the May 2, 2006 meeting in a letter dated May 25, 2006.

This SIR documents the implementation of the Site Investigation Work Plan components, analytical results by ESS Laboratory in Cranston, RI and incorporates historical Site information with these 2006 results to define the nature and extent of contamination at the Site. Based on these results, a Human Health and Ecological Risk Assessment were prepared and Remedial Alternatives were evaluated for the Site soils and Mashapaug Cove.

This SIR also contains the laboratory data reports received to date from ESS Laboratory. This submittal of the SIR meets the March 2006 Consent Order requirement for submittal of laboratory reports within seven days of receipt from our subcontractor. Additional laboratory reports regarding the slag removal confirmatory soil sampling results will be provided upon receipt.

MACTEC will forward two additional hard copies of the SIR to RIDEM under separate submittal as requested. Please review and provide comments on this Supplemental SIR. Should there be any questions please to do not hesitate to contact either Mr. Michael Murphy or myself at 781-245-6606, or Mr. Greg Simpson at Textron, Inc. at 401-457-2635.

Sincerely,
MACTEC Engineering and Consulting, Inc.

David E. Heislein
Project Manager

Michael J. Murphy
Sr. Principal Environmental Scientist

Enclosures: Supplemental Site Investigation Report – One bound hard copy and one electronic copy on compact disk

cc: Senator Juan M. Pichardo, District 2 (One Hard Copy)
Representative Thomas Slater (One Hard Copy)
Repository – Knight Memorial Library (One Hard Copy)
Thomas Deller, City of Providence (One Hard Copy)
Tim Regan, EA Engineering, Science and Technology, Inc. (One Electronic Copy)
G. Simpson, Textron, Inc. (Electronic Submittal)
D. McCabe, Textron, Inc. (Electronic Submittal)
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JULY 2006

MACTEC

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Project: 3650050041.01

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Section 7 of the "Remediation Regulations"
Site Investigation Report (SIR) Checklist

Contact Name:

Contact Address:

Contact Telephone:

Site Name:

Site Address:

OFFICE USE ONLY
SITE INVESTIGATION REPORT (SIR) Site:
PROJECT CODE:
SIR SUBMITTAL DATE:
CHECKLIST SUBMITTAL DATE:

☐ 7.03.A List specific objectives of the SIR related to characterization of the release, impacts of the release and remedy.

- ***Investigation Objectives are described in Section 1.0***
- ***Sampling Results are presented in Section 4.0***
- ***Impacts are summarized in Section 7.0***
- ***Remedy Alternatives are discussed in Section 6.0***

☐ 7.03.B Include information reported in the Notification Of Release. A copy of the release notification form should be included in the SIR. Include information relating to short-term response, if applicable.

- ***Not applicable. The Site is an inactive hazardous waste site. Manufacturing operations ceased in 1986. Environmental investigations performed from 1986 to present have documented historic Site-related impacts to media.***

☐ 7.03.C Include documentation of any past incidents or releases.

- ***Impacts to Site media that are presented in Section 4.0 are considered evidence of releases from historic (pre-1986) manufacturing activities.***

- 7.03.D Include list of prior property owners and operators, as well as sequencing of property transfers and time periods of occupancy.
  - ***Site History is discussed in Section 2.1.***
- 7.03.E Include previously existing environmental information which characterizes the contaminated-site and all information that led to the discovery of the contaminated-site.
  - ***This report references previous comprehensive environmental investigations. The comprehensive sampling completed in 2006 in many cases supplants earlier limited historical sampling and provides a robust snapshot of current conditions.***
- 7.03.F Include current uses and zoning of the contaminated site, including brief statements of operations, processes employed, waste generated, hazardous materials handled, and any residential activities on the site, if applicable. (This section should be linked to the specific objectives section demonstrating how the compounds of concern in the investigation are those that are used or may have been used on the site or are those that may have impacted the site from an off-site source.)
  - ***The portion of the Site that is the focus of the Supplemental SI (the Site) has no current use. Compounds of concern are described in Section 2.3.***
- 7.03.G Include a locus map showing the location of the site using US Geological Survey 7.5-min quadrangle map or a copy of a section of that USGS map.
  - ***Included as Figure 1.1.***
- 7.03.H Include a site plan, to scale, showing:
  - ***Recent conditions are shown on the aerial photo presented as Figure 2.1.***
  - Buildings
    - ***Not Applicable – There are no current buildings on the Site.***
  - Activities
    - ***Not Applicable – There are no activities on the Site.***
  - Structures
    - ***Not applicable – There are no structures on the Site.***
  - North Arrow
    - ***All figures included in this report include a north arrow.***
  - Wells

- ***Historic wells located on the Site are shown on Figure 3.1.***

 UIC Systems, septic tanks, underground storage tanks (UST), piping and other underground structures:

- ***Not Applicable – There are no existing underground structures on the Site. Water intake and stormwater discharge pipes were identified by historical plans and site observations. These were incorporated into the Supplemental SI activities.***

 Outdoor hazardous materials storage and handling areas:

- ***Not Applicable***

 Extent of paved areas:

- ***Not Applicable – Some areas in the northeastern portion of the Site were paved but they are aged, decayed, and judged to be less than 20% intact. Some of these areas are obscured by shallow fill or debris.***

 Location of environmental samples previously taken with analytical results:

- ***Historic sampling locations are shown on Figures 2.2 and 2.3. Historic results are included in Tables 3.2, 3.3 and 4.1. Many historic samples are of limited use since they are up to 20 years old. A comprehensive discussion of historic results is presented in the Work Plan. Results are discussed within Section 4.0 of this report as they appear pertinent to current findings (e.g., recent RIDEM results are included with the 2006 data set for the purposes of characterization of nature and extent but earlier results of dubious sampling and analytical origin are excluded).***

 Waste management and disposal areas.

- ***A pile of construction debris from the razing of Site structures is present on the Site and is shown on Figure 2.1.***

 Property lines.

- ***The property line for the Site is shown on Figure 2.1.***

 7.03.I Include a general characterization of the property surrounding the area including, but not limited to.

 Location and distance to any surface water bodies within 500 ft of the site.

 Location and distance to any environmentally sensitive areas within 500 ft of the site.

 Actual source of potable water for all properties immediately abutting the site.

- Location and distance to all public water supplies, which have been active within the previous 2 years and within one mile of the site.
- Determination as to whether the release impacts any off-site area utilized for residential or industrial/commercial property or both.
- Determination of the underlying groundwater classification and if the classification is GB, the distance to the nearest GA area.
  - ***This information is presented in Section 2.0.***

7.03.J Include classifications of surface and ground water at and surrounding the site that could be impacted by the release.

- ***Presented in Section 2.0.***

7.03.K Include a description of the contamination from the release, including.

- Free liquids on the surface
  - ***Not Applicable – There are no free liquids. Site has been inactive for 20 years.***
- LNAPL and DNAPL
  - ***Not Applicable – There are no known or suspected LNAPL or DNAPL release.***
- Concentrations of hazardous substances which can be shown to present an actual or potential threat to human health and any concentrations in excess of any of the remedial objectives.
  - ***Human Health Risk has been assessed and is summarized in Section 5.1 and described in Appendix G.***
- Impact to environmentally sensitive areas
  - ***Impact to Mashapaug Pond is described in Section 4.0.***
- Contamination of man-made structures
  - ***Not applicable.***
- Odors or stained soil
  - ***Observations from sampling activities are provided on field logs (Appendix C) and summarized in Section 4.0.***
- Stressed vegetation
  - ***There are no areas of stressed vegetation that are considered to be a potential indicator of a release to surface soils. There are areas of fill with constituents such as slag, brick, wood, and debris that result in sparse vegetative cover.***
- Presence of excavated or stockpiled material and an estimate of its total volume

- ***A pile of demolition debris is present on the northeastern portion of the property that is estimated to be 5,500 cubic yards of material. MACTEC understands that the City of Providence will be removing this material in 2006.***

 Environmental sampling locations, procedures and copies of the results of any analytical testing at the site:

- ***The scope of work is described in Section 3.0 and the results of analytical testing are discussed in Section 4.0.***

 List of hazardous substances at the site:

- ***Not Applicable. The Site is inactive and there are no stored hazardous substances on the property. Impacts to Site media from historic activities are the focus of this report and are described in Sections 2.0 and 4.0.***

 Discuss if the contamination falls outside of the jurisdiction of the Remediation Regulations, including but not limited to USTs, UICs, and wetlands:

- ***Impact to the adjacent cove area of Mashapaug Pond is one of the focuses of this study. The methods that are used to assess contamination that was identified through sampling are presented in a Human Health Risk Assessment and an Ecological Risk Assessment that are appended to this report.***

 7.03.L Include the concentration gradients of hazardous substances throughout the site for each media impacted by the release:

- ***Figures detailing the extent of impact are provided in Section 4.0 within the discussion of analytical results for each Site media.***

 7.03.M Include the methodology and results of any investigation conducted to determine background concentrations of hazardous substances identified at the contaminated site:

- ***This study did not include a background evaluation.***

 7.03.N Include a listing and evaluation of the site specific hydrogeological properties which could influence the migration of hazardous substances throughout and away from the site, including bit not limited to, where appropriate:

- ***Hydrogeological investigations were not part of this study. Previous reports such have documented hydrogeological conditions.***

 Depth to GW

- ***Depth to groundwater varies from zero (at the edge of Mashapaug Pond) to approximately 30 feet (at the highest elevations on the Site).***

- Presence and effects of both the natural and man-made barriers to and conduits for containment migration.
  - ***There are no known man-made barriers or conduits to contaminant migration.***
- Characterization of bedrock
  - ***Not applicable. There are no suspected releases to bedrock from activities on the Site.***
- Groundwater contours, flow rates and gradients throughout the site
  - ***This Supplemental SI did not investigate Site groundwater. Site groundwater conditions have been characterized in the 1995 Remedial Investigation Report (ABB-ES, 1995) and are summarized in Section 4.4 of this current Supplemental SIR.***

- 7.03.O Include a characterization of the topography, surface water and run-off flow patterns, including the flooding potential, of the site
  - ***Site topography is shown on Figure 3.1.***
- 7.03.P Include the potential for hazardous substances from the site to volatilize and any and all potential impacts of the volatilization to structures within the site.
  - ***Not applicable. There are no occupied structures that could receive impact from vapor migration. One currently abandoned structure (a former railroad terminal) is located in an area of the Site with no known or suspected releases of volatile organic compounds (VOCs).***
- 7.03.Q Include the potential for entrainment of hazardous substances from the site by wind or erosion actions.
  - ***The potential for mobilization of surface soil from wind exists but is low and would occur primarily during construction activities.***
- 7.03.R Include detailed protocols for all fate and transport models used in the Site Investigation.
  - ***Not applicable.***
- 7.03.S Include a complete list of all samples taken, the location of all samples, parameters tested for and analytical methods used during the Site Investigation. (Be sure to include the samples locations and analytical results on a site figure).
  - ***Supplemental SI sample locations are shown on Figure 3.1 and Figure 3.2. A list of all samples collected, analytical parameters, and methods is provided in Tables 3.2 through 3.5.***

- 7.03.T Include construction plans and development procedures for all monitoring wells. Well construction must be consistent with the requirements of Appendix H of the Groundwater Quality Regulations.
  - ***Not applicable.***
- 7.03.U Include procedures for handling, storage and disposal of wastes derived from and during the investigation.
  - ***Soil sampling activities did not generate any soil waste that required disposal. Small quantities of excess soil were retuned to the surface locations where each was collected. Excess sediment that was left over after collection of the cores and sampling was consolidated and returned to the cove.***
- 7.03.V Include a quality assurance/quality control (QA/QC) evaluation summary report for sample handling and analytical procedures, including, but not limited to, chain-of-custody procedures and sample preservation techniques.
  - ***This discussion is provided in Section3.8.***
- 7.03.W Include any other site-specific factor, that the Director believes, is necessary to make an accurate decision as to the appropriate remedial action to be take at the site.
- 7.04 Include Remedial Alternatives. The Site Investigation Report **must** contain a minimum of **2** remedial alternatives other than no action/natural attenuation alternative, unless this requirement is waived by the Department. It should be clear which of these alternatives is most preferable. All alternatives must be supported by relevant data contained in the Site Investigation Report and consistent with the current and reasonably foreseeable land usage, and documentation of the following:
  - Compliance with Section 8 (RISK MANAGEMENT);
  - Technical feasibility of the preferred remedial alternative;
  - Compliance with Federal, State and local laws or other public concerns; and
  - The ability of the performing party to perform the preferred remedial alternative.
  - ***Remedial alternatives are discussed in Section 6.0.***

- 7.05 **Certification Requirements**: The Site Investigation Report and all associated progress reports must include the following statements signed by an authorized representative of the party specified:
  - A statement signed by an authorized representative of the person who prepared the Site Investigation Report certifying the completeness and accuracy of the information contained in that report to the best of their knowledge; and
  - A statement signed by the performing party responsible for the submittal of the Site Investigation Report certifying that the report is a complete and accurate representation of the site and the release and contains all known facts surrounding the release to the best of their knowledge
    - ***The certifications are provided in Section 8.0.***
- 7.06 **Progress Reports**: If the Site Investigation is not complete, include a schedule for the submission of periodic progress reports on the status of the investigation and interim reports on any milestones achieved in the project.
    - ***Remaining activities and a schedule for there completion are provided in Section 7.0***
- 7.07 **Public Notice**: Be prepared to implement public notice requirements per Section 7.07 and 7.09 of the Remediation Regulations when the Department deems the Site Investigation Report to be complete.

LIST OF ACRONYMS

ASI	Aqua Survey, Inc.
ASTs	above-ground storage tanks
AVS/SEM	acid volatile sulfides/simultaneously extracted metals
BaA	benzo[a] anthracene
BaF	benzo[b]fluoranthene
BaP	benzo[a]pyrene
bgs	below ground surface
CDFs	polychlorinated dibenzo furans
COPC	constituents of potential concern
CSM	conceptual site model
CT	Central Tendency
cy	cubic yards
1,2-DCE	1,2-dichloroethene
DO	dissolved oxygen
ELCR	excess lifetime cancer risk
GPS	Global Positioning System
GZA	Goldberg Zoino & Associates
HLA	Harding Lawson Associates
Kd	distribution coefficient
LOR	Letter of Responsibility
MACTEC	MACTEC Engineering and Consulting, Inc.
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
MS/MSD	matrix spike/matrix spike duplicate
NOR	Notice of Responsibility
PA	Preliminary Assessment
PAH	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDD	polychlorinated dibenzo dioxins
PCE	tetrachloroethene or perchloroethylene
PID	photoionization detector
ppm	parts per million
PPM	priority pollutant metals
ppq	parts per quadrillion
ppt	parts per trillion
QA/QC	quality assurance/quality control

RAWP	Remedial Action Work Plan
RIDEM	Rhode Island Department of Environmental Management
RIDOH	Rhode Island Department of Health
RME	Reasonable Maximum Exposure
SI	Site Inspection or Site Investigation
SIR	Site Investigation Report
SLERA	screening level ecological risk assessment
SVOCs	semi-volatile organic compounds
1,1,1-TCA	1,1,1-trichloroethane
TCE	trichloroethene or trichloroethylene
TEF	Toxicity Equivalence Factor
TEQ	Toxic Equivalence
Textron	Textron, Inc.
TOC	total organic carbon
TPH	total petroleum hydrocarbons
UCL	Upper Concentration Limit
URI	University of Rhode Island
USEPA	United States Environmental Protection Agency
USTs	underground storage tanks
µg/kg	micrograms per kilogram
µg/L	microgram per liter
VOCs	volatile organic compounds

1. INTRODUCTION

This Supplemental Site Investigation Report (Supplemental SIR) describes the nature and extent of contamination, characterizes human health and ecological risks, and identifies and evaluates remedial objectives for a portion of the former Gorham manufacturing facility and for Mashapaug Cove, which are both located within the property at 333 Adelaide Avenue in Providence, Rhode Island (Figure 1.1). The property at 333 Adelaide Avenue is also known as the Former Gorham Manufacturing Facility site. Supplemental investigation activities were conducted between December 2005 and July 2006 to address data gaps and to support completion of a human health and ecological risk assessment for the upland area of the Site and for Mashapaug Cove. This Report has been prepared pursuant to Sections 7.0 (Site Investigation) and 8.0 (Risk Management) of the State of Rhode Island Department of Environmental Management (RIDEM) *Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases* (hereafter referred to as the Remediation Regulations) on behalf of Textron, Inc. (Textron) by MACTEC Engineering and Consulting, Inc. (MACTEC).

Gorham Silver manufactured silver flatware and bronze statues and other products at the Facility from 1890 to 1986. The location and general footprint of the former manufacturing facility are shown on Figure 1.1. The City of Providence is the current owner of the property at 333 Adelaide Avenue. The Park Parcel is a small portion of the property at 333 Adelaide Avenue and the boundaries of the Park Parcel have been defined in the Superior Court *Consent Order (Park Parcel)* dated March 29, 2006 between RIDEM and the City of Providence (hereafter referred to as the Consent Order). Exhibit A of the Consent Order (reproduced here as Figure 1.2) identifies the Park Parcel with cross hatching and indicates that the Park Parcel includes Parcel D and a portion of Parcel C. As shown in Figure 1.2, Mashapaug Cove is a small portion of Mashapaug Pond and it is surrounded on three sides by the Park Parcel. The northern boundary of Mashapaug Cove is the property line for 333 Adelaide Avenue. In this Supplemental SIR, the Inner Cove is considered to be the southern portion of Mashapaug Cove, and the Outer Cove is the northern portion of Mashapaug Cove. For the purposes of this Supplemental SIR, the Park Parcel and Mashapaug Cove are collectively referred to as "the Site". The Site covers approximately eight acres of the 37 acre property at 333 Adelaide Avenue and it borders the southeastern shore of Mashapaug Pond. Mashapaug Cove has an area of approximately 4.4 acres, which is approximately equally split between the Inner Cove and the Outer Cove.

Previous environmental studies of the 333 Adelaide Avenue property identified impacts to environmental media from former manufacturing activities. In 1999, a Method 1 risk assessment, performed consistent with the Remediation Regulations for all of the 333 Adelaide Avenue property, identified remedial requirements for soil based on Industrial/Commercial Direct Exposure Criteria (Industrial/Commercial Criteria) and GB Leachability Criteria for groundwater. A Remedial Action Work Plan (RAWP) was approved for the entire property in 2001, (Harding ESE, 2001). Under the approved RAWP, Remediation of the petroleum contaminated soils on Parcels A, B and C have been completed. Remediation of the groundwater containing chlorinated solvents is ongoing. This leaves the remediation of the Site soils still to be done using a soil cover, under the approved RAWP. The remaining areas of the property at 333 Adelaide Avenue (outside of the Site) have been redeveloped, or are in the process of redevelopment by the City of Providence and the Greater Providence YMCA. The approved RAWPs for those redevelopment projects include capping requirements. The capping of soils within the undeveloped portion of the property has not yet been completed.

The March 29, 2006 Consent Order required additional investigation of the Park Parcel to further characterize environmental conditions of the upland portion of the Park Parcel and the submittal of a SIR for the Park Parcel. An Amended Letter of Responsibility (LOR) issued by RIDEM to Textron and the City of Providence, dated April 5, 2006, requires a Site Investigation of the "Park Parcel, including Mashapaug Cove" and the submittal of an SIR. This SIR utilizes the definition of the "Park Parcel" that is contained in the Consent Order. Therefore, "the Site" addressed by this SIR includes the uplands area known as the Park Parcel as well as Mashapaug Cove.

