



FORMER GLOUCESTER MGP PHASE II  
COMPREHENSIVE SITE ASSESSMENT  
FORMER GLOUCESTER MGP

**Prepared for**

GZA GeoEnvironmental, Inc.

**Prepared by**

Anchor QEA, LLC

**July 2011**

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## LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilograms
µg/L	micrograms per liter
ADL	Arthur D. Little, Inc.
Alpha	Alpha Analytical Lab
AMEC	AMEC Earth and Environmental
Anchor QEA	Anchor QEA, LLC
ARCADIS	Arcadis U.S., Inc.
AST	above-ground storage tank
AUL	Activity and Use Limitation
AVS	Acid Volatile Sulfide
BTEX	benzene, toluene, ethylbenzene, and xylene
BWSC	Bureau of Waste Site Management
Coneco	Coneco Environmental Corporation
COPEC	Constituents of Potential Ecological Concern
CRA	Comprehensive Response Action
CSA	Comprehensive Site Assessment
CSM	conceptual site model
CSO	combined sewer outfall
cy	cubic yards
DUA	Data Usability Assessment
DEIR	Draft Environmental Impact Report
DEM	Department of Environmental Management
DEQE	Department of Environmental Quality Engineering
DMMP	Dredged Material Management Plan
DPS	Downgradient Property Status
EA Engineering	EA Engineering, Science, and Technology, Inc.
EDR	Environmental Data Resources, Inc.
EECS	EECS, Inc.
EERC	Energy and Environmental Research Center
Eh	oxidation/reduction potential
EPA	Environmental Protection Agency

EPG	Environmental Partners Group, Inc.
EPH	extractable petroleum hydrocarbon
ERC	Environmental Risk Characterization
GPS	Global Positioning System
GZA	GZA GeoEnvironmental, Inc.
IDW	investigation derived waste
IRA	Immediate Response Action
ISI	Initial Site Investigation
LSP	Licensed Site Professional
LTBI	Location to be Investigated
M&E	Metcalf & Eddy, Inc.
MassDEP	Massachusetts Department of Environmental Protection
MCP	Massachusetts Contingency Plan
MCZM	Massachusetts Coastal Zone Management
mg/kg	milligrams per kilogram
MLW	mean low water
MLLW	mean lower low water
MGL	Massachusetts General Law
MGP	Manufactured Gas Plant
MODF	mineral oil dielectric fluid
MSE	microscale solvent extraction
MTBE	methyl tert butyl ether
n	number of samples
NAPL	nonaqueous phase liquid
National Grid	Massachusetts Electric Company d/b/a National Grid
ND	Non-detect
NOAA	National Oceanic and Atmospheric Administration
NRC	National Response Center
OHM	oil and/or hazardous material
ORP	oxidation reduction potential
PAC	physiologically available cyanide
PAH	polycyclic aromatic hydrocarbons
PAH16	16 priority PAH
PAH34	alkylated PAH

PCB	polychlorinated biphenyls
ppm	parts per million
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
QC	quality control
RAH	Readily Apparent Harm
RAM	Release Abatement Measure
RAO	Response Action Outcome
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RRA	Remedial Response Action
RTN	Release Tracking Number
SEM	Simultaneously Extracted Metals
Site	former Gloucester Manufactured Gas Plant
SOC	Soot Organic Carbon
SOW	Scope of Work
SPME	Solid Phase Micro Extraction
SSOW	Supplemental Scope of Work
SSOW-2	Supplemental Scope of Work – 2
SSOW-3	Supplemental Scope of Work – 3
SVOC	semi-volatile organic compounds
TCLP	toxicity characteristic leaching procedure
TG&B	TG&B Marine Services, Inc.
TOC	Total Organic Carbon
TPAH	total PAH16
TPH	Total Petroleum Hydrocarbon
TRV	toxicity reference value
URAM	Utility Related Abatement Measure
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
VOC	volatile organic compounds
VOT	visible oil and/or tar
VPH	volatile petroleum hydrocarbon

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## **1 INTRODUCTION**

Anchor QEA, LLC (Anchor QEA) has prepared this Phase II Comprehensive Site Assessment (CSA) for the marine portion of the former Gloucester Manufactured Gas Plant (MGP) Site (the Site) located along Harbor Loop in Gloucester, Massachusetts (Figure 1.0 – 1). This report has been prepared for Massachusetts Electric Company d/b/a National Grid (National Grid) in accordance with the requirements of the Massachusetts Contingency Plan (MCP), 310 CMR 40.0000.

This report is intended to be an Appendix to the Phase II CSA submittal that is being prepared by GZA GeoEnvironmental, Inc. (GZA) of Norwood, Massachusetts, on behalf of National Grid. As such, the information contained in this report is solely for the marine portion of the Site. Phase II information pertaining to the upland portion of the Site and the Site in general is included in GZA's Phase II CSA report unless otherwise noted in this report.

The project team for the Site has included Anchor QEA, GZA, Arcadis U.S., Inc. (ARCADIS) of Beverly, Massachusetts, EECS, Inc. (EECS) of Milford, Massachusetts, and AMEC Earth and Environmental (AMEC) of Westford, Massachusetts. ARCADIS was replaced by Anchor QEA and EECS was replaced by GZA during the Phase II work. AMEC's work consisted of the preparation of a Method 3 Stage II Environmental Risk Characterization (ERC) for the marine portion of the Site.