Textron prepared a Supplemental SI Work Plan in June 2006 and that Work plan is presented in Appendix A. The Work Plan incorporated comments provided by RIDEM on a previous Work Plan (RIDEM, 2005) as well as comments provided by RIDEM during and after a meeting held on May 2, 2006 and attended by RIDEM, Textron, and MACTEC (RIDEM, 2006b). This SIR documents the findings of the Supplemental SI, combines that information with previous information collected for the Site, includes a Human Health and Ecological Risk Assessment, and evaluates Remedial Alternatives for the Site upland areas and for Mashapaug Cove.

This Report is organized as follows: Section 2.0 provides General Site Information including additional detail on Site History, Physical Setting, and Previous Environmental Investigations. Section 3.0 describes the Scope of Work accomplished for the Supplemental SI. Section 4.0 presents the results of the field investigation and laboratory analyses. Section 5.0 summarizes the findings of the Risk Assessment (which is appended to this Report). Section 6.0 presents the Remedial Alternatives Evaluation. Section 7.0 presents investigation conclusions and identifies remaining data gaps. Section 8.0 presents Certifications required by the Remediation Regulations. Section 9.0 identifies reference documents used in the preparation of this Report.

2. GENERAL SITE INFORMATION

2.1 PROPERTY AND SITE HISTORY

The Former Gorham Manufacturing Site is a 37-acre parcel of land where Gorham Silver engaged in the manufacture of silverware, both sterling and plated, and bronze castings from approximately 1890 to 1986. Operations included casting, rolling, polishing, and lacquering, forging, and plating, annealing, soldering, degreasing, machining, and melting. Vapor degreasers reportedly used trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,1-trichloroethane (1,1,1-TCA). Figure 1.1 shows the former facility and its general location in Providence. More recent conditions are shown in the areal photograph in Figure 2.1. In this figure, the Site is located immediately north of Adelaide Avenue and west of the railroad tracks. The former manufacturing facility has been razed, partly remediated and is in the process of redevelopment. A retail development has been completed on the southeastern portion (Parcel A). A public high school is currently under construction on a second parcel (Parcel B). The high school will be constructed under the requirements of a RIDEM approved RAWP, dated October 11, 2001. The Greater Providence YMCA will soon be constructing, a facility that will include offices, recreational, and after-school daycare facilities and athletic fields on Parcel C under a RIDEM approved RAWP, dated October 11, 2001.

In 1967, the Gorham Manufacturing business and property were purchased by Textron and operated as a division of Textron until 1986, when Textron sold the facility to the Winoker Group. The Winoker Group subsequently sold the facility to another group of investors, the Adelaide Development Corporation, which in turn sold the facility to the Seaman Equity Group. In 1990, Seaman defaulted on its taxes and the City of Providence foreclosed. The City of Providence currently owns the property at 333 Adelaide Avenue including the Site.

2.2 PHYSICAL SETTING

The 333 Adelaide Avenue property (including the northeast portion of the Site) is bordered to the east by railroad tracks (Figure 2.1). Adelaide Avenue and a residential neighborhood bound the 333 Adelaide Avenue property to the south. The Site constitutes the northern portions of the 333 Adelaide Avenue property. To the north and west, the Site is bounded by Mashapaug Pond. On the opposite (northern) shore of Mashapaug Pond is an industrially-zoned area.

The Site uplands can be divided into three areas moving from southwest to northeast for the purposes of physical description. The first of these is the portion of the parcel extending from its southern boundary to the tip of the western peninsula that bends into Mashapaug Pond. This area is heavily wooded with moderate to steep slopes that descend to the Pond. There is no historic information or current visual evidence that would suggest that this portion of the parcel was subject to industrial uses. There are structures present which we have surmised were used for water extraction.

The second (central) area is the portion that borders the southern shore of Mashapaug Cove. This area includes a steep wooded embankment that leads down to wooded lowland that is adjacent to the cove. A slag pile previously located in the central portion of this area was recently removed from the property by Textron (July 2006) in accordance with the Consent Order. The slag apparently was associated with a smelter that was housed in Building V of the former facility. Post-excavation confirmatory soil sampling has been conducted and the samples have been submitted for laboratory analysis. Results of the laboratory analysis will be submitted to the Consent Order-required parties under separate cover. These results will also be incorporated into the remedial activities for Site soils. The embankments along the southern end of Mashapaug Cove are underlain by heterogeneous fill, consisting of granular reworked soils with varying amounts of casting sands, construction and demolition and miscellaneous debris such as fire brick, old wood beams, and metal debris. The fill varies in thickness from one-foot at the northern edge of the former West Parking area (former facility area) to approximately 20-feet along the embankment to the south of the southern shore of Mashapaug Cove. Several historic groundwater wells used for industrial purposes still exist (but are not in use) near the southwestern shore of the cove.

The third portion of the parcel lies to the northeast. It borders the cove and pond and includes the eastern shore of Mashapaug Cove, a steep hill to the east, and a flat upland area that formerly housed an employee recreational building (known as the 'Casino') and associated parking lots. In addition, in the northeast corner of the Site is a plot of land that is in active use by the Amtrak High Speed railroad. Also in the upland area in the northeast corner is a vacant building that was identified as a garage or carriage house historically. There are approximately 30-feet of difference in elevation between the former manufacturing facility upland parcel and the lower shoreline of Mashapaug Cove. At the time of the Supplemental SI a large pile of soil and debris still remained in the northeast upland parcel. MACTEC understands that consistent with the requirements of the

Consent Order, the City of Providence will be removing this pile in the near future. Some sampling activities were accomplished beneath and within the area of debris as described in Section 3.0.

A large portion of the Park Parcel is currently wooded and heavily vegetated. The Western Peninsula has variable elevation and is a wooded environment. The peninsula is accessible via one or more paths. The tip of the peninsula is relatively more open than the wooded areas adjacent to it. The Cove shore area is a small, relatively flat area at the bottom of the embankment with brush and saplings. There is a very steep embankment between the developed portion of the property to the south of the Park Parcel and the shore of Mashapaug Cove. The Eastern Peninsula has trees and vegetation, but is generally more open and accessible than the areas immediately to the south of Mashapaug Cove. The uplands portion of the Site is currently enclosed by a chain-link fence.

Mashapaug Pond has been previously classified as having Class C water quality or eutrophic conditions (low dissolved oxygen (DO) and excessive algae/nutrients). However, RIDEM recently, in 2006, reclassified Mashapaug Pond as Class B surface water. Class B waters are designated for fish and wildlife habitat and primary and secondary contact recreational activities. They should be suitable for compatible industrial process and cooling, hydropower, aqua-cultural uses, navigation, and irrigation and other agricultural uses. These waters should have good aesthetic value. Water depth in the Inner Cove varies from less than a foot to approximately 3.5 feet, while depths in the Outer Cove vary from one foot to eleven feet.

In August 2002, RIDEM and the Rhode Island Department of Health (RIDOH) issued a letter (RIDEM and RIDOH, 2002a) to inform the public concerning water quality in Mashapaug Pond and to identify safe uses of the pond. That letter concluded that fish caught from the pond are not safe to eat due to contamination by PCBs and dioxins, that bacteria levels are apparently high following rainstorms rendering the pond unsafe for swimming, and blue-green algae found in the pond can produce toxins that can harm humans and animals that swim in or drink pond water during algal blooms, further rendering the pond unsafe for direct contact and consumption at those times. None of these conditions has been attributed to conditions at the Site itself or the former manufacturing facility.

A "Do's and Don'ts Flyer" was released by RIDEM and RIDOH (RIDEM and RIDOH, 2002b) that indicates that catch and release fishing and boating are safe activities for Mashapaug Pond. The flyer strongly urges people not to drink pond water, not to eat fish caught in the pond, not to swim, wade, play, or bathe in pond water, and not to boat whenever thick scum, algal mats, or foul odors occur on the pond. A copy of the RIDEM/RIDOH advisory letter and flyer is presented in Appendix B. This advisory concerning safe uses of the pond indicates that a visitor to the Site should be unlikely to have significant exposures to Site-related constituents during recreational activities at the pond (minimal exposure to cove surface water and sediment). However, the RIDEM/RIDOH advisory has not been completely effective in preventing direct contact recreational uses of the cove such as wading and swimming.

Groundwater beneath the Site is classified by RIDEM as Class GB, not suitable for public or private drinking water use. Groundwater beneath or near the Site is not used as a source of drinking water. There are no public or private wells within a four-mile radius of the Site (ABB-ES 1995a and 1995b). The nearest public water supply is the Scituate Reservoir located approximately nine miles to the west.

Groundwater beneath the former facility flows predominantly in a northerly direction and discharges into Mashapaug Cove. There is a groundwater divide approximately parallel to the eastern property boundary, in the southeastern portion of the property. The depth to groundwater beneath the 333 Adelaide Avenue property ranges from approximately 3-feet along the north bank area (south shore of Mashapaug Cove) to 30-feet below grade in the southeastern area of the 333 Adelaide Avenue property. Historical investigations have identified low levels of volatile organic compounds (VOCs) (PCE, TCE and 1,1,1-TCA) in groundwater immediately upgradient of Mashapaug Cove along the southern shore. There are no occupied buildings proposed for the Site; therefore, potential vapor migration from groundwater to soil gas and indoor air of occupied buildings is not a concern for the Site. This VOC groundwater plume has previously been determined to pose minimal impact to surface water within the Cove (Section 3.5; HLA, 1999).

2.3 REGULATORY BACKGROUND AND PREVIOUS INVESTIGATIONS

Environmental investigations have been carried out at the 333 Adelaide Avenue property and Mashapaug Pond since 1985. The Site was not the focus of most of those investigations. Mashapaug Pond water and sediment samples were first collected from several locations by the

University of Rhode Island (URI) in 1986. A consultant (Goldberg Zoino & Associates (GZA)) also collected a surface water sample from Mashapaug Cove in 1986. Approximate locations of historic surface water and sediment samples collected from Mashapaug Pond are shown on Figure 2.2.

RIDEM completed a United States Environmental Protection Agency (USEPA) Potential Hazardous Waste Site Identification Form in 1987 in response to a complaint by the Providence Police Department. This occurred after the facility ceased operations in 1986. RIDEM completed a Preliminary Assessment (PA) of the 333 Adelaide Avenue property in 1989 which designated the property as a Medium Priority for a Site Inspection (SI). A SI Report was prepared by Camp Dresser & McKee in 1993 under contract to RIDEM. The SI recommended further investigation of the property. ABB Environmental Services and, subsequently, Harding Lawson Associates (HLA), both now known as MACTEC, completed several environmental investigations on behalf of Textron since 1993.

In 1995, a Remedial Investigation Report (ABB-ES, 1995a) and a Supplemental Remedial Investigation Report (ABB-ES, 1995b) were prepared to assess site conditions, including portions of the Site. The results of the earlier investigations (circa 1986 to 1995) were summarized in the Remedial Investigation Report.

A Supplemental Investigation Report (HLA, 1998) was prepared in 1998 for the Site. In 1999 a Site Investigation Summary Report and Risk Assessment (HLA, 1999) was prepared and submitted to RIDEM that addressed the entire 333 Adelaide Avenue property, including the Site.

This report was formally approved by RIDEM in a June 15, 2001 RIDEM Remedial Decision Letter. In April 2001, Harding ESE (now MACTEC), prepared and submitted to RIDEM on Textron's behalf the *Remedial Action Work Plan, Former Gorham Manufacturing Facility, Providence, Rhode Island*.

In November 2002 MACTEC submitted a Method 3 Risk Assessment Work Plan (MACTEC, 2002) to RIDEM to assess the proposed redevelopment of the undeveloped portion of the 333 Adelaide Avenue property as a park with walking trails. Following review comments from

RIDEM in September 2003, MACTEC submitted the *Method 3 Human Health Risk Assessment – Park Parcel* (MACTEC, 2004) to RIDEM in August 2004.

Current soil conditions at selected locations within the Site, material from the slag pile, and sediment conditions at selected locations in Mashapaug Cove were investigated in December 2005 on RIDEM's behalf and are documented in a SIR submitted by Fuss & O'Neill, Inc. to RIDEM in April 2006.

Figure 2.3 shows the locations of soil samples collected during previous investigations from the Site. Surface soil sampling was also conducted by MACTEC in 1994, 1998, 2001 and 2002, including both surface soils and surface sediment found in erosion channels along the bank that lead into the Cove (SD-001 through SD-008). The 1998 surface soil analytical results for VOCs, semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH) and metals are presented in the *Supplemental Site Investigation Report, Proposed Park Subdivision, Former Gorham Manufacturing Facility, 333 Adelaide Avenue, Providence, Rhode Island* (HLA, 1998).

Additional surface soil sampling was conducted along the bank of the Cove in 2001 and 2002 by MACTEC. This soil sampling program is summarized and results are presented in the *Method 3 Human Health Risk Assessment – Park Parcel* (MACTEC, 2004). Samples SS-300 through SS-306 were collected from the Cove shore area (Figure 2.3). These surface soil samples were analyzed for VOCs, polynuclear aromatic hydrocarbons (PAHs) and metals. Arsenic was consistent with background concentrations except for the isolated area on the northeastern shore of the Cove (BK-4). Lead was found in the surface soils along the shoreline of the Cove and copper was found at increased concentrations along the western boundary area along Mashapaug Cove (MACTEC, 2004).

Four surface soil samples and one sample of material from the slag pile (SS-1001) were collected by RIDEM in 2005 from the Site along the south shore of the cove. Notable findings included lead (up to 14,000 milligrams per kilogram (mg/kg)) in the sample of material from the slag pile, copper concentrations ranging from 68 mg/kg to 4400 mg/kg in soil samples, and various PAHs (up 20 mg/kg). Among the PCBs, only one Aroclor (Aroclor 1260) was detected in only one of the samples (SS-1005) at a low concentration (0.022 mg/kg). Few pesticides were detected, and those were detected at low concentrations. Dioxins and furans were reported at concentrations generally

below one microgram per kilogram (µg/kg). Concentrations of 2,3,7,8-TCDD were 1.1 pg/g or less in four of the samples. The concentration was 21 pg/g in sample SS-1003. Hexachlorinated, heptachlorinated, and octachlorinated dioxins and furans were the most prevalent homolog groups detected in the soil samples. The sample of material from the slag pile was reported to have fewer dioxin and furan compounds and lower concentrations than the soil samples.

The previous environmental investigations have demonstrated that soil at the 333 Adelaide Avenue Property, particularly the former manufacturing facility parcel, has been impacted by historical industrial operations. Constituents of potential concern (COPC) in soils at the Site include VOCs (principally the chlorinated hydrocarbons trichloroethene, tetrachloroethene, and 1,1,1-TCA and their degradation products 1,2-dichloroethene (1,2-DCE) and vinyl chloride), SVOCs (principally PAHs), metals (arsenic, copper and lead primarily), and TPH. The south bank of the Cove is an area of exposed fill material. Variable concentrations of VOCs, PAHs, metals and TPH were reported to be associated with these fill materials.

The available information indicates that limited manufacturing activities (other than withdrawal of groundwater for use in manufacturing operations and the operation of Building V) were conducted within the Site. A portion of Building V, the former smelting building, is within the Site and the former slag pile is associated with that building. The data suggest that impacted fill from the former manufacturing facility parcel impinges upon the southerly portion of the Site. That fill material contains metals and PAHs

Constituents detected in sediments and surface soils adjacent to the Cove include TPH, SVOCs, VOCs, and metals. The 2005 RIDEM sediment samples identified various chlorinated VOCs in cove sediments. Sediment samples from drainage swales and erosion channels that serve as a pathway for the discharge into Mashapaug Cove showed sporadic detections of SVOCs, TPH, and some metals. Surface soil samples from low lying areas adjacent to the Cove also showed some detections of metals.

Based on discussions with RIDEM and comments received on earlier reports and Work Plans, MACTEC prepared a Supplemental SI Work Plan in June 2006 to address data needs required in the Consent Order. This Work Plan is presented in Appendix A. The Scope of Work completed to date under that Work Plan is described in the following section.

3. SUPPLEMENTAL SITE INVESTIGATION ACTIVITIES

This section describes the investigation activities that were completed in June 2006 as part of the Supplemental SI.

3.1 SOIL SAMPLING

Surface soil samples were collected by MACTEC on June 5, 2006 through June 9, 2006. A total of 31 soil samples were collected and submitted for various analyses to ESS Laboratory in Cranston, RI. Sampling locations, rationale, collection methods, and the analytical program are described in the Supplemental SI Work Plan (MACTEC 2006a). Soil sample field data records for each sample describe the sampling technique, soil conditions, and analyses requested. These are provided in Appendix C. MACTEC used a Global Positioning System (GPS) system to document each sample location. GPS was also employed to establish the accurate location of the fence on the northeastern portion of the Site and to establish the dimensions of the debris pile. These features and the actual location of the June 2006 soil samples are shown on Figure 3.1. Table 3.1 identifies the list of Supplemental SI soil samples that were collected as well as the analytical parameters for each of those samples. Soil samples were delivered to ESS Laboratories in Cranston, Rhode Island under Chain of Custody. The Chains of Custody are presented in Appendix C.

The general approach used in this SI involved the collection of surface soil samples within the Park Parcel at a depth of 0 to 12-inches bgs. The parameters analyzed for at each location were combined with historical data to provide the full suite of analyses (VOCs, SVOCs, TPH, metals, PCBs and pesticides) at each location. Changes to the scope of work described in the Work Plan were as follows:

Surface soil sample SS-SI009 was not collected. This sample was one of five samples planned to characterize soils from drainage pathways below possible historic pipe outfalls located to the south of Mashapaug Cove. MACTEC identified historic pipe outfalls and related drainage pathways at SS-SI007, SS-SI008, and SS-SI010 and collected a fourth sample from a drainage pathway where no historic pipe was present (SS-SI011). MACTEC did not collect the fifth sample (SS-SI009) since no pipe or drainage pathway was observed at its planned location.

Surface soil sample SS-SI025 was not collected. This sample was one of four samples that were planned to characterize soils beneath a large debris pile located on the northeastern portion of the Site. The City of Providence provided access to the three other locations (SS-SI022, SS-SI-023, and SS-SI024) by using heavy equipment to create avenues into the debris pile area from the north, east, and south sides. The west side was inaccessible since the debris pile is lodged against a fence and the adjoining property is a wooded slope that extends westward towards Mashapaug Pond. MACTEC believes that the three other samples provide sufficient data to assess soil conditions in this general area.

The sampling grid across the former parking area at the north easternmost portion of the Site was modified to reflect the actual dimensions of the area. The grid shown in the Work Plan extended too far to the east onto property currently used by the railroad. MACTEC established a grid consisting of nine 70 by 70 foot squares across the area defined by the fence and collected a soil sample from each grid square (SS-SI012 through SS-SI020). Samples were collected from the approximate center of each grid square with the exception of SS-SI012 which was biased to a localized depression.

Sample SS-SI021 is an addition to the planned scope of work. MACTEC identified two historic discharge pipes and drainage pathways leading from the northeastern area of the Site instead of the single pipe that was scoped. Therefore samples were collected below each of the pipes. These samples are SS-SI002 and SS-SI021.