### **1.1 Objectives**

The objectives of the CSA investigation activities described in this report include the following:

- Identifying the sources, nature, and extent of oil and/or hazardous material (OHM) potentially attributable to the Site within Gloucester Harbor sediment and surface water
- Assessing the risk to human health, safety, public welfare, and the environment posed by the Site-related OHM
- Identifying potential Immediate Response Actions (IRAs), Release Abatement Measures (RAMs), Utility Related Abatement Measures (URAMs), or other Remedial Response Actions (RRAs) that may be warranted at the Site

- Determining if a Response Action Outcome (RAO) can be achieved for the Site at the completion of the Phase II CSA or if additional Comprehensive Response Actions (CRAs) are necessary at the Site before a RAO can be achieved

To achieve these objectives, a number of investigation programs were developed and then implemented during the Phase II CSA. The investigation programs were outlined in four Scopes of Work (SOWs) that were previously submitted to the Massachusetts Department of Environmental Protection (MassDEP). These SOWs included the original Phase II SOW and a Supplemental Scope of Work (SSOW) for the Site that were prepared by EECS and ARCADIS and submitted to the MassDEP in April 2007 and May 2008, respectively. Second and third SSOWs (SSOW-2 & SSOW-3) were submitted to the MassDEP by GZA and Anchor QEA in December 2009 and April 2011, respectively. The marine field investigation activities outlined in these SOWs were undertaken between May 2007 and August 2007, between May 2008 and June 2008, between December 2009 and August 2010, and during April and May 2011, respectively. The investigation programs are described in more detail in subsequent sections of this report.

## **1.2 Identification of LSP and Person Undertaking Response Action**

National Grid is undertaking, and intends to continue to undertake, the actions required by the MassDEP under Massachusetts General Law (MGL) Chapter 21E and the MCP, with respect to MGP waste at this site. Matthew Barvenik, LSP of GZA is the Licensed Site Professional (LSP) of record for this site (License Number 1631). The contact information for National Grid and the LSP are included on the MassDEP Phase II CRA Transmittal Form (BWSC-108) that accompanies GZA's Phase II CSA report.

## **1.3 Site Location and Description**

The Site is located along Harbor Loop in Gloucester, Massachusetts (Figure 1.3 – 1), within a heavily used, industrialized, waterfront area of Gloucester. The former MGP structures were primarily located on the properties that currently comprise the Solomon Jacobs Park and the property currently owned by National Grid. Portions of the building situated on the National Grid property are currently leased to the City of Gloucester Harbormaster's office (referred to at times throughout this report as the Harbormaster).

The former MGP property is abutted to the southwest by the Gloucester Station of the United States Coast Guard (USCG), to the northwest by commercial buildings and portions of the Fitz Hugh Lane Park, to the north by the Gloucester Maritime Heritage Center, which consists of an aquarium, museum, and working marine railway, and to the east and south by Gloucester Inner Harbor.

The Site and the area in the vicinity of the Site are zoned for marine industrial use by the City of Gloucester. However, residential properties are located within one-half mile of the Site to the northwest and north and across Gloucester Inner Harbor to the south and southeast.

### **1.3.1 Marine Portion of Site**

The marine portion of the Site includes the portion of Gloucester Inner Harbor located adjacent to the upland properties where the former MGP was located (Figure 1.3 – 1). The marine portion of the Site includes waterfront structures associated with the industrial, commercial, and navigational uses of the Inner Harbor. The waterfront structures include the pier that is situated on National Grid-owned property. National Grid currently leases the pier to the City of Gloucester. A portion of the pier extends onto the City of Gloucester owned property. The City of Gloucester allows its portion of the pier to be used as a temporary docking facility by the public. The Gloucester Harbormaster also uses the pier as a base of operations. The pier is used throughout the year but most extensively in the warmer months.

Also included in the waterfront area to the southwest is the Gloucester Station of the USCG and an associated pier and pile-anchored floating dock, and to the north is the Gloucester Maritime Heritage Center working marine railway and associated docks. The remainder of the Inner Harbor portion of the Site includes the entrance channel (i.e., Federal Navigation Channel) to the Inner Harbor. The State Fish Pier is located northeast of the Site.

The marine portion of the Site was divided into two areas, identified in this report for ease of reference as the Dock Area and the Navigation Channel Area, due to the differing environmental conditions in these areas. The Dock Area represents the area within approximately 20 feet of structures (e.g., seawalls and docks) and is located landward of the

Harbor Commissioner's Line. Two marine railways (one currently active and another abandoned) and several docks where marine vessels tie up are located within the area. The area is also adjacent to the shoreline where industrial facilities (i.e., MGP, paint manufacturing, steamboat terminal, additional marine railways, fishing docks, fish oil, and glue manufacturing) have previously been located. The Navigation Channel Area is seaward of the Dock Area and represents an area that does not contain structures. It is more distant from industrial activities and is located mostly within the federal Navigation Channel.

## **1.4 Site Bathymetry and Hydrogeology**

### **1.4.1 Marine Bathymetry**

Gloucester Harbor marine bathymetry in the vicinity of the Site has been modified significantly from natural conditions by dredging. Based on dredging records collected in the Massachusetts Navigation and Dredging Management Study that was completed by the United States Army Corps of Engineers (USACE) for the State of Massachusetts, a reported total of 1,178,370 cubic yards (cy) of material has been dredged from Gloucester Harbor and the Annisquam River since 1932. Much of this volume was dredged prior to 1965, when, according to USACE, the federal channel and anchorage areas were last dredged. Additional dredging in the harbor since 1965 has included projects performed by the Massachusetts Department of Environmental Management (DEM) at various locations and many private dredging operations (Massachusetts Office of Coastal Zone Management [MCZM] 2000).

Documented historical dredging in the vicinity of the Site that would be expected to modify the bathymetry from natural conditions includes the following:

- Removal of approximately 1,800 cy of material in the slips located between the upland portion of the Site and the main Navigation Channel. The proposed dredge depth in the slips was to elevation -14 feet mean low water (MLW) based on a September 1984 dredge permit issued by the Commonwealth of Massachusetts Department of Environmental Quality Engineering (DEQE; Massachusetts DEQE 1984). According to Personal Communication (Parsons 2010), the proposed dredging within the Harbormaster slip was not apparently completed due to the observation of what was identified as visually contaminated sediment, but the dredging in the vicinity of the USCG was completed.
- Removal of approximately 600 cy (Coneco Environmental Corporation [Coneco]

1996) in the vicinity of the USCG to a depth of -8 feet MLW.

Bathymetry near the Site corresponds to mean lower low water (MLLW) water depths that vary from shallow (particularly near the seawall that separates the upland from the marine portion of the Site) to more than 20 feet deep in the main Navigation Channel that passes in front of the Site (Figure 1.4.1 – 1). In general, the slips are shallow near the shore and deepen to depths up to 15 to 20 feet as you move closer to the Navigation Channel of the Gloucester Inner Harbor. Depths in the main Navigation Channel generally vary between 20 and 23 feet, which is greater than but close to the USACE channel design depth of 20 feet.

Dredging records indicate both unconsolidated sediment and rock were removed from areas within Gloucester Harbor, which contributed to the development of the present bathymetry.

#### **1.4.2 Marine Hydrogeology**

Gloucester Harbor is a coastal embayment with a mean tidal range of about 8.7 feet. Tides are semi-diurnal (generally two high tides and two low tides per day). There are no significant freshwater inflows to the harbor except for the Annisquam River. The Annisquam River is a tidal river fed by fresh water tributaries, and drains into Gloucester Outer Harbor. Gloucester Harbor has various smaller coves and embayments between rocky headlands that are located at the seaward mouth of the harbor.

Based on the lack of freshwater inputs, coastal hydraulics and circulation in the harbor are expected to be driven primarily by tides and by storm events. Storm events are dominated by winter storms that typically generate wind and waves that approach from the northeast. The Gloucester Harbor entrance is relatively narrow and oriented to the southwest, reducing the influence of storms on the harbor hydraulics and circulation. This is supported by the sediment grain size reported in other parts of the harbor (MCZM 2000) and in the Phase II CSA investigations. Sediments are primarily fine grained, consistent with a low hydraulic energy depositional environment. This is also consistent with National Oceanic and Atmospheric Administration (NOAA) tidal current predictions that indicate tidal currents are generally expected to be less than 1 knot in the Inner Harbor.



The nearshore groundwater and porewater interaction with harbor surface water is addressed in GZA's Phase II CSA report and in the SSOW-3 Data Memorandum, which is included as an Appendix to GZA's Phase II CSA report.

## **1.5 Scope of Work**

### **1.5.1 Scope of Work: Marine**

The SOW conducted as part of the Phase II CSA was intended to meet the MCP requirements for CSA reports (310 CMR 40.0835) and included the following:

- A review of historical information
- Comprehensive field investigations and laboratory testing, including collecting sediment, surface water, and porewater samples for laboratory chemical, physical, and biological testing
- Preparing a MCP Method 3 Stage II ERC to evaluate the risk of harm posed by the Site to the environment
- Preparing this report

As mentioned previously, the SOW for the marine portion of the Site was submitted to MassDEP in the following four documents:

- Phase II CSA SOW submitted by National Grid to MassDEP in April 2007 (EECS 2007)
- SSOW submitted by National Grid to MassDEP in May 2008 (EECS 2008)
- SSOW-2 submitted by National Grid to MassDEP in December 2009 (GZA 2009)
- SSOW-3 submitted by National Grid to MassDEP in April 2011 (GZA 2011)

The April 2007 SOW included a review of environmental investigations performed previously for the Site and for other sites in Gloucester Inner Harbor. A summary of those environmental investigations is presented in this CSA in Section 2.2.1.

The April 2007 SOW was implemented by EECS and ARCADIS between May 2007 and August 2007 (see Section 3.1.1). Based on the findings of the 2007 investigations, a plan for a supplemental environmental field and laboratory investigation was developed by EECS and ARCADIS. The SOW for the supplemental investigations was included in the May 2008 SSOW.

The May 2008 SSOW was implemented by EECS, ARCADIS, and AMEC between May 2008 and June 2008 (see Section 3.1.2). The 2008 SSOW included sediment, surface water, and biological sampling, laboratory analyses, and analyses of field and laboratory investigation data to develop a Stage II ERC.

The December 2009 SSOW-2 was implemented by Anchor QEA and GZA between December 2009 and August 2010 (see Section 3.1.3). The data were collected to supplement previously collected data. Sediment samples were also collected to assess the concentration of select metals (i.e., arsenic, chromium, copper, lead, mercury, and zinc) in the Dock Area due to the historical industrial uses of the waterfront. Five composite samples were collected for waste characterization analysis for use in the Phase III Remedial Action Plan (RAP). In addition, sediment samples were collected to characterize the sediment for off-site disposal in regards to polychlorinated biphenyls (PCBs).

SSOW-3, which was submitted to the MassDEP in April 2011, was implemented by Anchor QEA and GZA in April 2011 (see Section 3.1.4). The data were collected to further assess the porewater in deeper sediment and the location of the marine Site boundary. The nearshore groundwater and porewater interaction with harbor surface water is addressed in GZA's Phase II CSA report and in the SSOW-3 Data Memorandum, which is included as an Appendix to GZA's Phase II CSA report. The marine Site boundary data and sediment cores collected in support of the porewater data will be discussed in this report.

A general description of the combined SOWs for this CSA follows. A more detailed description is presented in Section 3.0. The Phase II CSA and Supplemental CSA SOWs included the following:

- Review of previous environmental investigations in Gloucester Inner Harbor, including the EECS Phase I Initial Site Investigation (ISI; EECS 2006)
- The 2007 field and laboratory investigation included the following:
  - Collecting a combined total of 148 push cores and vibracores for visual characterization; selected cores were sampled for laboratory chemical and physical analyses.