As mentioned previously, excavation and removal of the slag pile was completed on July 17, 2006. Confirmatory samples were collected from the bottom and sidewalls of the excavation to document conditions remaining at the completion of excavation. Four such confirmatory samples were described in the Work Plan. However, RIDEM required a greater number of samples to be collected every 15-feet along the sidewalls and bottom of the excavation. Textron will provide the results to RIDEM and other parties as required by the Consent Order under separate cover when the analytical data are available.

In general, conditions encountered were as anticipated. Soil samples collected along the western portion of the Site (along the slope above Mashapaug Pond) appeared to be from undisturbed native sandy soil. Samples collected from the southern shore of Mashapaug Cove included

samples from drainage pathways below industrial fill and from lowland soils bordering the pond that could have received runoff from historic operations. Samples from the northeastern portion of the Site were generally from two environments. Those samples located from the slope above the pond or from the drainage pathways below outfall pipes appeared to be native sandy soils. Samples collected from the upland area of the debris pile and from the adjacent sampling grid generally appeared to be fill soils which contained varying amounts of construction debris. Hand excavations indicated that a thin layer of fill (generally one to two feet) likely overlies the original native sandy soil in this area of the Site.

The collection of soil samples and associated laboratory analyses was implemented to fill data gaps with respect to nature and extent of contamination and to evaluate the potential for exposures to soil. A full suite of chemical analysis was applied to soil samples collected from new locations as shown in Table 3.1. Selected chemical analyses were applied to soil samples that were collected from previously sampled locations to augment a limited suite of analyses associated with previous samples. The intention was to compile a data set of soil samples with a full suite of analytical parameters for use in delineating nature and extent, evaluating fate and transport, and evaluating risks and remedial objectives. Table 3.2 presents a summary of the combined historical and Supplemental SI soil samples and analytical parameters. This table shows the sample depths and the set of analytical parameters (with analytical methods identified) at each of the sample locations (combined historical and Supplemental SI samples).

3.2 MASHAPAUG POND INVESTIGATION AND SURFACE WATER AND SEDIMENT SAMPLING

Aqua Survey, Inc (ASI) of Flemington, New Jersey, under subcontract to MACTEC, conducted a geophysical and bathymetric survey, collected surface water samples, and collected sediment cores from Mashapaug Cove and Mashapaug Pond between June 21, 2006 and June 25 2006. On June 21 and June 22, ASI completed a magnetometer survey, a side-scan sonar survey, and a sub-bottom profile survey. The objective of these surveys was to identify any metals debris that might represent waste drums and to profile bottom conditions to develop a better understanding of bottom topography and conditions. ASI's geophysical findings are included in Appendix D. The survey did not identify any obvious targets that would indicate the presence of drums or other waste. Following the geophysical survey, ASI collected sediment cores and pond surface water samples from the locations specified in the Work Plan and shown in Figure 3.2.

3.2.1 Geophysical and Hydrographic Surveys

Geophysical and hydrographic surveying was completed in Mashapaug Cove for the purposes to (1) determine the presence or absence of metallic debris in the cove, (2) define the surface or bathymetry of the bottom of the cove, and (3) determine sub-bottom conditions such as stratigraphy and depth to bedrock below the cove to the extent practical. ASI completed these surveys between June 21 and 22, 2006.

The following subsections discuss the results of the geophysical and hydrographic surveys. Appendix D contains ASI's report and contains details pertaining to the equipment used and survey methodology.

3.3 BATHYMETRIC SURVEY

Figure 3.3 shows the results of the bathymetric survey completed in Mashapaug Cove as color contours. Depths are shown in feet below the lake surface. The lake level during the survey was constant at an elevation of 34.9 feet NAVD88. The cove bottom is characterized by shallow water that ranges from 1.8 to 3.5 feet in depth over the area surveyed. The deepest portions of the cove extend from the mouth of the cove to the southeast and southern portions of the cove forming a curvilinear channel. Depths within this channel exceed 3 feet.

Another secondary channel appears to exist in the northwestern portion of the cove. This northwest to southeast trending channel appears to parallel the point bounding the north and northwestern portion of the cove.

In addition to obtaining bathymetry data, sub-bottom profiling was also completed along 10-foot survey lines across the entire Cove to identify potential buried metal drums and debris, depth to bedrock and sediment thickness subsurface stratification. This sub-bottom profiling was not able to identify buried metal or generate geologic cross sections of the sediments or bedrock due to the presence of gases trapped in the cove sediments near the water-sediment interface. These gases are associated with the decomposition of the organic debris in the sediment and limit the passage of sound waves deeper into the subsurface (gases cause high acoustic impedance) such that the penetration of the sonar was limited to less than 2 feet below the sediment surface.

3.4 MAGNETIC SURVEY

A magnetometer survey was conducted to screen for the presence of submerged ferrous debris that could pose as a potential source of contamination (e.g., potential waste drum). Survey lines were extended across the Inner Cove in 20 foot intervals. Figure 3.4 presents the results of the magnetic survey with total magnetic field values shown as color contours. Areas of higher magnetic intensity are shown in yellow and red indicating the presence of ferrous metallic debris or objects.

Figure 3.4 also identifies 16 distinct magnetic anomalies, three of these were also confirmed by the side scan sonar. When ASI reviewed the magnetometer survey results they applied a screening value equivalent to a 55-gallon metal drum to determine if any anomaly might represent a possible drum present in the sediment or buried beneath the sediment. ASI's data did not identify any metal drums present in the cove. Instead they identified buried pipes and small metallic objects within the sediment. Several of these pipes were visually observed by ASI and were known intake pipes of cove water for process operations. These intake pipes were located along the western and southern shores of the Inner Cove. Mag-6 shown on Figure 3.4 was the largest anomaly identified by the magnetometer survey; however, ASI was not able to locate or identify this object through the probing of the area. It was determined that the anomaly was made up of several small objects scattered along the shore. Surface water and sediment samples were collected from this general area as identified by SW/SED-19 and SW/SED-26. Figure 3.4 includes a summary description of the 16 distinct anomalies identified by ASI based on the metallic signature and visual observations of the objects. For example, Mag-10 on Figure 3-4 is located in the vicinity of the former slag pile and the location of two former water intake pipes identified during the slag pile removal. Mag-10 likely represents those former water intake pipes. The water intake pipes and small objects present in the cove sediment do not warrant further investigation.

3.4.1 Side Scan Sonar Survey

A side scan sonar survey was completed along the same 20-foot intervals as the magnetometer survey to supplement the results of the magnetic survey. Figure 3.5 shows a photo-mosaic image of the side scan sonar results. Four sonar targets were found during the survey. The shorelines, especially the western shoreline, have a significant number of submerged fallen trees and limbs. Three of the four sonar targets appear to be pieces of pipe and are associated with the magnetic anomalies. The fourth sonar target appears to be a cluster of small targets (SED-26) as discussed above.

3.4.2 Collection of Sediment Cores

On June 21, 2006 ASI collected sediment cores from locations SED28 through SED32 and delivered them to shore for processing and sampling by MACTEC personnel. ASI collected sediment cores from locations SED10 through SED 27 and delivered them to shore for processing and sampling by MACTEC on June 22, 2006.

Sediment cores were obtained from the 23 locations specified in the Work Plan (SED10 through SED32) using a Vibracoring system. The Vibracore equipment was mounted on a vessel that was also equipped with GPS technology. Figure 3.6 is a photograph of the sediment coring equipment and ASI personnel during sediment coring activity at Mashapaug Cove on June 21, 2006. At each location, ASI advanced a 4-inch diameter tube fitted with a polyethylene core liner. The tube was advanced until resistance prevented further progress. The depth of penetrations varied depending on the nature of the substrate. Depths achieved ranged from 6.8 to 9 feet below the sediment surface. The tube was retrieved and the liner removed and sealed. Each retrieved core was ferried to shore where MACTEC field personnel processed the cores and collected samples for laboratory analysis. The processing of these sediment cores and sample collections is described in greater detail below.

3.4.3 Collection of Surface Water Samples

ASI navigated to each location using GPS and collected surface water samples from locations SW10, SW11, SW12, and locations SW16 through SW27 on June 21, 2006. Samples were delivered to ESS Laboratory under chain of custody on June 21, 2006. Surface water samples collected from locations SW25 and SW27 on June 22, 2006 were delivered under chain of custody to ESS Laboratory for laboratory analysis on June 22, 2006. Table 3.4 lists all of the surface water samples collected as well as the analytical parameters for each sample. Figure 3.7 shows the measured water depth at each sampling location. Note that early June 2006 included heavy rainfall and MACTEC estimates that the pond water level was higher than would be considered an average condition.

Surface water samples were collected using a peristaltic pump to collect samples directly from the cove. PVC tubing was attached to a rod with the intake located one foot above the bottom of the rod. The rod was lowered within the water column to the sediment interface so that the tubing

intake was approximately one foot above the surface water/sediment interface. All surface water samples were analyzed for VOCs, PAHs and the 13 PPM, both total and dissolved. Dissolved metals were collected after inserting a 0.45 micron filter into the discharge line from the pump. Three locations were also analyzed for dioxins plus furans, pesticides and PCBs. These analyses were added after discussions with RIDEM and were collected from two locations within the cove (SED-19 and SW-27) and from one location that represents general conditions outside the cove and within the pond (SW-11).

3.4.4 Characterization of Sediment Cores

Sediment cores were opened, screened for vapors with a photoionization detector (PID) and recorded, visually observed and logged, photo-documented and finally sediment samples were collected consistent with the Work Plan. All observations and sample collection information was entered onto Sediment Core Logs. The various strata in each core were identified and described with respect to depths and thickness, color, texture, and estimated silt, sand, and clay content. The presence of decaying organic matter (plants stems, branches, leaves) and/or peat-like material was documented when observed. Any material that was not considered typical sediment material (such as clinkers or pieces of slag) was also identified and documented. The Sediment Core Logs are presented in Appendix C.

3.4.5 Collection of Sediment Samples

To assess potential human health and ecological receptor exposures and risks, samples from each sediment core location were submitted from the upper foot of the core. To develop an understanding of contaminant distribution, deeper samples were also analyzed from each core. The majority of these were obtained from a depth of approximately 3 feet below the top of the core. If visually atypical sediments were observed at a particular interval, that interval was also sampled.

Table 3.5 identifies the sediment samples that were collected and also identifies the analytical parameters associated with each sample. The first two numerical digits of the sediment sample identifier is the sample location identifier and the last two digits identify the bottom depth of the sample. Sediment samples with sample IDs ending in “01” are surficial sediment samples collected within the top foot of the core. Samples were typically collected in the top six inches of the core, but leaf litter and very high moisture content sometimes made it necessary to collect samples beyond the 6-inch interval. Deeper sediment samples had their depth designated by the last digit of

the sample identifier. The last digit of the sample identifier represents the bottom depth of the sample in feet. For example, SED1001 was collected at location SED10 and the bottom depth of the sample is 1 foot. Sample SED1103 was collected at location SED11 and the bottom depth of the sample is 3 feet. The Sediment Core Logs provide additional detail on the top depths of the samples. Surficial sediment samples were analyzed for PAHs, thirteen PPMs, TPH, dioxins/furans, PCBs, pesticides, and total organic carbon (TOC). The deeper samples were analyzed for the principal Site-related COPCs (VOCs, PPMs, and PAHs). All sediment samples were delivered to ESS Laboratory on June 21 and 22, 2006.

Five sediment samples were collected on June 29, 2006 by MACTEC for additional analysis for acid volatile sulfides and simultaneously extracted metals (AVS/SEM) to evaluate bioavailability of divalent metals in sediment. These were collected near shore at the approximate locations opposite locations: SED15; SED20; SED22; SED24; and SED26. These samples were delivered under chain of custody to ESS Laboratory on June 29, 2006. Chains of Custody are presented in Appendix C. These AVS/SEM sediment sample locations address possible historic pipe discharge points along the south shore of the cove.

3.5 QUALITY ASSURANCE/QUALITY CONTROL

Sample collection included field duplicate samples of soil, surface water and sediment. One matrix spike/matrix spike duplicate (MS/MSD) pair was analyzed for both soil and sediment data sets. Samples were submitted to ESS Laboratory, Cranston, RI. Samples were delivered to the laboratory at the end of each sampling day. ESS subcontracted analysis of the dioxin samples and repackaged and forwarded those containers directly upon delivery.

Once the data was received, MACTEC reviewed the data packages for completeness and compliance with the data quality objectives. MACTEC did not identify any quality assurance/quality control (QA/QC) issues that would reduce the usability of the data.

4. SUPPLEMENTAL SITE INVESTIGATION FINDINGS

This section presents the investigation findings and analytical results from the 2006 Supplemental SI. Chemical analysis was performed primarily by ESS Laboratory while the dioxin and furans analysis and the sediment AVS/SEM analyses were subcontracted to other laboratories by ESS Laboratory. Results and findings for the Site soil samples and for Mashapaug Cove surface water and sediment samples presented in Appendix E are discussed below. Additional discussion of groundwater conditions and potential interactions between groundwater and surface water and sediment of Mashapaug Cove are included.

4.1 SOIL ANALYTICAL RESULTS

Figure 4.1 presents the locations of historical and recent soil samples for the Site. Table 4.1 presents the results for all soil samples collected during the 2006 Supplemental SI as well as historic results from samples located on the Site. Results are discussed by chemical class in the following subsections. Table 4.2 presents a comparison of the historical and recent Site soil data to Method 1 Direct Exposure Criteria (Industrial/Commercial and Residential) and the GB Leachability Criteria. Table 4.2 utilizes the compliance criteria specified in the Remediation Regulations Subsection 8.10.

4.1.1 VOCs

VOCs were analyzed in a total of 10 surface soil samples from the 2006 Supplemental SI. VOC results are also available for seven historic samples from locations within the Site. The 17 locations of historic and Supplemental SI samples which included VOC analysis are shown on Figure 4.2. No VOCs were reported in any of the 2006 Supplemental SI samples or in historic samples at concentrations above RIDEM Remediation Regulations for Method 1 Industrial/Commercial Criteria. Compounds that were previously identified in groundwater at the Site such as chlorinated hydrocarbons (i.e., PCE, TCE, 1,1,1-TCA, and 1,1-DCA) were reported sporadically in a few samples. All chlorinated hydrocarbon soil concentrations from the 2006 Supplemental SI are below Industrial/Commercial Criteria and the lower Direct Exposure Criteria for Residential use (Residential Criteria). Xylenes were reported with the highest frequency, however concentrations are well below any applicable criteria.

4.1.2 SVOCs

SVOCs, specifically PAHs, were analyzed in all 31 surface soil samples collected during the 2006 Supplemental RI. Results are also available for 46 historic samples that are located on the Site. Twenty separate PAHs were reported in one or more samples from the combined data set of 77 samples. Five of these (benzo[a] anthracene (BaA), benzo[a]pyrene (BaP), benzo[b]fluoranthene (BaF), dibenzo[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were reported in one or more samples at a concentration above the Industrial/Commercial Criteria. However, as shown in caps Table 4.2, only B(a)P, B(a)A, and B(b)F have a data set that is not in compliance with the Method 1 criteria based on Section 8.10 of the Remediation Regulations. In other words, only those compounds have concentrations that do not meet the multiple compliance criteria for soil criteria. BaP was reported above the criterion of 0.8 mg/kg in 30 samples while the other four compounds were reported above their respective Industrial/Commercial Criteria in only one to three samples. Figure 4.3, Figure 4.4 and Figure 4.5 plot the historical and recent results for BaP, BaA, and BbF, respectively. The figures illustrate that the majority of samples exceeding the Industrial/Commercial Criteria are clustered along the south side of Mashapaug Cove and in the northeastern area of the Site. Both of these areas include samples from disturbed soils and areas of industrial fill. In particular, the samples from the northeastern area of the Site (e.g., SS-SI0015, -016, -017, -020, -022, -024, etc.) were collected from a thin (0.6 to 2 foot thick) layer of fill that is judged to include debris from the demolition of the original manufacturing facility. Samples with exceedances from locations along the south side of the Mashapaug Cove include locations with visible industrial fill and samples from drainage pathways that lead from the Site into Mashapaug Cove.

There is one apparent outlier with BaP above the Industrial/Commercial Criteria. Sample SS-210, located at the southwestern corner of the Site had BaP at a reported concentration of 0.9 mg/kg which is slightly above the Industrial/Commercial Criteria of 0.8 mg/kg. This location is in woodland on gently sloping land approximately 60 feet from the edge of Mashapaug Pond. There are no visual indications of impact or fill soils at this location.

4.1.3 Inorganics and Metals

Inorganics, specifically PPMs, were analyzed in 22 surface soil samples from the 2006 Supplemental SI. Various inorganic results are also available for 57 historic soil samples from the Site. Within the overall data set of 79 soil samples, four inorganic parameters were reported in one

or more samples at a concentration above the appropriate Industrial/Commercial Criteria. These were:

- Arsenic (17 of 79 results);
- Lead (13 of 78 results);
- Beryllium (1 of 65 results); and
- Copper (2 of 79 results)

Of these, only lead (4 of 22 locations) and arsenic (2 of 22 locations) were reported above the Industrial/Commercial Criteria in samples from the 2006 Supplemental SI. Figure 4.6, Figure 4.7 and Figure 4.8 plot the historical and recent results for Arsenic, Lead, and Copper, respectively.

Based on the compliance criteria in Section 12.0 and 8.10 of the Remediation Regulations, only arsenic, lead, and copper have concentrations that are not in compliance with the Method 1 criteria. The distribution of arsenic at levels above the Industrial/Commercial Criterion of 7 mg/kg is clustered in the eastern portion of the Site. Of note, only two 2006 samples (SS-SI008 and SS-SI023) exhibit arsenic above the criterion.

Lead concentrations at levels above the Industrial/Commercial Criterion of 500 mg/kg are clustered in the section of the Site that borders the southern shoreline of Mashapaug Cove. This area includes the slag pile, other industrial fill and debris, and lowland soils that lie between the fill banks and the cove.

The isolated occurrences of beryllium and copper at levels above the Industrial/Commercial Criteria are co-located with elevated lead in samples along the southern shore of Mashapaug Cove.

4.1.4 PCBs

PCBs (as Aroclors) were analyzed in 31 surface soil samples collected during the 2006 Supplemental SI. Results are also available from 10 historic soil samples collected within the boundaries of the Site for a total of 41 sample locations on the Site. As shown in Table 4.2, no Total PCBs concentration (sum of all reported detected Aroclors) were reported above either the Industrial/Commercial Criteria or the Residential Criteria in any of the 2006 samples or in the historic samples. Aroclors (Aroclor 1242 and/or Aroclor 1254 and/or Aroclor 1260) were detected at low concentrations in eight samples located to the south of Mashapaug Cove and in two samples

from the northeastern portion of the Site. Figure 4.9 shows the locations where PCBs were analyzed and detected.

4.1.5 Pesticides

Pesticides were analyzed in all 31 soil samples collected during the 2006 Supplemental SI. Pesticides were not analyzed historically in previous Site samples. Low concentrations of various pesticides were detected in 22 of the 31 samples. As shown in Table 4.2, no pesticide was reported at a concentration above the compound-specific Industrial/Commercial Criteria in any sample. Pesticides detected with the greatest frequency were 4, 4'-DDT (22 of 31 samples with a maximum reported concentration of 0.95 mg/kg versus the criterion of 17 mg/kg) and 4,4'-DDE (16 of 31 samples with a maximum of 0.12 mg/kg versus the criterion of 17 mg/kg). The low levels of pesticides reported appear to indicate that a potential Site-related release of pesticides has likely not occurred. Therefore, a figure showing pesticide distribution is not presented.

4.1.6 Dioxin

In this report the term dioxin is used to refer to both dioxin congeners (dioxins or polychlorinated dibenzo dioxins (PCDDs)) and furan congeners (furans or polychlorinated dibenzo furans (CDFs)), a group of related compounds with similar risk characteristics. The congener-specific dioxin and furan concentration data have been consolidated into a simple measure for each of the samples that have been analyzed. That single measure is referred to as the Toxic Equivalence (or TEQ) of the sample. The TEQs are media-specific concentrations that are normalized to the toxicity of the 2,3,7,8-TCDD congener, generally considered to be the most toxic of the dioxin, furan, and dioxin-like compounds. The TEQs are calculated by multiplying the medium-specific concentration of each congener or congener group by a Toxicity Equivalence Factor (TEF) and summing those products. The TEF is a measure of the toxicity of a particular congener or congener group relative to toxicity of 2,3,7,8-TCDD. The human health risk assessment process typically utilizes the mammalian TEFs published by the World Health Organization listed in Table 4.3. In simple terms, the dioxins/furans TEQ indicates the concentration of 2,3,7,8-TCDD that would have the same toxicity as the mixture of dioxins and furans being evaluated. Congeners that do not contain chlorine at the 2,3,7, and 8 positions are not assigned a TEF, since they do not have the same chemistry as the 2,3,7,8-TCDD congener.

A total of 33 soil samples from the 2006 Supplemental SI and the 2005 RIDEM investigation were analyzed for dioxin. The results and calculated TEQ for each sample are presented in Table 4.4.

Figure 4.10 presents concentrations of TEQ calculated for exposure to humans (all mammals). The figure includes the 31 samples collected during the 2006 Supplemental SI and results for two earlier samples (SS-1002 and SS-1003) collected in the 2005 RIDEM investigation. Five of the 33 locations have TEQ-Mammal values above 0.000038 mg/kg (38 parts per trillion (ppt)). MACTEC has calculated using the procedures and assumptions identified in the Remediation Regulations, a Method 2 Direct Contact Exposure Criteria for soil for Industrial/Commercial land use. The calculated Industrial/Commercial criterion is 38 ppt. The derivation of the Method 2 standard for dioxin TEQ as well as several other analytical parameters is presented in Appendix F. Four of the five soil samples with TEQ concentrations above the Industrial/Commercial criterion are grouped along the south shore of the cove at locations below debris fill or in drainage pathways that lead from debris-impacted soil into the cove. The remaining sample (SS-SI0024) was collected from beneath a pile of demolition debris.

The dioxins and furans detected in Site soil samples are predominantly congeners other than the 2,3,7,8-TCDD congener. The dioxins and furans detected in "impacted" soil samples are predominantly furans (tetra-, penta-, hexa-, hepta-, and octa –chlorinated compounds) and to a lesser extent dioxins (penta-, hexa-, hepta-, and octa-chlorinated compounds). Figure 4.11 shows the distribution of dioxin and furan homolog groups for soil sample SS-SI007 that was collected from the bottom of the drainage swale at the southeast corner of the Mashapaug Cove shoreline. This sample has a TEQ of 948 ppt (the highest reported at the Park Parcel) vs. the Industrial/Commercial criterion of 38 ppt. As shown in Figure 4.11, the penta-, hexa-, and hepta-chlorinated furans are the predominant homolog groups in this "impacted" soil sample. Figure 4.12 shows the homolog group distribution for soil sample SS-SI-208 which has one of the lowest TEQ concentrations (1.3 ppt) among the soil samples. The concentrations of the homolog groups are much lower than in SS-SI007 and the predominant homolog group is the octa-chlorinated dioxin rather than the tetra-, penta-, hexa-, and hepta-chlorinated furans that are predominant in the "impacted" sample SS-SI007. The dioxin/furan distribution or signature in soil sample SS-SI007 appears to be similar to that reported in the literature (Brzuzy and Hites, 1996) for municipal waste incineration sources (Primarily penta-, hexa-, and hepta-chlorinated furans and hepta- and octa-chlorinated dioxins). It appears that the signature seen in sample SS-SI208 may be consistent with the signature reported in the literature (Rappe, 1994) for wood burning/smoke particulates (primarily octa-chlorinated furans, hepta-chlorinated dioxins and octa-chlorinated dioxins) or

global atmospheric deposition from combustion (primarily octa-chlorinated dioxins) (Brzuzy and Hites, 1996 and Bonn, 1998).

4.2 MASHAPAUG COVE SURFACE WATER RESULTS

A total of 15 water samples were collected from Mashapaug Pond during the 2006 Supplemental SI. Results are presented in Table 4.5 and are discussed by chemical class in the following subsections. Only the 2006 Supplemental SI results are discussed as they provide a snapshot of current conditions and are judged to be a large enough data set to assess general differences between water within and outside of the cove.

4.2.1 VOCs

VOCs were reported at low concentrations in each of the 15 samples of surface water. Frequency of detection varied from cis-1,2-Dichloroethene (c1,2,-DCE) which was reported in all 15 samples to PCE, reported in one sample. VOCs detected included six chlorinated hydrocarbons that have been associated previously with groundwater at the 333 Adelaide Avenue property and are present in groundwater upgradient of Mashapaug Cove. Groundwater will be discussed in Section 4.2. The compounds detected and the frequency of detection are:

- Cis-1,2-Dichlorethene (15 of 15 samples)
- 1,1,1-TCA (11 of 15 samples)
- TCE (11 of 15 samples)
- Vinyl Chloride (10 of 15 samples)
- 1,1-Dichloroethane (5 of 15 samples)
- PCE (1 of 15 samples)

Other VOCs reported in 2006 data included toluene (12 of 15 samples) and xylenes (up to 15 of 15 samples). Figure 4.13 shows the total (summed) concentrations of VOCs in surface water samples from the 2006 Supplemental SI.

In general, the maximum concentrations of detected VOCs were found in samples collected from within the cove, particularly at locations SW-19, SW-25, and SW-27. An exception is cis-1,2-DCE, which was reported at very consistent levels of around 5 micrograms per liter (µg/L) in 12 samples collected from locations within the cove but had the highest reported concentration of any VOC in surface water at locations SW-11 (10.8 µg/L), located outside of the cove. Samples further from the cove, (SW-10 and SW-12) exhibited lower, but detectable levels of chlorinated VOCs (1.5 – 2.2 milligrams per liter (mg/l)).

4.2.2 SVOCs

PAHs were reported in only one of the 15 surface water samples. SW-19 contained very low levels (<1 µg/L) of BaP, BaA, benzo(g,h,i)perylene, chrysene, and dibenzo(a,h)anthracene. Napthalene was reported in 4 of 15 water samples at very low concentrations (<3 µg/L, just above the laboratory quantitation limit of 2 µg/L).

4.2.3 Inorganics

Up to five metals were reported above the laboratory quantitation level of 0.2 µg/L in five of the 15 surface water samples. Chromium, copper, lead, silver, and/or zinc were reported at locations SW-18, SW-19, SW-21, SW-22 and SW-23. All of these locations are within the Mashapaug Cove. No metals/inorganics were detected in field-filtered surface water samples as shown in Table 4.5

4.2.4 PCBs

PCBs were analyzed in two samples from the interior of the cove (SW-19 and SW-27) and one location outside of the cove (SW-11). No PCBs were detected in these samples. Note that these samples do exhibit impact from other Site COPCs (e.g., chlorinated VOCs discussed above).

4.2.5 Pesticides

Pesticides were analyzed in two samples from the interior of the cove (SW-19 and SW-27) and one location outside of the cove (SW-11). The pesticide 4,4'-DDT was reported in the sample from SW-11 at a trace concentration (0.08 µg/L). No other pesticides were reported in any surface water sample.

4.2.6 Dioxins

Dioxin analysis was conducted for three unfiltered surface water samples: SW11; SW19; and SW27. At least one dioxin/furan congener was detected in each of the samples. The TEQ concentrations for the three samples ranged from 1.28 x 10^{-8} mg/l (1.8 parts per quadrillion (ppq)) to 6.22 x 10^{-8} mg/l (6.22 ppq).

4.3 MASHAPAUG POND SEDIMENT INVESTIGATION RESULTS

4.3.1 Physical Characterization of Sediments in Mashapaug Cove

Sediment character within Mashapaug Cove varied from soft decaying organics (peaty material) to silt, clay, sand, and gravelly sand that were present in horizontal layers generally half a foot to several feet thick. Lithology often varied between adjacent core locations, however a few

generalizations can be made. At the six locations in the Outer Cove area (SD-10 through SD-15), the upper three feet of sediment was predominantly sand with silt and clay layers present deeper at some locations. Eleven of the 12 samples submitted from these locations came from sandy strata either at the surface (between 0 and 1 feet deep) or from the deeper sample (between 2 and 3 feet deep).

The Inner Cove appears to have a shallow flat bottom with water depths at the time of sampling varying only between 2.4 and 3.5 feet at locations greater than 20 feet from the shore. Locations in the eastern half of the cove often had soft organic (peaty) silt or silty clay (e.g., SD-19, SD-20, SD-24, SD-25, SD-27 and SD-28) while locations in the north or western portion of the cove had higher frequency of sandy strata (e.g., SD-16, SD-17, SD-21, SD-22, SD-23). The core at SED26 contained a much thicker organic silty layer than most of the samples from within the inner Cove. That core also contained clinkers and some undetermined foreign material. Other than slag, this is the only evidence of non-native material in any of the cores. The samples located along the south shore near the former slag pile (SD-29, SD-30, SD-31, and SD-32) generally contained silt and sand layers and several samples included evidence of slag in upper part of the cores. The slag was subsequently removed from the shallow portion of the cove immediately to the north of the slag pile.

Figure 4.14 is a photograph of the sediment core from location SED31 collected from the Inner Cove near the former slag pile. This core, with a very dark, organic silt layer in the top two feet underlain by sandy strata is fairly typical of the cores collected from within the Inner Cove. Figure 4.15 is a photograph of the sediment core from location SED23 collected from the southwest portion of the Inner Cove at a location that appears to be an outwash area from a stormwater drainage swale. As shown in this photograph, the core does not exhibit the typical dark, organic silty layer that was found at the top of the cores from many locations within the Inner Cove. Figure 4.16 is a photograph of the core from SED12, which is located outside the northeast portion of the Outer Cove. This core also has almost no dark, organic surficial layer that is typical of many locations in the Inner Cove. PID readings were generally background (0 to 0.3 ppm). The highest PID readings of 4.8 and 5 ppm were noted in SD-15 and SD-19, respectively. Slightly elevated readings of about 1 ppm were noted at SD-25 and SD-27.

4.3.2 Chemical Characterization of Sediments in Mashapaug Cove

A total of 48 sediment samples were analyzed from 23 locations within Mashapaug Cove during the 2006 Supplemental SI. The 2005 RIDEM and the 2006 Supplemental SI sediment data are presented in Table 4.7. Four samples collected by RIDEM in 2005 are included in the discussion of current results as MACTEC believes they also represent current conditions and there is confidence in their plotted locations and collection and analytical methods. Three sediment samples collected from Mashapaug Cove by Mr. Robert Dorr in 2005 provided valuable information for the development of the Work Plan for investigation of the Cove. The 2006 investigation collected samples to confirm the results of Mr. Dorr's samples. Other historic data are considered too aged (e.g., 1986) to reflect current conditions or is of unknown data quality.

4.3.3 VOCs

VOCs were analyzed in 47 samples from the 2006 Supplemental SI plus five samples collected by RIDEM in 2005. Results for all VOCs detected in these 52 samples are shown in Table 4.7. A total of 15 different VOCs were reported in one or more sediment samples. As discussed previously in subsection 3.2.5, samples from two or three depths were analyzed from each of the Supplemental SI locations to profile differences with depth. The 2005 RIDEM samples were only collected from the shallow interval. A total of 28 samples were analyzed for VOCs from between 0 and 2 feet below the cove bottom (most of them within one foot of the sediment surface). A total of 23 samples were analyzed for VOCs from between 2 to 4 feet below the cove bottom and one sample was analyzed from a depth of 6 to 7 feet below the sediment surface.

The principal VOCs reported in sediments are chlorinated hydrocarbons. These include compounds previously reported in groundwater (TCE, PCE, and 1,1,1-TCA) and transformation compounds (biodegradation products) such as 1,2-DCE and vinyl chloride. The highest VOC concentrations were nearly all reported from the shallowest sampling interval at each location. Figure 4.17, Figure 4.18, Figure 4.19, and Figure 4.20 plot the concentrations of cis-1,2-DCE, TCE, PCE and Vinyl Chloride in the surficial sediment samples, respectively.

The figures illustrate that, although chlorinated VOCs were not detected in the majority of samples, higher concentrations of chlorinated compounds were reported in several locations near the southern shore of the cove (e.g., SD-25 and SD-31) and in several samples near the center of the cove (i.e., SD-19, SD-25 and SD-1003) than elsewhere in the cove. With one exception, the

highest concentrations of these compounds were reported in the shallow interval when compared to deeper results. In many cases the result from the deep sample was one or two orders of magnitude less than the shallow results. For example, cis1,2,-DCE was reported at 103 mg/kg in the 0-1 foot depth interval at SD-27 and at 0.04 mg/kg in the sample from 2.5 to 3 feet in the same core. The one exception was at SD-19 where the highest concentrations of TCE were reported from both the shallow (58.4 mg/kg at 0-1 feet) and deeper (88 mg/kg 2 to 3 feet) intervals.

4.3.4 SVOCs

SVOCs were analyzed in 48 samples from the 2006 Supplemental SI and five samples collected by RIDEM in 2005. Results for all SVOCs detected in these 53 samples are shown in Table 4.7. A total of 17 different compounds were detected in the sediment data set. Most compounds were reported in shallow sediment samples while samples deeper than two feet generally did not contain detectable PAHs. Compounds detected with the greatest frequency in shallow sediment include: BaP (17 of 28 samples), BaA (18), BbF (21), flouranthene (23), chrysene (17), phenanthrene (19), and pyrene (22). Distribution of BaP, BaA, and BaF are depicted on Figure 4.21, Figure 4.22 and Figure 4.23 respectively. The pattern of impact shown on each figure indicates elevated PAHs concentrated near the southeastern shore of the cove. The maximum reported concentrations are at SD-20. Stormwater from the new shopping center discharges near this location and this result may be indicative of an influence from the large pavement areas that drain the new development. Otherwise, the overall distribution pattern is consistent with possible Site-related impacts related to fill and historic discharge along the southeastern side of the cove. Sample (SD-12) located outside the cove contained PAHs that might be associated with surface runoff or stormwater discharge from the former parking lot in the northeast corner of the Site.

TPH was analyzed in all 28 shallow sediment samples and was detected at 19 of 28 locations. Detected concentrations ranged from 57.8 mg/kg to 2600 mg/kg. Figure 4.24 shows the distribution pattern of TPH concentrations in surficial sediment samples. Three of the four highest TPH levels are currently observed at or adjacent to SD-20 on the west side of the cove. This may also reflect current impact from stormwater run-off from the large area of new pavement and related vehicular traffic on the retail development.

4.3.5 Inorganics

Inorganic analyses, specifically the 13 PPMs, were run on 48 samples from the 2006 Supplemental SI plus five samples collected by RIDEM in 2005. Results for all inorganics and metals detected in

these 53 samples are shown in Table 4.7. The ranges of various metals reported in shallow sediment are shown on Figure 4.25 through Figure 4.30. In general, the figures show that the highest levels of metals in sediment are found within the Inner Cove. There is also a prominent drop in concentrations between the surficial sediment samples (collected within the top two feet of sediment) and the deeper samples (generally collected between 2 and 4 feet deep, with a few deeper intervals). Arsenic is the exception to this conclusion, since the average sediment concentration is higher in deeper samples than in surficial samples. The average arsenic concentration in deeper sediments is the result of elevated concentrations in samples SED1903, SED2503, SED2507, SED2602, SED2803, SED2904, and SED2403. Table 4.8 illustrates the difference in concentration between the shallow samples and deeper samples for various metals:

Both the lateral and vertical concentration distribution suggests that metals concentrations in surficial sediments may have resulted from stormwater-related erosion of soils from the areas to the south of Mashapaug Cove. Concentrations of lead and copper especially in soil along the southern bank of Mashapaug Cove have previously been identified as requiring remediation. Metals impacts to sediments appear to be predominantly confined to the upper foot of the sediment column.

4.3.6 PCBs

PCBs were analyzed in all of the 23 shallow samples (between 0 and 2 feet) collected during the 2006 Supplemental SI along with the five samples collected by RIDEM in 2005. PCBs were detected in only 3 of the 28 samples. Results are shown in Table 4.7. One Aroclor was reported in samples SD-19, SD-24, and SD-30. All results were less than 0.61 mg/kg. Based on the low frequency of detection and the low concentrations reported, PCBs do not appear to be a significant concern in the Mashapaug Cove sediment.

4.3.7 Pesticides

Pesticides were analyzed in all of the 23 shallow samples (between 0 and 2 feet) collected during the 2006 Supplemental SI and the five samples collected by RIDEM in 2005. Results are shown in Table 4.7. Pesticides were detected in only three samples at very low concentrations (SD-12, SD-20, and SD-32). These samples are spatially separate and one (SD-12) is located well outside of the Inner Cove. Based on the distribution and general absence of detection, pesticides do not appear to be a significant concern in sediment.

4.3.8 Organic Carbon

The organic carbon content of the sediments within Mashapaug Cove is important to the understanding of fate and transport of other chemical species within the cove. Hydrophobic chemicals readily sorb to organic carbon in sediments. As a result, VOCs, SVOCs, dioxins and furans, and metals to some extent may bind to and accumulate in sediments that have higher TOC content. As shown in Table 4.9, organic carbon content of the surficial sediments varies widely throughout the cove. Table 4.9 lists TOC content of the surficial sediment samples from the cove in increasing order (lowest TOC to highest TOC). The sample locations with the highest TOC sediment concentrations were SED18, SED16, SED19, SED11, SED25, SED27, SED31, SED29, SED28, SED14, and SED26. The TOC content of theses samples range from 2.9% to as high as 11.5%. With the exception of SED11 and SED14, these locations are within the inner Cove. SED11 and SED 14 appear to be located in a deeper channel in the Outer Cove. The Outer Cove sample locations (with the exception of SED11 and SED14) generally have the lowest TOC sediment content, with TOC content less than 1%.

4.3.9 Dioxins and Furans

As shown in Table 4.7, dioxin and furan analysis was conducted for all 28 surficial sediment samples. Dioxins and furans were detected in all of the samples. As has been done for soil and surface water dioxin data, a TEQ has been calculated for each sediment sample as shown in Table 4.8. The range of TEQ concentrations in sediment samples from Mashapaug Cove is 9.38×10^{-7} mg/kg (0.9 ppt) to (3.62×10^{-3} mg/kg (362 ppt). The maximum TEQ concentration is reported for sample SED1901 (within the inner Cove) and the lowest TEQ concentration is reported for sediment sample SED 1001 (outside the Outer Cove). The distribution of dioxin TEQ in sediment samples is presented in Figure 4.30.