- Collecting surface water samples at high and low tide from three locations in Gloucester Inner Harbor
- The 2008 field and laboratory investigation included the following:
  - Collecting a combined total of 73 push cores and vibracores for visual characterization; selected cores were sampled for laboratory chemical and physical analyses.
  - Collecting 25 shallow sediment samples with a Ponar sampler for laboratory physical, chemical, and biological analyses
  - Collecting surface water samples at high and low tide from six locations in Gloucester Inner Harbor
- The 2009/2010 field and laboratory investigation included the following:
  - December 2009/January 2010:
    - Collecting a total of 42 vibracores for visual characterization; selected cores were sampled for laboratory chemical analyses
    - Collecting six shallow sediment samples with a Ponar sampler for laboratory chemical analyses
    - Collecting surface water samples at low tide from five locations in Gloucester Inner Harbor
  - August 2010:
    - Collecting a total of 44 vibracores for visual characterization; selected cores were sampled for laboratory chemical analyses
    - Collecting 12 shallow sediment samples with a Ponar sampler for laboratory chemical analyses
    - Conducting a video survey of the marine railway
- The 2011 field and laboratory investigation included the following:
  - Conducting an initial harbor near-bottom surface water screening survey
  - Collecting a total of ten vibracores for visual characterization; samples from select cores were submitted to the laboratory for archiving purposes
  - Collecting 21 shallow sediment samples with a Ponar sampler for laboratory chemical analyses

- Installing temporary well points at 23 locations; at five locations, well points were installed at multiple depths; water samples were submitted for laboratory chemical analyses
- Conducting a visual seawall survey

To map field investigation locations, the portion of the Inner Harbor located in the former MGP property vicinity and measuring about 1,400 feet (oriented southwest-northeast) by about 1,300 feet (oriented northwest-southeast) was divided into 25-foot by 25-foot grids. Each grid was assigned a unique identifier. From these investigations, the following combined samples were collected for laboratory analyses:

- One hundred fifty-nine shallow (considered to be from the mudline to a depth of 0.5 foot below the mudline or alternatively in this report identified as the 0.0 to 0.5 feet depth) sediment samples collected from cores, including one hundred thirty-eight located within the grid area, and twenty-one collected from more remote locations to characterize Local Conditions.
- Eighty deep (considered to be from depths greater than 0.5 feet or alternatively in this report identified as > 0.5 feet) sediment samples collected from cores, including sixty-six located within the grid area, and fourteen collected from more remote locations to characterize Local Conditions.
- Fifty-five shallow sediment samples collected with a Ponar sampler, including thirty-seven located within the grid area, and eighteen collected from more remote locations to characterize Local Conditions.
- Twenty-three surface water samples, including twelve located within the grid area, and eleven collected from more remote locations to characterize Local Conditions.
- Twenty-four porewater samples collected from well points within the grid area. These samples are discussed in GZA's Phase II CSA report and in the SSOW-3 Data Memorandum which is included as an Appendix to GZA's Phase II CSA report.

The data collected during the historical information review and field and laboratory investigation programs were evaluated for quality assurance consistent with MassDEP Data Usability Assessment (DUA) requirements, analyzed, and interpreted (Appendix 1.5.1 – A). The data were then used for evaluating the nature and extent of OHM and the characterization of potential risk associated with OHM including preparing a MCP Stage II ERC.

The information obtained during implementation of the SOWs is presented below in a format that is consistent with the MCP requirements for a Phase II CSA Report (310 CMR 40.0835).

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## 2 SITE AND REGULATORY HISTORY

### 2.1 General Site and Regulatory History

A detailed description of the general site and regulatory history associated with the Site is presented in GZA's Phase II CSA report.

### 2.2 Previous Investigations

#### 2.2.1 *Marine*

Previous investigations to evaluate the presence of OHM in Gloucester Harbor in the vicinity of the Site include the following:

- Data included in the 1984 DEQE Permit Number 133 for the Gloucester Community Dredging Project
- Data reported in a 1987 and 1988 water quality survey (Duerring 1989)
- A letter to the USCG (Coneco 1996)
- A letter to the USACE (MCZM 2000)
- Data summarized in the Environmental Partners Group, Inc. (EPG) Class C RAO and Activity and Use Limitation (AUL) report for the Gloucester Marine Railway Site located adjacent to the former Gloucester MGP site (EPG 2004)
- Data summarized by EA Engineering, Science, and Technology, Inc. (EA Engineering) in an IRA Completion Report in 2006 for the USCG Gloucester facility following a release of oil-like material during marine bedrock drilling activities (EA Engineering 2006)
- The Phase I ISI performed by EECS (EECS 2006)
- Data included in a letter to the MassDEP regarding Gloucester Inner Harbor Dredging (CLE Engineering 2009)

Reported sample locations are shown on Figure 2.2.1 – 1 and statistics associated with the data are presented in Table 2.2.1 – 1.

Information included in several of these investigation reports was reviewed prior to developing the Phase II SOW (EECS 2007) to preliminarily evaluate Gloucester Harbor sediment and surface water to support development of a field investigation plan that would meet the Phase II requirements of the MCP. The information included in the previous

investigations was evaluated and combined with the information developed during the 2007 Phase II CSA field and laboratory investigation, and the 2008 Phase II CSA field and laboratory investigation. A summary of the historical information follows.

**DEQE Permit 133, 1984** – The data collected for this permit were to support the Gloucester community dredging project. Approximately 21 properties were incorporated in the permit, including an area around the pier that is situated on National Grid-owned property. The sampling method and the depth of the samples are unknown.

As noted in Section 1.4.1, because the data were reported to support subsequent dredging activities, it is unknown how much of the characterized sediment remains. The DEQE Permit 133 data were not considered to be of adequate data quality for use in the CSA because of the age of the data and because of the uncertainty associated with the samples.

**Duerring, 1989** – Four sediment samples were collected within Gloucester Inner Harbor in support of the 1987 and 1988 water quality survey. It is unknown how these samples were collected or the depth interval samples were collected from. The data included in the Duerring report (1989) were not considered to be of adequate data quality for use in the CSA because of the age of the data and because of the uncertainty associated with the samples.