The distribution of dioxins and furans (the signature) in sediment samples is presented in Figures 4.32, 4.33, and 4.34 for samples SED1901 (Impacted Inner Cove), SED1101 (impacted Outer Cove), and SED1201 (Unimpacted Outside the Outer Cove) respectively. As shown in Figure 4.32, the distribution of dioxin and furan homolog groups in the impacted inner Cove sediment sample is quite similar to the distribution shown for the impacted soil sample (SS-SI007) as shown in Figure 4.11. The predominant homolog groups are the tetra-, penta-, and hexa-chlorinated furans. As shown in Figure 4.33, the distribution of dioxins and furans in sample SED1101 which is located in the Outer Cove is similar (but not identical) to that seen in sample SED1901. The

unimpacted sediment sample SED1201, as shown in Figure 4.34, has a very different signature and much lower concentrations. The predominant homolog groups in that unimpacted sample are the octa-chlorinated dioxin and the octa-chlorinated furan, with no other significant contributors.

4.4 GROUNDWATER

Groundwater at the 333 Adelaide Avenue property has been impacted by the VOCs, primarily perchloroethylene (PCE), trichloroethylene (TCE), and 1,1,1-TCA. These compounds and their associated degradation byproducts form two contiguous plumes, one extending to the north and one to the east from the vicinity of former Building W.

Geology and groundwater quality, elevation, flow directions, and hydraulic gradients in areas upgradient of the Site and within the Site have been evaluated during previous investigations and in previous environmental reports. The May 1995 *Remedial Investigation Report, Gorham Manufacturing Facility, 333 Adelaide Avenue, Providence, Rhode Island* (ABB-ES, 1995) presented the findings concerning groundwater quality and groundwater hydrology. Much of the following information has been taken from that 1995 report.

4.4.1 Surficial Geology and Soils

The site lies on a glacial outwash plain which consists of sorted sands and local deposits of gravel. Glacial outwash deposits were encountered in borings advanced on site during the RI field program. Geologic cross-sections were constructed using the data collected from the borings to detail the stratigraphy across the 333 Adelaide Avenue property. This information was presented in Figures 3-1, 3-2 and 3-3 of the 1995 RI Report.

The 333 Adelaide Avenue property is underlain by approximately 55 feet of brown, fine to medium sand. Within this unit, a layer with 10 percent to 40 percent coarse sand and gravel was encountered in three borings, MW-101D, MW-103 and MW-105 at thicknesses of approximately 5 feet, 3 feet and 10 feet, respectively. In the North Bank (this the area immediately south of the southern shore of Mashapaug Cove) and West Parking Areas (not within the Site), this top portion of the fine to medium sand unit consists mostly of re-worked soil fill with lesser proportions of casting sands, bricks, wood, pipes, pallets, cloth, glass, canisters and occasional crushed drums. The fill materials gradually increase in thickness from approximately 1 foot in the southern portion of the West Parking Area to

approximately 20 feet at the embankment of the Cove. Underlying the fine to medium sand unit is a grey, fine sand with silt.

A review of aerial photographs of the property taken in 1939 and 1956 show that the North Bank and West Parking Areas were constructed over an embayment that was filled over time.

4.4.2 Bedrock Geology

Bedrock underlying the 333 Adelaide Avenue property has been mapped as the Rhode Island Formation (Quinn, 1959). This formation has been described as an interbedded graywacke, conglomerate, sandstone, shale and meta-anthracite, whose beds are greatly folded and faulted. The depth to bedrock in the vicinity of the site is approximately 200 feet below sea level. During the 1995 RI, bedrock was not encountered in the deepest boring which extended to 30 feet below sea level (80 feet bgs).

4.4.3 Groundwater Resource

Groundwater beneath the site is classified GB, as it has been designated as not being suitable for public or private drinking water use. The local aquifer is designated by RIDEM as a groundwater reservoir. Groundwater beneath the Site is not used as a source of drinking water. According to information gathered during the site inspection (SI) performed for this Site (CDM, 1993), there are no public or private wells within a four mile radius of the Site. The nearest public water supply is the Scituate Reservoir located approximately nine miles to the west

4.4.4 Groundwater Hydrology

Figure 4.35 (Figure 2-5 of the RI Report) identifies the monitoring well locations at the time of the RI on the 333 Adelaide Avenue property. Groundwater beneath the 333 Adelaide Avenue property flows predominantly northward toward Mashapaug Pond and discharges to the Pond. Figure 4.36 (Figure 3-4 of the RI Report) is a groundwater contour map for January 1995 and it shows groundwater flow directions. This figure indicates that groundwater to the southwest, south, and southeast of Mashapaug Cove flows in the direction of Mashapaug Cove. In addition, monitoring results from the 1995 RI show that there is a groundwater divide approximately parallel to the eastern property boundary, in the southeastern portion of the property (near Buildings W, T and A). East of

this divide, groundwater flows east toward the railroad tracks, consistent with the regional groundwater flow pattern.

The depth to groundwater beneath the 333 Adelaide Avenue property, as measured in January 1995, ranges from approximately 3 feet along the North Bank area (GZA-6) which is within the Site to 30 feet below grade in the southeastern area of the 333 Adelaide Avenue property (MW-101S).

The horizontal hydraulic gradient across the central portion of the 333 Adelaide Avenue property was reported as is 0.0026 ft/ft (as measured between wells GZA-4 and MW-JS). Gradients along the southern shore of Mashapaug Cove are steeper. The hydraulic gradient on the Site, immediately south of Mashapaug Cove, between GZA-2, located along the embankment and GZA-5, located along the bank of the cove, was reported as 0.015 ft/ft. The vertical hydraulic gradient along the southern shore of Mashapaug Cove is upward, indicating that groundwater discharges into Mashapaug Pond.

Hydraulic conductivities obtained from slug tests conducted during the RI ranged from 3.22×10^{-3} to 3.77×10^{-2} cm/s (9.1 to 107 ft/d) in wells MW-108S, located in the central portion of the 333 Adelaide Avenue property and MW-101S, located in the southeast portion of the property, respectively. The variability in hydraulic conductivities is attributable to the heterogeneity in the outwash deposits beneath the site. The hydraulic conductivity in monitoring well MW-109D and MW-110D (both located immediately upgradient of Mashapaug Pond) was reported to be 1.12×10^{-3} cm/s and 5 x 10-^{4} cm/s. The hydraulic conductivity data were presented in Table 3-2 of the RI.

Based on these data, the interstitial velocity of groundwater flow across the site towards the pond ranges from 0.12 ft/d to 1.39 ft/d (44 to 507 ft/yr) assuming an effective porosity of 0.20. Using these estimates, groundwater could traverse the entire property within a range of approximately one to 18 years.

4.4.5 Groundwater Quality and Potential Chemical Transport

Metals detected in groundwater at the 333 Adelaide Avenue property include aluminum, arsenic, copper, iron, lead, magnesium, mercury, nickel, and zinc. These metals occur generally in low concentrations and, except for nickel and mercury, they are widely distributed over the Site. Nickel and mercury were detected only in the vicinity on the main production buildings. No total or amenable

cyanide was detected in groundwater at the site. Therefore, metals, inorganics, and cyanide migration to Mashapaug Cove via groundwater flow does not appear to be a concern.

PCE, TCE, 1,1,1-TCA and degradation products of these VOCs define a plume which appears to originate in the general vicinity of the former Building W, and extends beneath the central portion of the property. Figures 4.37 and 4.38 show the shallow plume locations with respect to PCE and TCE respectively and also show the location of former Building W. One shallow PCE and TCE plume is located immediately upgradient of Mashapaug Cove (the area between MW-108 and GZA-5 immediately south of the cove) and another small plume is located to the southwest of the cove (area around MW-111D and B3/MW-C). The impacted area around MW-111D and B3/MW-C does not appear to extend to the cove. Figures 4.39 and 4.40 show the deep plume locations with respect to PCE and TCE respectively and also show the location of former Building W. Analytical data for deep wells between the plume and Mashapaug Cove indicate the deep plume does not extend to the cove.

Textron is conducting on-going remediation of the chlorinated solvent source area in groundwater using chemical oxidation technology and a groundwater monitoring program is being implemented in conjunction with the remedial activities. The recent groundwater monitoring data show low levels of TCE consistent with historical data in monitoring wells upgradient of Mashapaug Cove.

The information described above suggests that the potential for substantial discharge of chlorinated solvent impacted groundwater to surface water would be small.

As reported in the July 1999, *Site Investigation Summary Report and Risk Assessment, Former Gorham Manufacturing Site, 333 Adelaide Avenue, Providence, Rhode* Island (HLA, 1999), a surface water investigation was conducted on April 15, 1999 to evaluate potential discharge of groundwater to surface water in Mashapaug Cove and Pond. HLA collected three surface water samples from Mashapaug Cove (SW-2, SW-3, and SW-4) and one background surface water sample from the Mashapaug Pond (SW-1) to determine current effects of groundwater discharging from the 333 Adelaide Avenue property on the water quality of the cove and pond. Sample locations are shown on Figure 2.2. All four samples were collected from the middle of the water column using a stainless steel Bomb sampler. Samples were submitted to ESS Laboratory for Method 8260 VOC analysis. Analytical results were as follows: cis-1.2-dichloroethene at 3 µg/l, 6 µg/l, 4 µg/l, and 4 µg/l in samples SW-1, SW-2, SW-3, and SW-4 respectively. TCE was reported

at 1 µg/l, 2 µg/l, 2 µg/l, and 1 µg/l in samples SW-1, SW-2, SW-3, and SW-4 respectively. No other VOCs were detected in any of those samples. The laboratory reports for those samples were presented in Appendix G of the 1999 *Site Investigation Summary Report and Risk Assessment*. As described in Section 1.4.2 of that 1999 report, the very low detected concentrations of only two VOCs were less than the previous round in 1986 and do not indicate any impacts to surface water from the discharge of the northern plume to the cove.

The June 2006 surface water sampling and analysis yielded similar results to the April 1999 surface water sampling and analysis program. The 2006 surface water samples were collected from within one foot of the sediment/surface water interface rather than in the middle of the water column as was done in 1999. The surface water VOC data are summarized in Table 4.5. Concentrations of individual compounds including TCE, PCE (detected in only one of fifteen samples), 1,1,1-TCA, cis-1,2-dichloroethene, and vinyl chloride were detected at very low concentrations (typically below 5 µg/l). These data indicate that there is little surface water impact associated with potential groundwater discharge into surface water of Mashapaug Cove.

4.4.6 Potential Groundwater/Sediment Interaction

The low VOC concentrations in groundwater upgradient of Mashapaug Cove and the very low concentrations of VOCs in surface water samples collected during the June 2006 surface water sampling and analysis program in Mashapaug Cove indicate that there is not substantial transport of VOCs to surface water via groundwater discharge. However, the June 2006 sediment sampling and analysis program in Mashapaug Cove did indicate that sediments at several sampling locations within the cove did contain a similar suite of VOCs as has been reported in groundwater. Concentrations in sediment samples of TCE, PCE, 1,1,1-TCA, cis-1,2-dichloroethene, vinyl chloride, and other degradation products were reported to be greater than 1 mg/kg, with several compounds having at least one reported concentration greater than 10 mg/kg. The maximum reported concentrations of cis-1,2-dichloroethene and TCE were 175 mg/kg and 88 mg/kg respectively. Cis-1,2-dichloroethene and TCE had the highest (among VOCs) arithmetic mean concentrations in sediments from Mashapaug Cove (5.9 mg/kg and 3.3 mg/kg respectively). Since the degradation product cis-1,2-dichloroethene is the VOC with the highest mean concentration in sediment, there is evidence that substantial biodegradation is likely occurring in the organic sediments within the cove.

These data are suggestive of a link between groundwater discharge and sediment quality in Mashapaug Cove. While hydrophobic organic compounds are known to sorb to and accumulate in organic sediments and in clayey sediments, the SVOCs, PCBs, and dioxins and furans are generally considered to have a much higher likelihood of sorption and accumulation in sediments than would VOCs. Certainly, in sandy sediments with low total organic carbon levels, VOCs would not be expected to sorb to any large degree. However, most of the sediments sampled in Mashapaug Cove had substantial TOC content (most samples greater than 2% and the highest value reported to be greater than 11.5%).

The U.S. Geological Survey Publication *Natural Attenuation of Chlorinated Volatile Organic Compounds in a Freshwater Tidal Wetland, Aberdeen Proving Ground, Maryland* (USGS, 1997) indicates that substantial TCE biodegradation occurs in organic sediments and it also reports that cis-1,2-dichloroethene sorbs to the organic sediments, with a distribution coefficient (Kd) obtained from batch tests, of approximately 2 liters/kg. This indicates the sorbed concentrations of this compound would be expected to be approximately twice the concentration in the water within the sediment layer. This is based on a short-term batch test designed to evaluate the sorption mechanism only. This report also states that calculated coefficients of retardation indicate that sorption alone would cause the movement of the VOCs in the wetland sediments to be 6 to 10 times lower than the adjective groundwater flow. This seems to suggest that over time, with continuous groundwater discharge through organic sediments, that there would be an accumulation of VOCs (that might be countered by biodegradation) within the sediments.

If it were assumed that at sediment sample location SED19 that the concentration of cis-1,2-dichloroethene in groundwater passing through the surficial sediment represents degraded TCE (same molar concentration), we could calculate the ratio of solid phase concentration (from sample SED1901) and liquid phase concentrations (like a Kd). In February 2006, the TCE concentration in monitoring well GZA-5 was 22 µg/l. This concentration is 1.679×10^{-7} mole/l. The same molar concentration of cis-1,2-dichloroethene would be 16.28 µg/l or 0.01628 mg/l. Using the sediment cis-1,2-dichloroethene concentration in SED1901 (175 mg/kg), the ratio of solid phase concentration to liquid phase concentration would be (175 mg/kg)/((0.01628 mg/l) or 10,749. Clearly, based on these assumptions, the ratio of solid phase and liquid phase concentrations at SED1901 would not be explained solely by the sorption mechanism described by the Kd value (a

Kd value equal to approximately 2 was calculated for the same compound in a batch test as described above).

If the VOC concentrations reported in sediments are associated with discharging groundwater, further study appears to be needed to fully understand the accumulation or retardation mechanisms that would explain the sediment concentrations. Other explanations for the VOC concentrations reported in sediments may also need to be investigated.

4.5 CONCEPTUAL SITE MODEL

The conceptual site model (CSM) identifies the nature and sources of releases, migration mechanisms, receiving media, potential receptors, and potential exposure pathways. The CSM information is used in scoping the risk assessment activities and in the identification of remedial objectives. The following text describes the CSM for the evaluation of the Park Parcel soils and the surface water and sediment of Mashapaug Cove. Figure 4.41 is a summary of the CSM. Many of the sources at the former facility have been addressed through remedial actions and may no longer represent a source from which hazardous materials could migrate. The 2005 RIDEM investigation of the Site as well as the Supplemental SI have identified materials (dioxins and furans in particular) in soil and sediments that had not previously been identified at the former manufacturing facility. The specific source of the dioxins and furans is not known. However, the distribution of dioxin and furan homolog groups in soil and sediment appears to be consistent with the signature associated with municipal waste incineration.

The northeastern portion of the Site is not known to have been the location of former manufacturing or waste disposal activities. The specific source of the arsenic and PAHs that have been identified in soil in portions of that area is not known. It appears that imported fill or fill from the former manufacturing facility is present beneath the pavement on the former parking area in the northeast portion of the Park Parcel. It also appears that fill materials have been brought to that area and then placed on top of the existing pavement from the former parking area. The source of that material has not been identified.

4.5.1 Sources

Investigations of the former Gorham Manufacturing Facility and the remainder of the property at 333 Adelaide Avenue have identified evidence of releases of hazardous materials associated with

the former facilities to soils and groundwater. The 1995 RI Report indicated that six categories of release, or potential release had been identified. These include: oil from removed and out-of-service USTs; VOCs in soil and groundwater from above-ground storage tanks (ASTs), production activities (particularly in the areas of Buildings W and T), or incidental disposal; fill material of the West Parking and North Bank Areas; surface soils containing PCBs near the transformer pad and Building N; releases of oil from machines to building basements; and possible contaminants conveyed from the site in stormwater runoff. Subsequent to the RI Report, an additional source has been identified. A slag pile located immediately south of Mashapaug Cove appears to have been accumulated from smelter operations that were performed in Building V of the former facility. The slag pile consisted of very dense, metals-containing, solid material that was present in chunks ranging in diameter between an inch or two to perhaps nine or ten inches. The slag pile has been excavated and removed from the property in July 2006.

In particular, the bronze casting, silverware manufacturing, and plating activities have resulted releases of metals (in particular lead and copper) to soils on Parcels A, B, and C. In addition, a slag pile located immediately south of Mashapaug Cove appears to have been accumulated from smelter operations that were performed in Building V of the former facility. Chlorinated VOCs have been detected in groundwater in the areas of former Buildings W and T. The Building W area is a probable source area for PCE in groundwater. However, the specific source or point of release of PCE in the vadose zone soil nor in the shallow groundwater has not been identified. Free floating product (fuel oil), measuring 1.5 ft thick in well MW-H and 0.1 ft in well MW-I, and petroleum contaminated soils were identified at the former location of the two former 19,000-gallon USTs. Remedial activities including excavation and treatment of petroleum residuals in the former facility area have been conducted.

4.5.2 Migration Pathways and Receiving Media

Investigations to date indicate that metals and PAHs and other persistent materials in surficial soils and fill material have the potential to migrate with soil material via overland flow during and immediately after precipitation events. It appears that historically, and recently, soils from the former facility area and along the filled area immediately to the south of Mashapaug Cove have been subjected to this mechanism and a number of drainage swales have been identified between the higher elevation former facility area and the shoreline of Mashapaug Cove. Potentially, release of metals from the former slag pile might have occurred via infiltration of precipitation and subsequent leaching of metals. The

leachate may have infiltrated into groundwater and subsequently flowed to surface water or it may have flowed directly into the cove from the slag pile.

Persistent and bioaccumulating substances that are present in sediments have the potential to accumulate in biota and be biomagnified via food chain (both human and ecological) mechanisms. There are few persistent and bioaccumulating substances detected in sediments that may need to be evaluated for this type of migration/exposure pathway. USEPA identified a list of priority persistent and bioaccumulating substances. The list includes aldrin/dieldrin; benzo(a)pyrene; chlordane; DDT, DDD, DDE; hexachlorobenzene; alkyl-lead; mercury; mirex; octachlorostyrene; PCBs; dioxins and furans; and toxaphene. From that list of compounds, only benzo(a)pyrene and dioxins and furans have been reported in sediments frequently and at concentrations that are indicative of a release. Potential bioaccumulation of these substances into biota from the pond and into humans or non-human predators is a possibility.

There is an identified plume of chlorinated VOCs in groundwater which flows in a northerly direction from the higher elevation former facility area in the direction of Mashapaug Cove. The groundwater appears to discharge into Mashapaug Cove, passing through the sediments of the cove in the process. Available data indicate that minimal transfer of chlorinated VOCs from groundwater to surface water is occurring. The available sediment quality data suggest that the highly organic sediments of the cove may be acting as a sink for VOCs in groundwater that passes through the sediment. This has not been confirmed, and direct historical discharge of VOC-containing materials to the cove has also not been ruled out as a possible explanation of sediment quality.

There are currently no occupied buildings within the Park Parcel and therefore there is no current or potential migration pathway involving vapor migration from groundwater to indoor air. There have not been highly leachable materials identified in soils within the Site that might migrate to groundwater via leaching or infiltration.

4.6 POTENTIALLY COMPLETE EXPOSURE PATHWAYS

A complete exposure pathway requires four elements: 1) a source or mechanism of chemical release; 2) a transport or retention medium; 3) a point of potential human contact with the contaminated medium; and 4) a route of exposure at the point of contact (USEPA, 1989). Potential exposure pathways were determined by first identifying all sources of contamination and the

receiving media. Once sources were identified, relevant fate and transport mechanisms were evaluated to identify potential exposure media. Exposure points and exposure routes were then identified by determining the areas where receptors may potentially come in contact with contaminated media (i.e., the exposure points), and the likely mechanisms of exposure (i.e., exposure routes). Exposure pathways that have these four elements (i.e., a source or mechanism of release, a transport or retention medium, an exposure point where contact can occur, and an exposure route at the point of contact) are considered potentially complete pathways (USEPA, 1989).

The CSM indicates that inorganics and metals, SVOCs, and dioxins and furans are present in soils of the Park Parcel. Under the industrial/commercial land use (identified final use of the Site), an employee could potentially be exposed to surface soil. Utility or construction work could also occur under the industrial/commercial land use, thereby potentially exposing utility or construction workers to soil. Potential exposure pathways to the constituents detected in soil could include incidental soil ingestion, dermal contact, and inhalation of soil-derived dust and vapors.

Trespassers could potentially be exposed to soils at the site. Trespassers at the Site could include adults, adolescents and children, although children under the age of 8 are unlikely to be trespassing on this property. Potential exposure pathways to the constituents detected in soil could include incidental soil ingestion, dermal contact, and inhalation of soil-derived dust.

The groundwater at and downgradient of the Site is not used as a source of potable water, and there are no private water supply wells within ½ mile of the site. Potable water is supplied by the City of Providence municipal supply system. Therefore, there are no complete exposure pathways associated with potable or non-potable use of groundwater (either residential or industrial/commercial).

It appears groundwater discharges to Mashapaug Cove. VOCs, particularly chlorinated solvent compounds, are present at very low concentrations in surface water but appear to be present in sediment at several locations within Mashapaug Cove. The cove sediments also contain inorganics and metals, PAHs, and dioxins and furans. Industrial workers might be exposed to constituents in surface water and sediment (covered by two feet of water or less) during infrequent wading activities within the cove. Trespassers might be exposed to constituents in surface water and

sediments that are covered by surface water two feet or less in depth during wading and/or swimming activities. Environmental receptors (aquatic life, wildlife, birds) might be exposed to constituents in surface water and sediment.

Biota in the cove may have accumulated benzo(a)pyrene and dioxins and furans tissues. Humans who might catch and consume biota (such as fish or turtles) could potentially be exposed to these constituents. It should be noted there is a RIDEM/RIDOH advisory in place that advises people not to consume fish from Mashapaug Pond because of PCBs and dioxins reported in fish tissue. Biota in the cove might be exposed directly by accumulating the constituents in tissues, or predators (such as fish, predatory fish and birds, and semi-aquatic wildlife) may be exposure via consumption of prey.

In summary, the following potentially complete exposure pathways have been identified for the Site:

1) Industrial/commercial employee:
    a. potential direct contact with soil/incidental ingestion, dermal contact, and inhalation of dust

2) Construction and utility workers:
    a. potential direct contact with soil/incidental ingestion, dermal contact, and inhalation of dust and vapor inhalation

3) Adolescent and adult trespasser:
    a. potential direct contact with soil/incidental ingestion, dermal contact, and inhalation of dust
    b. potential incidental ingestion and dermal contact with surface water and sediment in Mashapaug Cove during wading/swimming activities
    c. potential consumption of fish or other biota obtained from Mashapaug Cove

4) Benthic invertebrates:
    a. potential direct contact with surface water and sediment

5) Aquatic organisms (aquatic invertebrates, fish, aquatic birds and mammals):
    a. potential direct contact with surface water and sediment
    b. potential consumption of prey items

5. SUMMARY OF RISK ASSESSMENT

The Human Health and Ecological Risk Assessment s are presented in Appendix G and Appendix H respectively. The following text summarizes the two risk assessments and provides information useful for the evaluation of the need for remediation.

5.1 HUMAN HEALTH RISK SUMMARY

5.1.1 Soil

A Method 1 Soil Objective approach was used to assess the risk for commercial/industrial use of the Site per Rule 8.02B of the Remediation Regulations (RIDEM, 2004) and the Amended Notice of Responsibility (NOR). Soil data were compared to the Industrial/Commercial Method 1 Direct Exposure Criteria and the Method 1 Leachability Criteria presented in Table 1 and Table 2 respectively of the Remediation Regulations. For compounds without Method 1 Direct Exposure Criteria a soil Method 2 Direct Exposure Criteria was calculated by MACTEC in accordance with Rule 8.02 C of the Remediation Regulations. Calculation of the Method 2 Direct Exposure Criteria is present in Appendix F. Soil data were then compared to the criteria to determine if data are in compliance with the Method 1 and Method 2 criteria. For the data for a given chemical to be in compliance, the following requirements must be met:

1. No single sample result exceeds the soil objective by a factor of 5;
2. No more than 10% of the individual sample results exceed the soil objective; and
3. No single sample result exceeds any UCL as defined by Rule 8.07.

The majority of the compounds detected at the Site are in compliance with the Industrial/Commercial direct exposure criteria and the leachability criteria. Compounds which are not in compliance with the Industrial/Commercial direct exposure criteria are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, arsenic, copper, lead, TPHs, dioxin TEQs. The following compounds had at least one result which exceeded five times the corresponding Industrial/Commercial Method 1 Direct Exposure Criteria: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, arsenic, lead, TPHs, and dioxin TEQs. The following compounds had more than 10% of results exceed the industrial/commercial Method 1 Direct Exposure Criteria: benzo(a)pyrene, arsenic, lead, TPHs, and dioxin TEQs. All compounds detected in soil were also compared to Upper Concentration Limits per Rule 8.07 of the Remediation Regulations. The UCL for any hazardous substance in soil is 10,000 ppm and the UCL for TPHs is 30,000 ppm. Copper and TPHs have at least one result which exceeds their respective UCL. The distributions of

concentrations of those chemicals which are not in compliance with the Industrial/Commercial direct exposure criteria and UCLs are presented in Figures 4.2 thru 4.10. Those figures identify the locations where concentrations are above criteria. Table 4.2 documents the comparison of environmental data to the direct exposure criteria and leachability criteria.

5.1.2 Sediment and Surface Water

A Method 3 Human health Risk Assessment (HHRA) for Mashapaug Cove was conducted in accordance with the Amended LOR. The risk assessment includes the assessment of human health risk at the Site subject to the requirements of the Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (hereafter referred to as the Remediation Regulations) dated March 31, 1993 and as amended in August 1996 and February 2004 (RIDEM, 2004) including RIDEM's Office of Waste Management requirements for arsenic in soil (section 12.0 of the Remediation Regulations). The risk characterization has been performed in accordance with Rule 8.04 of the Remediation Regulations. As required by Rule 8.04, the methodology used here is consistent with scientifically acceptable risk assessment practices and the fundamentals of risk assessment under EPA's Risk Assessment Guidance for Superfund. Supplemental guidance for this risk assessment was provided by the "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final" (USEPA, 1989), the "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors" (USEPA, 1991), and USEPA Region I guidance (USEPA Region I, 1995a and 1996a), and the Exposure Factors Handbook (USEPA, 1997b).

This HHRA utilized only the surface water samples collected in June 2006 by MACTEC to evaluate the risk from surface water. There are some historical surface water samples which were collected by URI, RIDEM and HLA, which the most recent sampling was preformed in 1999. It is assumed that the recent data are representative of the current conditions of the cove.

This HHRA utilized sediment data collected in June, 2006 by MACTEC and sediment data collected in December, 2005 by RIDEM. The sediment data collected by MACTEC was collected at locations SED10 through SED32. Multiple depth intervals were sampled during this event but only the 0 – 1 foot interval was used to represent exposures in this HHRA. The sediment data from RIDEM were collected at locations SD-1001 thru SD-1005 at an interval of 0-2 feet and have also been used in this HHRA.

Exposures were evaluated based on two scenarios, the RME and CT scenarios. The RME and CT scenarios are characterized by coupling the contaminant concentrations with conservative exposure parameters developed for each exposure scenario. The RME is the highest exposure that is reasonably expected to occur at a site. The CT exposure is the typical or average exposure that would be expected in a population.

This HHRA evaluates the risk to receptors in two separate exposure points, the Inner Cove and Outer Cove as defined previously in this report.

5.1.3 Industrial/Commercial Worker

Consistent with the Consent Order, Industrial/Commercial land use has been evaluated. Although it would be unlikely, it has been assumed that Industrial/Commercial workers could potentially wade in Mashapaug Pond. Potential exposures to surface water and aquatic (submerged) sediment by incidental ingestion and dermal contact could occur during wading. Only those sediments at locations with two feet or less of standing water have been considered accessible to human receptors. This assumption is consistent with USEPA Region 1 risk assessment practice.

Cancer and non-cancer risk estimates were calculated separately for each of the exposure media and exposure points identified. The risks for each medium are summed to derive a total risk for surface water and sediment at each exposure point. The total risk for surface water and sediment are then summed to derive a total risk to the commercial/industrial worker. It is assumed that a commercial/industrial worker visits the water bodies for wading only mid May through mid September. It is further assumed that during summer months, wading is defined as standing or walking in water to a depth of the knees. The RME scenario assumes that a commercial/industrial worker wades in the cove once a week from mid May to mid September for a total of 17 times per year. The CT scenario assumes that an Industrial/Commercial worker wades in the cove once every other week from mid May to mid September for a total of 9 times per year.

5.1.4 Trespasser

The upland portion of the Site is currently surrounded by a fence, and signs are posted along the fence advising people not to enter the Site. Trespassers could potentially circumvent the fence and enter the Site for various activities. It is assumed that area trespassers would include older children (ages 7 through 18), and adults (assumed ages 19 through 30). It is also assumed that a younger

child (ages 1 through 6) would not trespass onto the site and therefore were not evaluated in this HHRA. Potential exposures to surface water and aquatic (submerged) sediment by incidental ingestion and dermal contact may occur during wading and/or swimming. It is assumed that a potential trespasser could swim or wade in either the Inner Cove or Outer Cove. However, realistically, swimming and wading are more likely to occur at the Outer Cove. In the summer months which is when swimming and wading are likely to occur, the Inner Cove becomes covered with aquatic vegetation making it a less desirable place for wading or swimming as compared to the Outer Cove. Also the water in the Inner Cove is relatively shallow (generally less than 3 feet during the summer) which would make swimming difficult.

Cancer and non-cancer risk estimates are calculated separately for each of the exposure media and exposure point. The risks for each medium were summed to derive a total risk for surface water and sediment at each exposure point. The total risk for surface water and sediment were then summed to derive a total risk to the each receptor. It is assumed that a trespasser visits the water bodies for wading and swimming mid May through mid September. It is further assumed that during summer months, wading (defined as standing or walking in water to a depth of the knees) occurs more frequently than swimming (defined as total submersion of the body in water). For the RME scenario it is assumed a trespasser visits the cove 3 times a week. Also it is assumed that wading occurs all three times and swimming occurs once a week. For the CT scenario it is assumed a trespasser visits the cove 2 times a week. Also it is assumed that wading occurs both times and swimming occurs once a week.

Contact with submerged sediment is not likely to be substantial under any of the scenarios. However, if contact with sediment were to occur, it would be during wading activities when a person is standing in the water (i.e., standing in the sediment), and not when a person is actively swimming (i.e., when body parts do not contact the sediment for more than a minute or two). However, it is assumed here that on days when swimming occurs, sediment is contacted at the same rate as on those days when only wading occurs. A person would likely contact sediment on swimming days when he/she wades into and out of the water and as he/she takes breaks from active swimming. During the breaks from active swimming, a person may be standing in water, with most of their body immersed, with feet contacting sediment. Therefore, the exposure frequency for sediment is based on the exposure frequency for wading (51 RME and 34 CT days per year for

adults/older child). The exposure frequency for surface water is based on the total frequency for wading and swimming (51 RME and 34 CT days per year).

Calculated risks to each receptor were then compared to the remedial objectives as outlined in the Remediation Regulations (RIDEM, 2004):

1. The excess lifetime cancer risk (ELCR) for each carcinogenic substance does not exceed 1 x 10^{-6} and the cumulative posed by the site does not exceed 1 x 10^{-5};

2. The hazard index for each substance does not exceed a hazard index of 1 and the cumulative hazard index posed by the contaminated-site does not exceed 1 for any target organ.

Risk summaries for both the RME and CT scenarios are presented in Tables 4.42 and Table 4.43 respectively.

The RME and CT cumulative and individual chemical HI for the Industrial/Commercial worker and the trespasser exposures in the Outer Cove are below the target risk level. The CT cumulative and individual chemical ELCR for the Industrial/Commercial worker and the trespasser and the RME cumulative and individual chemical risk for the Industrial/Commercial worker in the outer Cove are below the target risk levels. Although the RME cumulative ELCR for the Trespasser in the Outer Cove meets the target risk level of 1 x 10^{-5}, the RME individual chemical cancer risk for arsenic is greater than the individual chemical risk limit of 1 x 10^{-6}. Therefore the Outer Cove risks meet the risk management criteria and no remediation would be required for the Outer Cove RME and CT Industrial/Commercial worker scenario and the CT trespasser scenario. However, for the RME trespasser scenario, the arsenic ELCR of 1.6 x 10^{-6} is above the individual chemical target risk of 1 x 10^{-6}.

For the Inner Cove RME and CT scenarios there are no individual chemicals which have a Hazard Index (HI) greater than one. Also the cumulative HI for each receptor is less than 1 for any target organ for both the RME and CT scenarios. The individual chemical ELCR for each carcinogenic substance for the Industrial/Commercial worker does not exceed the target cancer limit of 1 x 10^{-6} for both the RME and CT scenarios. Also the cumulative ELCR for the commercial/industrial worker does not exceed 1 x 10^{-5} for both the RME and CT scenarios.

The Inner Cove CT cumulative ELCRs for the adolescent trespasser and adult trespasser are 1 X 10^{-6} and 1 X 10^{-6} respectively giving the trespasser a cumulative receptor risk of 2 X 10^{-6} (below the cumulative risk limit). The Inner Cove CT individual chemical cancer risk for dioxin TEQ for the adolescent and adult trespasser combined is greater than the individual chemical cancer risk limit of 1 x 10^{-6}.

The Inner Cove RME cumulative ELCR for the adolescent trespasser and adult trespasser are 2 x 10^{-5} and 1 x 10^{-5} respectively giving the trespasser a cumulative receptor risk of 3 x 10^{-5} (above the cumulative risk limit). Dioxin TEQ is the largest contributor to the cumulative ELCR. Also for the RME combined adolescent and adult trespasser scenario the individual carcinogenic substance ELCR for TCE, vinyl chloride, benzo(a)pyrene, arsenic and dioxin TEQ are greater than 1 x 10^{-6}(above the risk limit).

In summary, the RME and CT ELCR and Hazard Index values for the Industrial/Commercial Worker for both the Outer Cove and the Inner Cove meet the Remediation Regulations risk limits. The RME and CT Hazard Index values for the trespasser for the Outer Cove and Inner Cove meet the Remediation Regulations limits. However, the RME and CT ELCR for the trespasser exceed at least one of the Remediation Regulation Limits for cancer risk at both the Outer Cove and the Inner Cove. Dioxin TEQ in sediment is the largest cancer risk contributor for the Inner Cove exposure scenarios.

5.1.5 Uncertainty

Due to the uncertainty associated with the potential human skin contact (dermal) exposure to PAHs and dioxins and furans in surface water the dermal exposure pathway for PAHs and dioxins and furans in surface water was not evaluated in the this report. There are a number of uncertainties associated with the dermal exposure pathway for dioxins and furans in surface water, including:

- Surface water is a dynamic exposure medium. As flow rates vary with precipitation events, the amount of suspended particulate matter (aquatic sediments especially) also varies. Sampling of surface water at a few points in time provides snapshots of conditions, but may not provide representative data for long-term exposure.
- PAHs and dioxins and furans have low water solubility and have an affinity for particulate matter and organic carbon. Dioxins and furans could be associated with suspended particulate matter as well as the dissolved phase. The available surface water samples were not filtered and, therefore, represent PAH and dioxin and furan concentrations that are not specifically representative of dissolved phase concentrations.

- The diffusion-based dermal exposure assessment model is based on an assumed dissolved-phase compound being present in water that is contacting the skin. The available surface water data may over-estimate the dissolved phase concentrations in surface water.
- The diffusion-based dermal exposure assessment model (from RAGS Part E) utilizes estimated permeability constants (K_p) for PAHs and dioxin and furan compounds. However, PAHs and dioxin's physical characteristics are identified by USEPA as being outside the Effective Prediction Domain (EPD) for the model used to estimate K_p values.

If the PAH and dioxin surface water data were included in the risk calculations, the estimated dermal contact cancer risks would increase. In that very conservative scenario, surface water dermal contact would become the predominant ELCR contributor.

5.2 ECOLOGICAL RISK ASSESSMENT FOR MASHAPAUG COVE

The screening level ecological risk assessment (SLERA) for Mashapaug Cove was performed in accordance with the following regulations and guidelines:

- RIDEM Remediation Regulations, as amended, February 2004.
- Framework for Ecological Risk Assessment. EPA-630-R-92-001. February, 1992.
- Guidance for Ecological Risk Assessment. EPA-630-R-95-002F. April, 1998.

This SLERA addressed only surface water and sediment within Mashapaug Cove. In accordance with §8.05 of the Rhode Island Remediation Regulation (RIDEM, 2004) and following the definition of "environmentally sensitive areas" in §3.16, this SLERA does not evaluate soil in upland areas surrounding the Cove.

Assessment endpoints for the SLERA was based on generic assessment endpoints associated with screening ecotoxicity endpoints. The endpoints are considered generic because they are based on a variety of organisms and are therefore considered to be representative of entire communities.

Assessment and measurement endpoints for the SLERA were:

SLERA Assessment and Measurement Endpoints

Assessment Endpoint	Measurement Endpoint
Sustainability (survival, growth, reproduction) of local populations of aquatic organisms (e.g., aquatic invertebrates, fish, aquatic birds and mammals) in surface water	Comparison of surface water concentrations to surface water quality benchmarks

Sustainability (survival, growth, reproduction) of local populations of benthic invertebrates in sediment	Comparison of sediment concentrations to sediment quality benchmarks

In the SLERA, maximum detected concentrations form the MACTEC and RIDEM datasets were compared to media-specific benchmarks for aquatic life and benthic macroinvertebrates. In order to facilitate risk characterization, the study area was divided into two exposure areas: the Inner Cove, and the area along the property line (Outer Cove).

Based on the available data, it appears that risk from VOCs, PAHs, pesticides, PCBs, and metals to ecological receptors from surface water and sediment along the property line (Outer Cove) and in the channel between the inner cove and property line is negligible. Risk to benthic and aquatic receptors from surface water and sediment chemicals of potential concern (COPCs) is negligible along the western part of the Inner Cove with respect to VOCs, PAHs, pesticides, PCBs, and metals. Risk from VOCs, PAHs, and metals could not be ruled out at the eastern part of the inner cove using screening tools. Cove-wide risk from dioxins could not be eliminated using screening tools.

The source of PAHs appears to be the storm drain which discharges near SED20. VOCs in sediment may be associated with a groundwater plume discharging into the pond.

Additional investigations are recommended to further evaluate and refine the list of COPCs. Background samples would be useful in better understanding COPCs which could not be ruled out using screening tools, such as Cove-wide dioxins and VOC, PAHs, and metals in the eastern portion of the inner cove. Additional AVS-SEM sampling, toxicity testing, or food chain models could also be conducted to facilitate risk management decisions.