**Coneco, 1996** – Four sediment samples were collected in the vicinity of the USCG property in support of a Chapter 91 dredging application. The samples were collected with a geoprobe and from the interval 0.0 to 4.0 feet. Similar to the DEQE Permit 133 data, because the data were collected in support of subsequent dredging activities, it is unknown how much of the characterized sediment remains.

Although the data presented by Coneco (1996) is of adequate quality for use in the CSA, due to the dredging activities that occurred following the collection of the sediment samples, it is unknown whether any of this material remains in place. Therefore, the data can be utilized to represent historical chemical concentrations in sediment in the harbor but are not considered representative of current sediment conditions.

**Massachusetts Coastal Zone Management, 2000** – Maguire Group summarizes the results of sediment investigations performed for the MCZM. The sediment samples included in the

Dredge Material Management Plan were collected by Arthur D. Little, Inc. (ADL). Most samples include a mixture of two to three individual samples combined to form a composite sample. The samples were collected within the federal Navigation Channel that is located offshore from the former Gloucester MGP site. Accordingly, the sediment chemical and physical properties potentially have been impacted by ongoing navigation.

The MCZM data (2000) were not considered to be of adequate data quality for use in the CSA because the location of the samples could not be verified due to compositing of samples over a relatively large area and samples were collected from a wide range of sediment depths.

**EPG, 2004** – The data summarized in the EPG report was collected from 2000 to 2001 by EPG and Metcalf & Eddy, Inc. (M&E). The sediment samples included shallow and deep samples collected in the vicinity of the marine railway and four additional samples (7S, 8S, 9S, and 10S) located remote from both the Gloucester Maritime Heritage Center site and the Site that were collected and analyzed to evaluate Local Conditions.

Surface water samples were also collected and tested for metals; however, quality assurance (QA) issues were reported for the samples based on sampling methods that likely introduced non-representative suspended sediment in the surface water samples. The presence of the suspended sediment would very likely result in skewed higher concentrations of OHM that preferentially sorbs to solids. While the surface water data presented by EPG (2004) were not considered to be of adequate data quality for use in the CSA because of the reported QA issues, the sediment data were considered of adequate quality to use in the Phase II CSA analysis.

**EA Engineering, 2006** – The data summarized in the EA Engineering report was collected from 2005 to 2006 by EA Engineering. The sediment samples included surface sediment samples and samples from approximately 0.5 feet below the mudline collected in the vicinity of the USCG floating dock. The samples were collected to assess sediment conditions following a release of oil-like material released during marine bedrock drilling operations.

The EA Engineering data was considered of adequate data quality to use in the Phase II CSA analysis.



**EECS, 2006** – The data presented in the EECS report was collected in 2006. The samples include three sediment samples and two surface water samples collected from locations adjacent to the former MGP.

The ISI investigation information was considered of adequate data quality to use in the Phase II CSA analysis.

**CLE Engineering, 2009** – The data presented in the CLE Engineering document includes sediment samples collected from locations within the North Channel and along the northwestern shoreline of Gloucester Inner Harbor. Most samples include a mixture of two to three individual samples combined to form a composite sample from an unknown depth.

While the sediment sample depths are unknown and composited samples were collected over a relatively far distance, the data presented by CLE Engineering were generally considered of adequate data quality to use in the Phase II CSA analysis.

Based on the age of the samples included in several of the previously summarized reports (generally more than 10 years old) and uncertainty regarding sample depth, collection method, laboratory analyses method, alteration of sediment due to dredging, and/or sample location, the data associated with the majority of these samples were considered only as very general background information.

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### 3 PHASE II FIELD INVESTIGATIONS

#### 3.1 Marine Investigations

Phase II CSA field investigations in Gloucester Harbor were performed in 2007, 2008, 2009/2010, and 2011 and included sediment, surface water, and porewater sampling. Some sediment cores were collected for visual characterization only. For other cores and grab samples, sediment samples were collected for laboratory analyses for chemical and physical parameters. Additionally, some sediment samples were collected from shallow sediment grab samples in 2008 and submitted to a laboratory for biological testing.

Surface water samples were collected from Gloucester Harbor for laboratory chemical analyses and field testing of physical properties in 2007, 2008, and 2009/2010.

As mentioned previously, to map field investigation locations, the portion of the Inner Harbor was divided into 25-foot by 25-foot grids. The grids were laid out over an area located beside the former MGP property. The area measures about 1,400 feet by 1,300 feet and is bounded by axes oriented southwest-northeast (identified as the “E” axis), and northwest-southeast (identified as the “N” axis). Each grid was assigned a unique identifier that included the grid location on the N axis, and the grid location on the E axis.

The dimensions of the gridded area were selected based on experience working on former waterfront MGP sites and the general dimensions of the areas impacted by MGP OHM at those sites, Gloucester Inner Harbor sediment quality data available during development of the Phase II CSA SOW, and our knowledge of Gloucester Harbor hydrodynamics and OHM transport potential. The gridded area dimensions were initially selected to extend beyond the area expected to have been impacted by MGP OHM. The gridded area was configured to be expanded if needed.

#### *Field Classification of Visible Oil/Tar in Sediment Samples*

One of the objectives of Phase II activities was to investigate the presence, if any, of Readily Apparent Harm (RAH) as defined in Section 40.0995 (3)(b)1.(c) of the MCP and as follows:

*Visible presence of oil, tar, or other non-aqueous phase hazardous material in soil within three feet of the ground surface over an area equal to or greater than two acres, or over*

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*an area equal to or greater than 1,000 square feet in sediment within one foot of the sediment surface.*

Visible oil and/or tar (VOT) was observed in 98 of 315 sediment cores collected within Gloucester Inner Harbor in the vicinity of the Site.

VOT was defined as the presence of nonaqueous phase liquid (NAPL) within the sediment cores. The degree of NAPL ranged from discrete droplets to sediment saturated with NAPL. Saturated sediment is defined as sediment pore space mostly occupied by NAPL. The NAPL appeared in a color and consistency similar to typical source oil/tars observed on MGP sites. However, for field classification purposes, terms were developed to provide consistency in describing residual MGP contamination that was not in the form of NAPL within the sediment (and, therefore, not considered VOT). The terms were used to help distinguish sediment that met the MCP definition of RAH from sediment that did not. Examples of these terms include “sheen” and “staining” and are defined as follows:

- Sheen indicates an oil/tar residue that is present in sediment or on water as a very thin film. Because sheen was present only as a very thin film, sheens did not have the same color or consistency as a typical source oil/tar and were considered a residue of the source oil/tar. Accordingly, sheens in general were not considered to be consistent with the visible presence of oil/tar. Sheens appeared in a range from spotty to light and discontinuous to heavy and continuous. Although sheens were not defined as VOT, to be conservative sediment cores containing “heavy sheens” within the upper foot of sediment were classified as including VOT and were, therefore, included in the RAH area.
- Staining indicates sediment particles had been in contact with oil/tar, which left residual material that discolored the sediment, but that oil/tar was not present as a visible separate phase material. Equipment used in the processing of sediment cores was observed as well as the core liner. Sediment was smeared on gloves, and the gloves were lightly rinsed with water. If no NAPL droplets were observed on the equipment, liner, or gloves, the sediment was considered stained. Stained sediment was considered not to represent VOT.

In summary, VOT was defined as the presence of NAPL within sediment cores. Degrees of contamination not considered VOT (i.e., sheens and staining) were defined to aid in

consistency of field descriptions. Varying combinations of sheen, staining, and NAPL were observed in sediment cores.

Details of the field investigations are presented below.

### **3.1.1 2007 Investigation**

Representatives from ARCADIS and EECS were on site from May 21 through May 31, 2007, and August 13 through August 17, 2007, to collect and process sediment cores and surface water samples (Table 3.1.1 – 1).

A total of 148 push cores and vibracores were collected by TG&B Marine Services, Inc. (TG&B) of Falmouth, Massachusetts, from a workboat. The cores were collected from locations that were selected to assess the nature and extent of VOT and OHM in the sediment. Push cores were collected from areas with soft surficial sediment. Vibracoring methods were used to penetrate into deeper sediments that could not be sampled using the push cores. ARCADIS and EECS field technicians processed the cores on shore.

Sediment core information was recorded by field personnel for the push cores and vibracores, including field sample location coordinates (determined using a vessel-mounted Global Positioning System [GPS] unit), time of collection, water depth (measured with a weighted line), core recovery, and penetration and is presented in Table 3.1.1 – 1. The core locations are shown on Figure 3.1.1 – 1.

In accordance with the Quality Assurance Project Plan (QAPP) prepared for the Site and included in the original Phase II SOW, the following procedures were followed when performing the investigation activities. Field activities did not significantly deviate from sampling procedures included in the SOW or QAPP.

#### *Push Core Collection Methods*

A 3-inch diameter clean aluminum core liner was cut to length and rinsed with seawater. A piston was inserted into the bottom of the liner, and a line attached to the piston was drawn up through the top of the liner. The liner was then filled with seawater. The top of the liner was attached to a pushrod. The bottom of the push core was lowered to approximately 1

inch above the sediment-water interface, and the piston line was tied off to keep the piston at the sediment-water interface. Pressure was exerted onto the pushrod to push the liner into the sediment. If the liner could not be pushed 2 to 3 feet into the sediment, a slide hammer was used to attempt additional penetration. Upon hitting refusal or the targeted penetration depth, the liner was then pulled from the sediment. The bottom of the core was immediately capped and taped. The pushrod was then detached. Standing water was drained from the top of the core, extra liner protruding above the top of the core was cut off, and the top was capped. Water depth, penetration, recovery, time, and the presence of VOT or sheens on the equipment or water surface were recorded in a field notebook. The latitude and longitude of the core location were recorded in the shipboard GPS unit.

#### *Vibracore Collection Methods*

A piston and a core catcher were attached to the aluminum liner. The line attached to the piston was drawn up through the top of the tube. The water depth was measured and the coring tube was lowered to the sediment-water interface. When the end of the core was at the sediment-water interface, the line attached to the piston was tied off. Pressure was exerted on the tube by hand, pushing it into the sediment until resistance was encountered. The vibrating head was then attached to the top of the aluminum tube. The head vibrated the tube at about 7,200 vibrations per minute. When the tube met refusal, the vibrating head was turned off and detached from the tube. The tube was then removed from the sediment. Upon reaching the surface, the catcher was removed from the core barrel and the end was capped and taped. The piston was then removed from the top of the core. Standing water was drained from the top of the core, extra liner protruding above the top of the core was cut off, and the top was capped. Water depth, penetration, recovery, time, and the presence of VOT or sheens on the equipment or water surface were recorded in a field notebook. The latitude and longitude of the core location was recorded in the shipboard GPS unit.

The push cores and vibracores were labeled, transported to shore, and stored upright. To process the core, the core was placed in a rack, and the liner was cut lengthwise on both sides with power snips. The core was then split open and photographed with a label and tape measure included in the field for identification and scale. Field personnel visually classified and recorded a description for each core. Samples were collected for laboratory analysis per the Phase II CSA SOW.

Samples were submitted to Alpha Analytical Lab (Alpha) of Westborough, Massachusetts, for analysis of polycyclic aromatic hydrocarbons (PAHs; Environmental Protection Agency [EPA] Method 8260-SIM), volatile petroleum hydrocarbons (VPHs; MCP Method VPH-04-1.1), total organic carbon (TOC; EPA Method 9060), and grain size (Method ASTM D422; Table 3.1.1 – 2). Samples were also submitted for grain size analysis to GeoTesting Express of Boxborough, Massachusetts.