6. REMEDIAL ALTERNATIVE EVALUATION

6.1 OVERVIEW

In accordance with RIDEMs Remediation Regulations, remedial action is required based upon the results of this Supplemental Site Investigation regarding the mobility, toxicity, and concentration of hazardous material released and the potential for these factors to potentially result in harming human health and the environment. The sampling activities conducted by MACTEC at the Site identified copper in soil at one location (SS-SI008, Figure 6.1) that is above the UCL. In addition, the following contaminants were reported in one or more samples at a concentration above the Industrial/Commercial Criteria: BaA, BaP, BaF, dibenzo[a,h]anthracene, indeno[1,2,3-cd]pyrene, arsenic, lead, beryllium, copper and TPH. Prior sampling by RIDEM and MACTEC identified elevated concentrations of lead in the slag material on the Site. In accordance with the Court Consent Order dated March 29, 2006, this slag was removed for off-site recycling and reuse. Confirmatory soil samples were collected on July 13 and 14, 2006 from the bottom and side walls of the excavation as requested by RIDEM. These laboratory data do not exceed UCLs so Textron will proceed with the site restoration. This confirmatory soil data from the slag removal will be provided to RIDEM as an addendum to this SIR and a Remedial Action Report summarizing the removal action will be prepared and submitted to RIDEM under separate cover.

6.2 UCL EXCEEDANCE

A small area of soil exceeding the UCL for copper was identified during this supplemental site investigation. Soil sample SS-SI0008 was found to contain 14,100 mg/kg copper exceeding the UCL of 10,000 mg/kg. In accordance with the Court Consent Order, dated March 29, 2006, the soil with the UCL exceedance will be removed for off-site disposal at a permitted facility. The copper exceedance shown on Figure 6.1 at SD-006 was not identified in subsequent sampling efforts (SD-006-002N, S, E, W), but was removed for off site disposal as part of the slag removal activities conducted in this area. The TPH UCL exceedance in SS-1 (Figure 6.1) was resampled in 2001. The TPH UCL exceedance could not be reproduced and confirmed and therefore soil removal is not required. The area of SS-1 will be included in the area capped by the soil cover remedial alternatives. There were no other compounds in soil samples found to exceed UCLs on the Site.

The SS-SI008 soil sample is located at the outlet of a former stormwater discharge pipe in a drainage swale immediately above soil samples SD-007 and -008 (Figure 6.1). Soil samples SD-007 and -008 did not contain any UCL exceedances and will be used to define the extent of soil removal. Excavation provides the most effective means to limit exposure by physically removing the impacted soils from the Site. Confirmatory sampling will verify that the UCL exceedance has been addressed. This work will be conducted in conjunction with the remediation of the Site soils.

6.3 SOIL CONCENTRATIONS EXCEEDING INDUSTRIAL CRITERIA

Surface soil samples on the Site contain concentrations of metals, PAHs, dioxin and TPH above the Industrial Direct Exposure Criteria thereby requiring a remedial action. The remedial alternatives must meet the following requirements as set forth in Section 9.03 of the RIDEM Remediation Regulations:

1. Prevent the infiltration/migration of hazardous substances at levels harmful to human health or the environment;
2. Prevent direct contact with hazardous substances at levels harmful to human health and the environment;
3. Eliminate volatilization and entrainment of hazardous substances; and
4. Minimize and manage surface runoff from the area including during and after the remedial action. The plan shall identify all locations of existing and/or proposed infiltration systems.

Based upon this regulatory framework, several remedial alternatives are available to achieve these goals. The No Action Alternative is included in this SIR in accordance with Section 7.04 of the RIDEM Remediation Regulations. The second remedial alternative involves capping the contaminated soil and waste fill with a geofabric and 15 inches of clean soil (12 inches of clean backfill and 3 inches of loam and seed). The third alternative is capping contaminated soil and waste fill with 21 inches of clean soil (18 inches of clean backfill and 3 inches of loam and seed), but no geofabric.

6.3.1 Proposed Remediation – No Action Alternative

This alternative has been included in accordance with Section 7.04 of the RIDEM Remediation Regulations for comparison purposes. This alternative will not address the elevated PAH, metals, dioxin or TPH concentrations exceeding the RIDEM Industrial/Commercial Direct Exposure at the Site. The fence installed by the City of Providence under the Court Consent Order dated March 29, 2006 will be maintained indefinitely to restrict access of adults and children to the Site.

6.3.2 Proposed Remediation –Engineered 15-Inch Cap and Excavation

This second remediation alternative involves the construction of a 15-inch thick engineered cap (12-inches clean soil and 3-inches loom and seed) over approximately 4.9 acres of contaminated soils and waste fill at the Site. As part of the engineered cap design, limited soil sampling may be conducted to further refine the horizontal extent of the soil cap. Consolidation of soil exceeding industrial standards and waste fill will also be incorporated into the grading and design of the cap for efficiency and cost-effectiveness. Stone will also be placed in the areas where the cap interacts with the shore line of Mashapaug Cove and Pond to protect against the erosion of the cap.

This engineered soil cap will address both the Site soils exceeding Industrial/Commercial Direct Exposure Criteria and more specifically arsenic concentrations equal to or greater than 7 mg/kg. In accordance with the Remediation Regulations, Section 12.04 (B) encapsulation of the arsenic contaminated soils will be achieved using 12-inches of soil cover with geofabric (meeting specific strength criteria) and the recording of an environmental land use restriction (ELUR). This remedial alternative also includes an additional 3-inches of loom and seed on the soil cover.

An ELUR as described in Section 8.09 of the Remediation Regulations will be instituted for the Site to prohibit residential and recreational use and other sensitive uses/activities on the parcel. In addition, signs will be posted along the existing fence line installed by the City of Providence to prohibit digging and disturbance of the cap. The ELUR will include specific measures for the preservation of the cap through the implementation of an Operation and Maintenance Plan and will restrict activities on the various surfaces of the cap to those that are consistent with cap construction.

Effectiveness: This option will prevent direct contact by humans and restore the Site. The fence installed by the City along the perimeter of the Site will remain in place. The geofabric will clearly delineate the extent of the engineered cap and will serve as a secondary barrier restricting contact should the soil cap be impacted. The geofabric will also provide structural support of the soil cap.

Implementability: The services, equipment, and materials required to implement this alternative are readily available. Long-term monitoring and maintenance of the cover would be required to ensure the continued isolation of contamination as required by the ELUR.

Costs: The costs for constructing a 15-inch soil cover with a geofabric barrier that would eliminate the Industrial/Commercial Direct Exposure Criteria on the Site is estimated to be $800,000. Costs are limited to activities conducted on the Site and not in areas of development conducted by the City of Providence.

6.3.3 Proposed Remediation –Engineered 21-Inch Cap and Excavation

This third remediation alternative involves the construction of a 21-inch thick cap (18-inches clean soil and 3-inches loom and seed) with no geofabric over an estimated 4.9 acres of contaminated soil and waste fill. This remedial alternative replaces the stability and protection of the geofabric with an additional 6 inches of soil to further restrict contact with the contaminated soils under industrial/commercial exposure scenarios. Following the strategy described in Section 6.3.2, this remedial alternative includes the use of soil and waste consolidation under the engineered cap and further contaminant delineation to define the horizontal extent of the cap. Specific areas of the capped area with soils exceeding 7 mg/kg arsenic will require two-feet of soil cover, in accordance with Section 12.04 of Remediation Regulations, and may be consolidated under the soil cap. Stone will also be placed along the shore of Mashapaug Cove and Pond to protect against the erosion of the cap.

An ELUR as discussed in subsection 6.3.2 will also be instituted for the Site. The ELUR for the Site will prohibit residential and recreational use and other sensitive uses/activities on the parcel. In addition, signs will be posted to prohibit digging and disturbance of the engineered cap.

Effectiveness: This option will prevent direct contact by humans and restore the Site. The fence installed by the City along the perimeter of the Site will remain in place. The additional 6-inches of soil included in this alternative will provide a thicker physical barrier between potential receptors and contaminated soil. However, there won't be a physical separation between the clean and contaminated soil should the 2-foot soil cover be penetrated.

Implementability: The services, equipment, and materials required to implement this alternative are readily available. Long-term monitoring and maintenance of the cover would be required to ensure the continued isolation of contamination as required by the ELUR.

Costs: The costs for constructing a 21-inch soil cover that would eliminate the industrial/commercial exposure on the Site is estimated to be $900,000. Costs are limited to activities conducted on the Site and not in areas of development conducted by the City of Providence.

6.4 COVE REMEDIATION

As required by the March 29, 2006 Court Consent Order and the Amended LOR dated April 5, 2006, the remedial alternatives for Mashapaug Cove sediments are discussed in this SIR. The preliminary remedial alternatives identified for the cove sediment include the No Action Alternative, capping or removal of contaminated sediment. However, the analytical results of the Cove sediment sampling presented in subsection 4.3 indicate that further sampling to define the horizontal extent of contamination is needed before an engineering cost estimate and evaluation of remedial alternatives can be conducted. Based upon further delineation of the horizontal extent of contamination, detailed remediation strategies will be developed and presented to RIDEM in an amended SIR.

6.5 REMEDIATION ALTERNATIVE RECOMMENDATION

MACTEC has determined that the one area of UCL exceedance (SS-SI0008) be excavated in accordance with the Court Consent Order, dated March 29, 2006, for off-site disposal at a permitted facility. For Site soils that exceed Industrial/Commercial Direct Exposure Criteria, the 15-inch engineered cap alternative will provide the most effective means to meet the goals of Section 9.03 of the RIDEM Remediation Regulations.

The 15-inch cap will prevent migration of contaminants, prevent direct contact with contaminants under potential industrial/commercial exposure scenarios, limit entrainment of hazardous substances, and manage surface runoff. The geofabric will provide a visual barrier against potential digging and provide structural stability for the soil cap.

The 15-inch cap provides a physical barrier including geofabric, 12 inches of clean fill, and 3 inches of seeded loam. The other cap alternative provides another 6 inches of clean fill, but no geofabric, and will cost an estimated $100,000 more than the 15-inch cap. This cost increase from the additional soil cover does not achieve the same protection and structural benefits as the

geofabric. The 15-inch cap meets the goals of the RIDEM Remediation Regulations and can be readily implemented.

7. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 SUPPLEMENTAL SITE INVESTIGATION SUMMARY AND CONCLUSIONS

This Supplemental SIR has been conducted in accordance with the requirements of the March 29, 2006 Consent Order as well as the August 2, 2005 LOR from RIDEM to Textron, Inc. and the April 5, 2006 Amended LOR to Textron, Inc. and the City of Providence issued by RIDEM with respect to the Site and Mashapaug Cove. These activities incorporated the following comments provided by RIDEM:

- RIDEM comments dated March 14, 2006 on the November 2005 Draft Work Plan (MACTEC, 2005);
- RIDEM amended LOR dated April 5, 2006 (RIDEM, 2006a);
- RIDEM comments made during a May 2, 2006 meeting with Textron and MACTEC; and
- RIDEM comments following the May 2, 2006 meeting in a letter dated May 25, 2006 (RIDEM, 2006b).

This SIR documents the implementation of the SI Work Plan components, analytical results by ESS Laboratory in Cranston, RI and incorporates historical Site information with these 2006 results to define the nature and extent of contamination at the Site. Based on these results, a Human Health and Ecological Risk Assessment were prepared and Remedial Alternatives were evaluated for the Site soils and Mashapaug Cove.

7.1.1 Environmental Sampling and Analysis

7.1.1.1 Site Soil

In 2006, MACTEC collected a total of 31 surface soil samples within the Site at a depth of 0 to 12-inches bgs. Analytical parameters for the Supplemental SIR at previously sampled locations complemented the previous analytical parameters so that the analytical parameters for each sample location would include (to the extent possible) the full suite of analyses (VOCs, SVOCs, TPH, metals, PCBs and pesticides, and dioxins and furans). The current Site soil data set contains at least 65 samples analyzed for PAHs, 77 samples analyzed for metals, 16 samples analyzed for VOCs, 31 samples analyzed for pesticides, 41 samples analyzed for PCBs, 28 samples analyzed for TPH, and 33 samples analyzed for dioxins and furans. This extensive Site soil data set is representative of current site conditions and is adequate for the delineation of nature and extent of

contamination, for evaluating risks for Industrial/Commercial land use, and for identifying and evaluating remedial alternatives for Site soil.

The March 2006 Consent Order also required the removal of the slag material along the southern shore of Mashapaug Cove which was completed on July 17, 2006. Confirmatory soil samples were collected along the exposed bottom and sidewalls of the excavation as required by RIDEM and analyzed for TPH, SVOCs, and 13 PPM. No UCL exceedances were found in these confirmatory soil samples, however, there were exceedances of the Industrial/Commercial Direct Exposure Criteria such that this area will be included in the remediation of Site soils. A Remedial Action Report will be prepared under separate cover summarizing the actions completed and the confirmatory soil samples analytical results.

7.1.1.2 Mashapaug Cove Sediments

The sediments of Mashapaug Cove were characterized in the 2006 Supplemental SI activities and 2005 RIDEM sample collection and analysis. Historical sediment data were not used in this SIR as much of the data are more than 10 years old, the analytical parameters are limited, very few samples were collected from Mashapaug Cove, laboratory reports are not available, and the sample collection procedures are not well documented. However, the Mashapaug Cove 2006 sampling program was developed to recreate and expand upon these historical sampling events. The current sediment data set for Mashapaug Cove includes five surficial sediment samples (0 -2 feet) collected by RIDEM in 2005, twenty three surficial sediment samples and twenty-five deeper sediment samples collected during the 2006 Supplemental SI. Surficial sediment samples were analyzed for PAHs, thirteen PPMs, TPH, dioxins/furans, PCBs, pesticides, and TOC. The 2005 RIDEM samples were analyzed for all of the same parameters except TOC. The 2006 Supplemental SI activities also included the collection of five surficial sediment samples for the analysis of AVS/SEM to evaluate the bioavailability of metals in sediment. The deeper samples were analyzed for the principal Site-related parameters (VOCs, PPMs, and PAHs) in order to address nature and extent of contamination (but not for characterization of human health or ecological risks).

The 2005/2006 Site data set is considered adequate to characterize nature and extent of contamination and to characterize risks within the Inner Cove. For the Outer Cove, the 2005/2006 data set is, for most analytical parameters, adequate to evaluate extent of contamination. There is an obvious decreasing gradient of concentrations for most parameters moving from the Inner Cove

to the Outer Cove and beyond the property line to the north. However, the horizontal extent of metals and dioxins and furans in sediments is not completely delineated with SED11 located just outside (north) the Site property line. Additional sampling and analysis is necessary to delineate the extent of sediment contamination by metals and dioxins and furans and to distinguish Site-related impacts from the current sediment conditions in Mashapaug Pond.

7.1.1.3 Mashapaug Cove Surface Water

A total of 15 surface water samples were collected from Mashapaug Cove in July 2006 from within one foot of the surface water/sediment interface. All 15 samples were analyzed for VOCs, PAHs, and inorganics and metals (both filtered and unfiltered), and hardness. Three surface water samples (SW11, SW19, and SW27) were analyzed for pesticides and PCBs, dioxins and furans. The 2006 Supplemental SI analytical data are considered the only data that represent current surface water conditions in the cove and are considered adequate to assess general differences between surface water quality in the Inner Cove and Outer Cove.

7.1.1.4 Bathymetric and Geophysical Surveys of Mashapaug Cove

ASI of Flemington, New Jersey, under subcontract to MACTEC, conducted a geophysical and bathymetric survey in June 2006 to (1) determine the presence or absence of metallic debris in the cove (e.g., potential waste drums), (2) define the surface or bathymetry of the bottom of the cove, and (3) determine sub-bottom conditions (e.g., stratigraphy and depth to bedrock) of the cove.

The deepest portions of the cove extend from the mouth of the Inner Cove to the southeast and southern portions of the cove forming a channel exceeding 3 feet in depth. Another secondary channel appears to exist in the northwestern portion of the Inner Cove. The magnetometer survey identified 16 distinct magnetic anomalies (Figure 3.6), but did not identify any metal drums present in the cove. Instead they identified buried pipes and small metallic objects within the sediment, several visually observed or were known water intake pipes used for historical Site operations. A side scan sonar survey was completed along the magnetometer survey lines to supplement the survey results confirming these magnetometer results. These survey results indicate that no further investigation is warranted for Mashapaug Cove.

7.1.2 Nature and Extent of Contamination

7.1.2.1 Site Soil

Copper, lead, arsenic, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, and dioxin TEQ were found to exceed the Industrial/Commercial Direct Exposure Criteria (Figures 6.1) in Site soils thereby requiring remediation. Soil sample SS-SI008 also contained copper at 14,100 mg/kg, above the 10,000 mg/kg UCL. No other soil concentrations above UCLs were identified on the Site. Figure 6.1 identifies a historical soil sample SS-1 that possibly exceeded the TPH UCL. SS-1 was resampled in 2001 and the UCL exceedance could not be confirmed vertically or horizontally; however, SS-1 will be included in the Site soil remediation. Note that the potential UCL exceedance for copper at SD-006 (resampled, but not confirmed in 2001) was removed during the slag removal.

7.1.2.2 Mashapaug Cove Sediments

The analytical data from the 48 sediment samples indicate that sediments, particularly within the Inner Cove, are impacted by metals, VOCs, PAHs, and dioxins and furans. Data suggest a gradient of concentrations, often with the highest concentrations in the Inner Cove and concentrations generally decreasing into the Outer Cove and the property line. Overall, frequency of detection and the magnitude of detected concentrations of metals, PAHs, and VOCs were lower in the deeper sediment samples (typically collected from 2.5 to 3 feet below the surface water/sediment interface) than in the surficial sediment samples. However, the average concentration of arsenic in the deeper sediments of the Inner Cove is higher than for the surficial sediments.

These strong gradients indicate that the TPH and VOC contamination is primarily limited to the Inner Cove. Metals impacts to sediment appear to be concentrated throughout the Inner Cove and in the area of sediment sample locations SED14 and SED11. The extent of metals in sediment to the north of sample SED11 is not delineated. The arsenic data for surficial sediments have a much smaller range of concentrations so that it is unclear whether the arsenic is Site related or the variability in concentrations might be consistent with the variability in concentrations throughout Mashapaug Pond.

7.1.2.3 Mashapaug Cove Surface Water

Overall there is very little chemical impact on surface water. Among metals, only chromium, copper, lead, silver, and zinc were detected in unfiltered samples. No metals were detected in

filtered surface water samples. Only five PAHs were detected (all below 1 µg/l) in only one of fifteen samples while naphthalene was detected (below 1 µg/l) in four of fifteen samples. No PCBs were detected in surface water. Only one pesticide compound (4,4'-DDT) was detected (0.00008 µg/l). Dioxins and furans were detected in each of the three surface water samples analyzed with the maximum dioxin TEQ concentration of 0.000000062 mg/l (62 parts per quadrillion). It appears the dioxins and furans are associated with suspended particulates in the water column, since these compounds have very low water solubility.

At least one VOC compound was detected in each of the surface water samples, but reported concentrations were in the low µg/l range. Total VOC concentrations ranged from 4.2 µg/l to 22.1 µg/l for the samples collected from within the Inner Cove. Total VOC concentrations for the Outer Cove and just north of the property line ranged from 1.5 µg/l to 13.1 µg/l.