Sediment core logs for cores collected in 2007 are presented in Appendix 3.1.1 - B.

Photographs of sediment cores are included in Appendix 3.1.1 – C.

### *Surface Water*

Surface water samples were collected from three locations from TG&B's workboat on May 29, 2007 (Figure 3.1.1 – 2). Two sets of water samples were collected from the three locations—one set at low tide and one set at high tide and submitted for analysis of PAH (Table 3.1.1 – 3). An additional two sets of water samples were collected from the same approximate locations on August 16, 2007—one set at high tide and one set at low tide. These samples were collected for analysis of available cyanide (Method OIA-1677) and shipped to the laboratory, but the samples were misplaced and not analyzed by the laboratory.

At each surface water sampling location water parameters were measured in the field with a YSI6920 at one-half of the water depth. The parameters included temperature, conductivity, salinity, dissolved oxygen, pH, oxidation reduction potential (ORP), and turbidity. A Kemmerer sampler was used to collect a water sample at one-half the water depth.

Sediment and surface water samples were collected as follows:

- A total of 66 sediment samples were collected for laboratory analysis from 47 locations within the grid area, including 47 samples from surface sediment (0.0 – 0.5 feet) and 19 samples from deeper sediment (>0.5 feet). Three of the surface sediment samples that were analyzed were collected as duplicates for quality assurance/quality control (QA/QC) purposes in accordance with the QAPP. The total number of samples does not include archived samples submitted to the laboratory in case additional information was desired as these samples were never analyzed. In

addition, one surface sediment sample was collected from each of two locations outside the grid for the purpose of characterizing Local Conditions.

- A total of 7 surface water samples were collected in May 2007 for laboratory analysis from three locations within the grid area—one set during high tide and one set during low tide, plus a duplicate. Seven additional samples were collected for laboratory analysis in August 2007, but were misplaced and were not analyzed.

The number of sediment cores collected and sediment samples analyzed were significantly greater than those proposed in the original Phase II SOW. This was a direct result of observations made in the field and an attempt to delineate the nature and extent of Site-related OHM in one mobilization, which ultimately was not accomplished during 2007.

Laboratory chemical analyses results for 2007 sediment and surface water samples are discussed below in Section 4.1.

### **3.1.2 2008 Investigation**

Representatives from ARCADIS, AMEC, and EECS were on site from May 20 to June 4, 2008, to collect and process sediment cores, shallow sediment samples collected with a Ponar sampler, and surface water samples (Table 3.1.2 – 1).

#### *Sediment Cores*

A total of 73 push cores and vibracores were collected by TG&B from a workboat. The cores were collected on a grid system and locations were selected to further assess the extent of VOT and OHM in the sediment based on the results from the 2007 field activities. Push cores were used in areas with softer surficial sediment. Vibracoring methods were used to attempt to penetrate deeper sediments that could not be accessed by the push cores.

ARCADIS and EECS field technicians processed the cores on shore.

Sediment core information for both the push cores and vibracores, including field sample location coordinates (determined using a vessel-mounted GPS unit), time of collection, water depth (measured with a weighted line), core recovery, and penetration is presented in Table 3.1.2 – 1. The core locations are shown on Figure 3.1.2 – 1.

Push cores and vibracores were collected in the same manner as was described for the 2007 field investigation except a polycarbonate liner was used inside the aluminum core barrel since sediment samples were collected for analysis of metals in 2008. In addition, due to the volume of sediment required for the analyses, two to three cores were collected at each location. The material from the sample interval was composited before being transferred to laboratory-supplied glassware.

Samples collected from sediment cores were analyzed by Alpha of Westborough, Massachusetts, for TOC, Resource Conservation Recovery Act (RCRA) 8 Metals (EPA Method 6020A), PAHs, alkylated PAHs (EPA Method 8260), total cyanide (MCP Method 9014), Acid Volatile Sulfide (AVS)/Simultaneously Extracted Metals (SEMs; EPA Method EPA-121-R91-100), tributyltins (SOP 3200), Total Petroleum Hydrocarbons (TPHs; EPA Method 8100), ammonia (EPA Method 4500NH<sub>3</sub>-BH), and pH (EPA Method 9045C; Table 3.1.2 – 2). Samples were also submitted for grain size analysis to GeoTesting Express of Boxborough, Massachusetts. Note that samples submitted to the laboratories were not necessarily analyzed for the full suite of parameters listed above. The selection for the samples to be analyzed for certain parameters was based on the sampling protocols listed in the SSOW and field conditions.

Sediment core logs for cores collected in 2008 are presented in Appendix 3.1.1 - B. Photographs of sediment cores are included in Appendix 3.1.1 – C.

#### *Ponar Samples*

Samples were also collected from 25 locations with a ponar sampler and split for benthic biology analysis and sediment contaminant bioavailability analysis (Figure 3.1.2 – 2). The samples were transported in 5-gallon buckets and sieved before being split and transferred to laboratory-supplied glassware.

Portions of the samples collected with the Ponar Sampler were submitted for benthic biology analysis. Portions of these samples were also submitted for analysis of alkylated PAHs, TOC, and porewater extraction and analyses using Solid Phase Micro Extraction (SPME) methods by the Energy and Environmental Research Center (EERC) at the University of North Dakota. A summary of the samples is presented in Table 3.1.2 – 3 and Table 3.1.2 – 4.



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### *Surface Water*

Water samples were collected from six locations from TG&B's workboat on June 2, 2008 (Figure 3.1.1 – 2). Two sets of water samples were collected at each location—one set at low tide and one set at high tide. At each location, water parameters were measured in the field with a YSI6920 at one-half of the water depth. The parameters included temperature, conductivity, salinity, dissolved oxygen, pH, ORP, and turbidity. A Kemmerer sampler was used to collect a water sample at about one-half the water depth. The samples were placed in laboratory-supplied glassware and transferred to the lab under chain of custody for analysis of available cyanide by Test America. A summary of the samples is presented in Table 3.1.2 – 5.