7.1.3 Fate and Transport

Investigations to date indicate that metals, PAHs and dioxins in surficial soils and fill material (including the former slag pile) have the potential to migrate with soil material via overland flow during and immediately after precipitation events. It appears that historically, and recently, soils from the former facility area and along the filled area immediately to the south of Mashapaug Cove have been subjected to this mechanism. A number of drainage swales have also been identified between the higher elevation former facility area and the shoreline of Mashapaug Cove.

Persistent and bioaccumulating substances that are present in sediments have the potential to accumulate in biota and be biomagnified via food chain (both human and ecological) mechanisms. Among the USEPA list of persistent and bioaccumulating toxins, only benzo(a)pyrene and dioxins and furans have been detected in sediments at concentrations that are indicative of a potential release.

Groundwater containing low levels of chlorinated VOCs is currently being remediated on Parcel A. This groundwater flows northerly from the higher elevation former facility area towards Mashapaug Cove and appears to discharge into the cove, likely passing through the cove sediments in the process. Available data indicate that minimal transfer of chlorinated VOCs from groundwater to surface water is occurring. The cove sediment data suggest that the highly organic sediments may be accumulating these dissolved VOCs as groundwater passes through the sediment. There are currently no occupied buildings within the Site and therefore there is no current or potential migration pathway involving

vapor migration from groundwater to indoor air. There have not been highly leachable materials identified in soils within the Site that might migrate to groundwater via leaching or infiltration.

7.1.4 Risk Characterization and Remedial Requirements

Human Health Risk Assessment: The Method 1 Industrial/Commercial Direct Exposure Criteria for copper, lead, arsenic, benzo(a)pyrene, benzo(a)anthracene, and benzo(b)fluoranthene and the Method 2 Industrial/Commercial Direct Exposure Criteria for Dioxin TEQ have been identified as remedial objectives for soils. The human health risk assessment concluded that risks associated with the potential exposure to surface water and sediment for the Industrial/Commercial scenario for Mashapaug Cove meet the RIDEM criteria for individual chemicals and for cumulative risk. Therefore, no remediation of either surface water or sediment is required under this exposure scenario. The human health risk assessment did not identify any human health risks for surface water that exceed risk management criteria for the Trespasser.

The human health risk assessment for the trespasser scenario concluded that the RME and CT non-cancer Hazard Index meets the risk management criteria for both the Inner Cove and the Outer Cove for surface water and sediment. However, the RME and CT excess lifetime cancer risks for the Trespasser exceed at least one of the cancer risk criteria for in both the Inner Cove and Outer Cove.

Specific to the Outer Cove, only arsenic in sediment is associated with cancer risk greater than one in one million, even though the cumulative cancer risk is less than one in one hundred thousand. It is not clear, however, that the arsenic sediment concentration used to evaluate the Outer Cove represents a Site-related impact or if it is typical of the variability within Mashapaug Pond sediments.

For the Inner Cove CT Trespasser scenario, the cumulative cancer risk for the sediment is less than one in one hundred thousand, but the cancer risk for dioxin TEQ is greater than one in one million. For the Inner Cove RME Trespasser scenario, the cumulative cancer risk for the sediment is greater than one in one hundred thousand, and the cancer risk for dioxin TEQ, TCE, vinyl chloride, benzo(a)pyrene, and arsenic are each greater than one in one million.

No risk-based remediation of sediment is required for the Industrial/Commercial scenario. To meet risk management criteria for the Trespasser scenario in the Inner Cove, dioxin TEQ, TCE, vinyl

chloride, Benzo(a)pyrene, and arsenic concentrations would need to be reduced or exposure to sediments in the Inner Cove would need to be reduced or eliminated. For the Outer Cove, sediment remedial requirements should be determined after additional investigation has been conducted to determine if the arsenic concentrations in the Outer Cove are Site-related or if they are typical of Mashapaug Pond sediment concentrations.

Based on available data, it appears that risk from pesticides, PCBs and metals to human receptors from surface water in both exposure points, Inner Cove and Outer Cove, is negligible. Risk to human receptors from sediment in the Outer Cove from VOCs, PAHs, pesticides, PCBs and metals, with the exception of arsenic, is negligible. Risk to the commercial/industrial worker from sediment in the Inner Cove from VOCs, PAHs, PCBs, pesticides, and metals are negligible. Sediment in the Inner Cove does pose a risk to the trespasser. Hazard Index meets the Remediation Regulation limits for both receptors for the Inner Cove and Outer Cove. Risk contributors associated with sediment in the inner cove include TCE, vinyl chloride, benzo(a)pyrene, arsenic and dioxin TEQ.

Ecological Risk Assessment: The SLERA evaluated potential risks to aquatic and benthic organisms (sediment dwellers) associated with potential surface water and sediment exposures in Mashapaug Cove. The SLERA concluded that ecological risks associated with metals, inorganics, VOCs, PAHs, pesticides, and PCBs in surface water are negligible and no further evaluation is required. The SLERA also determined that further evaluation of dioxins and furans reported in surface water is required to determine if ecological risks warrant remedial action.

The SLERA concluded ecological risks associated with pesticides and PCBs in sediments are minimal or negligible and require no further evaluation. The SLERA further concluded that the screening level assessment did not rule out the potential for significant ecological risk associated with metals, inorganics, PAHs, VOCs, and dioxins and furans in sediments within the cove. This indicates that a more refined, Site-specific ecological risk assessment should be conducted to determine the need for remedial action for sediments in the cove.

7.1.5 Evaluation of Remedial Alternatives

Remedial action is required for the Site soils due to the concentrations of metals, PAHs, and TPH exceeding Industrial/Commercial Direct Exposure Criteria. There was also one soil location at sample SS-SI008 that had copper (14,100 mg/kg) exceeding the UCL (10,000 mg/kg). In

accordance with the Consent Order this soil area will be removed and disposed off-site at a permitted facility and confirmatory soil samples collected. This work will be conducted in conjunction with the remediation of the Site soils.

Remedial alternatives evaluated to address these Site soils included (1) No Action Alternative (required under Section 7.04, Remediation Regulations), (2) capping the contaminated soil and waste fill with a geofabric and 15 inches of clean soil (12 inches clean backfill and 3 inches loam and seed) and (3) capping contaminated soil and waste fill with 21 inches of clean soil (18 inches clean backfill and 3 inches loam and seed), but no geofabric. An ELUR (Section 8.09, Remediation Regulations) will also be instituted for the Site as part of Alternatives 2 and 3. To prohibit residential and recreational use and other sensitive uses/activities on the parcel. In addition, signs will be posted to prohibit digging and distribution of the cap. The ELUR will include specific measures for the preservation of the cap through the implementation of an Operation and Maintenance Plan and will restrict activities on the various surfaces of the cap to those that are consistent with cap construction.

MACTEC has determined that Alternative No. 2, 15-inch engineered cap, will provide the most effective means to meet RIDEM Remediation Regulations (Section 9.03). This alternative will prevent contaminant migration, prevent direct contact with contaminants (industrial/commercial exposure scenarios), limit entrainment of hazardous substances, and manage surface runoff. The geofabric fabric will provide a visual barrier against potential digging and provide structural stability for the soil cap. This remedial approach has an estimated construction cost of $800,000 and the services, equipment, and materials required to implement this alternative are readily available. This 15-inch engineered cap meets the goals of the RIDEM Remediation Regulations and can be readily implemented.

As required by the Court Consent Order and Amended LOR, the preliminary remedial alternatives identified for Mashapaug Cove sediment include the No Action Alternative, capping or removal of contaminated sediment. However, the analytical results of the Cove sediment sampling indicate that further sampling to define the horizontal extent of contamination is needed before an evaluation of remedial alternatives can be conducted. Based upon further delineation of the horizontal extent of contamination, detailed remediation strategies will be developed and presented to RIDEM in an amended SIR.

7.2 CONCLUSIONS OF THE SUPPLEMENTAL SITE INVESTIGATION REPORT

The Site soil data set is representative of current site conditions and is adequate for the delineation of nature and extent of contamination, for evaluating risks for Industrial/Commercial land use, and for identifying and evaluating remedial alternatives for Site soil. Copper, lead, arsenic, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, and dioxin TEQ were found to exceed the Industrial/Commercial Direct Exposure Criteria in Site soils thereby requiring remediation. Soil sample SS-SI008 also contained copper at 14,100 mg/kg, above the 10,000 mg/kg UCL, thereby requiring remedial action. A 15-inch engineered cap (including geofabric) will provide the most effective means to meet RIDEM Remediation Regulations. This 15-inch engineered cap meets the goals of the RIDEM Remediation Regulations and can be readily implemented. The copper UCL will be addressed via excavation and off site disposal.

Removal of the slag material along the southern shore of Mashapaug Cove was completed on July 17, 2006. Confirmatory soil samples confirmed UCL exceedances were not present in the bottom and sidewalls of the excavation, select sample locations but did exceed Industrial/Commercial Direct Exposure Criteria such that this area will be included in the remediation of Site soils described above.

The magnetometer survey and side sonar survey of Mashapaug Cove did not identify any metal drums present in the cove. These surveys indicate that no further investigation concerning potential presence of drums is warranted for Mashapaug Cove.

The 2005/2006 Mashapaug Cove sediment data set is considered adequate to characterize nature and extent of contamination and to characterize risks within the Inner Cove. For the Outer Cove, the 2005/2006 data set is, for most analytical parameters, adequate to evaluate extent of contamination. There is an obvious decreasing gradient of concentrations for most parameters moving from the Inner Cove to the Outer Cove and beyond the property line to the north. However, the horizontal extent of metals and dioxins and furans in sediments is not completely delineated at the northern end of the cove. Additional sampling and analysis is necessary to delineate the extent of sediment contamination by metals and dioxins and furans and to distinguish Site-related impacts from the current sediment conditions in Mashapaug Pond.

The analytical data from the sediment samples indicate that sediments, particularly within the Inner Cove, are impacted by metals, VOCs, PAHs, and dioxins and furans. Data suggest a gradient of concentrations, often with the highest concentrations in the Inner Cove and concentrations generally decreasing into the Outer Cove and the property line. The source of VOCs detected in the sediments has not been definitively established.

The 2006 Supplemental SI analytical data are considered to be representative of current surface water conditions in the cove and are considered adequate to assess general differences between surface water quality in the Inner Cove and Outer Cove. Overall there is very little chemical impact on surface water.

Industrial/Commercial Scenario for Mashapaug Cove

- Inner Cove and Outer Cove
  - Non-cancer risk meets RIDEM risk management criteria;
  - Cancer risk meets RIDEM risk management criteria; and
  - No remediation of other surface water or sediment required.

Trespasser Scenario for Mashapaug Cove

- Inner Cove
  - Non-cancer risks meet RIDEM risk management criteria;
  - Cancer risk associated with surface water meets RIDEM risk management criteria; and
  - Cancer risk associated with potential sediment exposure does not meet RIDEM risk management criteria.

- Outer Cove
  - Non-cancer risks meet RIDEM risk management criteria;
  - Cancer risk associated with surface water exposure meet RIDEM risk management criteria;
  - Cancer risk associated with potential sediment exposure does not meet RIDEM risk management criteria. Arsenic in sediment is the predominant contributor to the risk, and it is not clear if the arsenic concentrations are Site-related.

The screening level ecological risk assessment (SLERA) concluded ecological risks associated with pesticides and PCBs in sediments are minimal or negligible and require no further evaluation. The SLERA further concluded that the screening level assessment did not rule out the potential for ecological risk associated with metals, inorganics, PAHs, VOCs, and dioxins and furans in sediments within the cove. This indicates that a more refined, Site-specific ecological risk

assessment should be conducted to determine the need for remedial action for sediments in the cove.

Detailed remedial alternatives evaluation and selection of a remedy for sediments of Mashapaug Cove should be conducted after completion of additional investigation/evaluation to define the site-specific human health and ecological risks, transport mechanisms, and the specific risk-based remedial objectives.

To meet RIDEM risk management criteria for the Trespasser scenario in the Inner Cove, contaminant concentrations would need to be reduced or exposure to the sediments would need to be reduced or eliminated. It is not clear that the arsenic concentrations in the Outer Cove sediment are typical of the variability within Mashapaug Pond or are Site-related so additional site investigation is warranted prior to determining the need for remediation of the Outer Cove sediments.

7.3 RECOMMENDATIONS FOR FURTHER EVALUATION

The following activities are recommended for the Site:

- The development of a Remedial Action Work Plan for the Site soils;
- The development of a Scope of Work for a Baseline Ecological Risk Assessment for Mashapaug Cove;
- The development of a Scope of Work for Supplemental Investigation to:
    - further determine extent of metals in sediments in the area of sample location SED11;
    - investigate the source of VOCs in sediment in the Inner Cove and in the area of sediment sample location SED15;
    - investigate the variability in arsenic concentrations in sediment within Mashapaug Pond;
    - investigate the potential bioaccumulation of dioxins and furans and PAHs in aquatic biota in Mashapaug Cove.
- Conduct further evaluation of the need for remediation of Mashapaug Cove sediments and evaluate remedial alternatives.

9. REFERENCES

ABB-ES, 1995a. Remedial Investigation Report, Gorham Manufacturing Facility, May.

ABB-ES, 1995b. Supplemental Remedial Investigation Report, Gorham Manufacturing Facility, December.

ABB-ES, 1997. Short-Term Response Action Report, Former Gorham Manufacturing Facility, July.

American Society for Testing and Materials (ASTM), 1998. Risk-based Corrective Action (RBCA) guidance, Standard Provisional Guide for Risk-based Corrective Action, PS 104-98, July.

Bonn, B. A., 1998. Polychlorinated Dibenzo-p-dioxin and Dibenzofuran Concentration Profiles in Sediment and Fish Tissue of the Willamette Basin, Oregon, Environ. Sci. Technol., 32 (6), 729-735.

Brzuzy, L.P. and R.A. Hites, 1996. Global Mass Balance for Polychlorinated Dibenzo-p-dioxins and Dibenzofurans, Environ. Sci. Technol, 9, 1803.

California Environmental Protection Agency (CAEPA), 1994. California Environmental Protection Agency Criteria for Carcinogens. November.

Grimsrud, D.T., Sherman, M.H., and Sonderegger, R.C. 1983. Calculating infiltration: Implications for a construction quality standard, 422. Proceedings of the ASHRAE-DOE Conference on the Thermal Performance of the Exterior Envelopes of Buildings II, ASHRAE SP38, Atlanta, GA, pp. 422-449. (Referenced in MDEQ, 1998).

Harding Lawson Associates (HLA), 1998a. Supplemental Site Investigation Report, Proposed Park Subdivision, Former Gorham Manufacturing Property, Adelaide Avenue, Providence, Rhode Island, October.

HLA, 1999. Site Investigation Summary Report and Risk Assessment, Former Gorham Manufacturing Site, 333 Adelaide Avenue, Providence, Rhode Island, July.

Hemond, H.F. and E.J. Fechner, 1994. Chemical Fate and Transport in the Environment. Academic Press.

Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt, 1990. Handbook of Chemical Property Estimation Methods. American Chemical Society. Washington, DC.

Massachusetts Department of Environmental Protection (MADEP), 1994. Background Documentation for the Development of the MCP Numerical Standards. April.

MADEP, 1995a. Guidance for Site Risk Characterization: In Support of the Massachusetts Contingency Plan; Bureau of Waste Site Cleanup and Office of Research and Standards; July.

MADEP, 1995b. Massachusetts Threshold Effects Exposure Limits and Allowable Limits for Ambient Air. December.

Massachusetts Contingency Plan (MCP), 310 CMR 40.0000, Commonwealth of Massachusetts, as amended through October 31, 1997.

Michigan Department of Environmental Quality (MDEQ), 1998. Part 213, Risk-Based Screening Levels for Groundwater and Soil Volatilization to Indoor Air Inhalation Criteria. Draft Operational Memorandum No. 4, Attachment 8. January.

Occupational Safety and Health Administration (OSHA), 29 CFR 1910.1000, Permissible Exposure Limits (PELs), March 23, 1999.

Rappe, C., 1994. Dioxin, Patterns and Sources Identification, Fresenius' Journal of Analytical Chemistry, 348, 63-75.

Rhode Island Department of Environmental Management (RIDEM), 1996. Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases. August.

RIDEM, 2006a. Amended Letter of Responsibility. April 5, 2006.

RIDEM, 2006b. Comments following the May 2, 2006 meeting in a letter dated May 25, 2006.

Superfund Chemical Data Matrix (SCDM), 1993. March.

United States Environmental Protection Agency (USEPA), 1987. Hazardous Waste Treatment, Storage and Disposal Facilities (TSDF) – Air Emission Models. Office of Air Quality. April.

USEPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final. Office of Emergency and Remedial Response. December.

USEPA, 1990. Basics of Pump-and-Treat Ground-Water Remediation Technology. Research and Development, March.

USEPA, 1991. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors. Office of Emergency and Remedial Response, Toxics Integration Branch; OSWER Directive 9285.6-03 (interim final). Washington, D.C.

USEPA, 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Emergency and Remedial Response. Washington, D.C.

USEPA, 1994. "Risk Updates", USEPA Region I, Waste Management Division; No. 2. August.

USEPA, 1995a. "Risk Updates", USEPA Region I, Waste Management Division; No. 3. August.

USEPA, 1995b. Region III Technical Guidance Manual, Risk Assessment, Assessing Dermal Exposure from Soil.

USEPA, 1996a. "Risk Updates", USEPA Region I, Waste Management Division; No. 4. November.

USEPA, 1996b. Soil Screening Guidance: User's Guide. Office of Solid Waste and Emergency Response. EPA/540/R-96/018. April.

USEPA, 1997a. Health Effects Assessment Summary Tables (HEAST), Annual Update: Office of Solid Waste and Emergency Response, EPA 540/R/95/036, PB94-921199.

USEPA, 1997b. "Exposure Factors Handbook, Volume 1; Office of Research and Development; EPA-600/P-95/002Fa; Washington, D.C.; August.

USEPA, 1998a. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment. Office of Emergency and Remedial Response, NCEA-W-0364 (interim guidance), Washington, D.C., May 7.

USEPA, 1998b. Region III Risk-Based Concentration Table. April.

USEPA, 1999. Integrated Risk Information System (IRIS). On-line data base. April.

United States Geological Survey (USGS), 1997. Natural Attenuation of Chlorinated Volatile Organic Compounds in a Freshwater Tidal Wetland, Aberdeen Proving Ground, Maryland, by Michelle M. Lorah, Lisa D. Olsen, Barrett L. Smith, Mark A. Johnson, and William B. Fleck, USGS Online Publication – WRIR-97-4171. 1997

Verschueren, K., 1983. Handbook of Environmental Data on Organic Chemicals. Second Edition.

TABLES

FIGURES

APPENDIX A

Supplemental Site Investigation Work Plan

APPENDIX B

RIDEM/RIDOH Advisory for Safe Uses of Mashapaug Pond

APPENDIX C

Field Data Records and Chains of Custody for 2006 Soil, Surface Water and Sediment Sampling

APPENDIX D

Mashapaug Cove Investigation Reports – Magnetometer Survey, Side Scan Sonar Investigation, Bathymetric Survey, Collection of Sediment Cores, and Surface Water Sampling

APPENDIX E

Laboratory Reports

(See Volumes II through IV)

APPENDIX F

Derivation of Method 2 Direct Contact Exposure Criteria

APPENDIX G

Human Health Risk Assessment

APPENDIX H

Screening Level Ecological Risk Assessment