Sediment and surface water samples were collected as follows:

- A total of 36 sediment samples were collected from 33 locations within the grid area, including 31 samples from surface sediment (0.0 – 0.5 feet) and seven samples from deeper sediment (>0.5 feet). Two of the surface sediment samples that were analyzed were collected as duplicates for QA/QC purposes in accordance with the QAPP. Nine surface sediment samples and two deeper sediment samples were collected from nine locations outside the grid for the purpose of characterizing Local Conditions. The total number of samples does not include the archived samples submitted to the laboratory in case additional information was desired as these samples were never analyzed.
- Twenty Ponar samples were collected from locations within the study area grid and from five locations outside the grid. In addition to the bulk sediment analyses performed on these samples (similar to the core samples), porewater was extracted from the samples for laboratory analyses.
- Surface water samples were collected during both high tide and low tide from six locations for a total of 12 samples.

Similar to the 2007 investigation activities, the number of sediment cores collected and sediment samples analyzed during the 2008 investigation were greater than those proposed in SSOW. This was a direct result of observations made in the field and an attempt to delineate the nature and extent of site-related OHM, which ultimately was not accomplished during 2008.

Laboratory physical and chemical analyses results for 2008 sediment and surface water samples are discussed below in Section 4.1. Laboratory biological and porewater/SPME analyses for Ponar sediment samples are discussed in the ERC which is included as an Appendix to GZA's Phase II CSA report.

### **3.1.3 2009/2010 Investigation**

#### **3.1.3.1 December 2009/January 2010 Investigation**

Representatives from GZA and Anchor QEA were on site from December 18 to December 23, 2009, and January 5 to January 7, 2010, to collect and process sediment cores, shallow sediment samples collected with a Ponar sampler, and surface water samples (Table 3.1.3.1 – 1).

##### *Sediment Cores*

A total of 40 vibracores were collected by TG&B from a workboat. The cores were collected on a grid system, and locations were selected in order to further assess the extent of VOT in the sediment, further delineate site-related OHM, and assess the concentrations of metals in the Dock Area. Anchor QEA and GZA field technicians processed the cores on shore.

Sediment core information including field sample location coordinates (determined using a vessel-mounted GPS unit), time of collection, water depth (measured with a weighted line), core recovery, and penetration is presented in Table 3.1.3.1 – 1. The core locations are shown on Figure 3.1.3.1 – 1.

Vibracores were collected in the same manner as the 2008 field investigation but only one core was collected at each location. The material from the sample interval was composited before being transferred to laboratory-supplied glassware.

Samples collected from sediment cores were analyzed by Alpha for: select Metals (arsenic, chromium, copper, lead, mercury, and zinc), PAHs, and TOC (Table 3.1.3.1 – 2). Select samples were also submitted for toxicity characteristic leaching procedure (TCLP) Metals (EPA Method 3020A) and hexavalent chromium (Method 7196A) analysis based on total metal concentrations in the samples in order to determine appropriate disposal options for any potential dredged material. In addition, composite samples from select cores were

submitted for Waste Characterization analysis (semi-volatile organic compounds [SVOCs; EPA Method 8260], volatile organic compounds [VOCs; EPA Method 5035], PCBs [EPA Method 8082], TPH, RCRA 8 Metals, ignitability [EPA Method 1010], reactivity [EPA Method SW-846], toxicity, corrosivity [EPA Method 9045C], and paint filter test [EPA Method 9095A]). Sediment from several cores collected from the Harbormaster slip was combined to create one of the composite samples. The same procedure was used to create one composite sample from the marine railway and two composite samples from the Navigation Channel. A summary of the samples is presented in Table 3.1.3.1 – 2.

Sediment core logs for cores collected in December 2009/January 2010 are presented in Appendix 3.1.1 - B. Photographs of sediment cores are included in Appendix 3.1.1 – C.

#### *Ponar Samples*

Samples were also collected from eight locations with a ponar sampler and archived for potential analysis of PAHs (Figure 3.1.3.1 – 1).

#### *Surface Water*

Water samples were collected from five locations from TG&B's workboat on December 22, 2009 (Figure 3.1.1 – 2). One set of water samples was collected at each location around the time of low tide. At each location water parameters were measured in the field with a YSI6920 at one-half of the water depth. The parameters included temperature, conductivity, salinity, dissolved oxygen, pH, ORP, and turbidity. A LaMotte JT-1 Water Sampler was used to collect a water sample at about one-half the water depth. The samples were placed in laboratory-supplied glassware and transferred to the lab under chain of custody for analysis of extractable petroleum hydrocarbons (EPHs; MCP Method EPH-04-1), VPH, and priority pollutant Metals (EPA Method 245.1) by Alpha, and available cyanide by Test America. A summary of the samples is presented in Table 3.1.3.1 – 3.

Sediment and surface water samples were collected as follows:

- A total of 58 sediment samples were collected from 39 locations within the grid area, including 41 samples from surface sediment (0.0 – 0.5 feet) and 17 samples from deeper sediment (>0.5 feet). Four of the surface sediment samples and two of the deeper sediment samples that were analyzed were collected as duplicates for QA/QC purposes in accordance with the QAPP. The total number of samples does not

include the archived samples submitted to the laboratory in case additional information was desired as these samples were never analyzed. All the samples were located within the grid area.

- Eight Ponar samples were collected from locations within the study area grid. Although all eight samples were submitted to the laboratory and identified as archive samples, only one sample was submitted for analysis.
- Surface water samples were collected during low tide from five locations.

Laboratory physical and chemical analyses results for December 2009/January 2010 sediment and surface water samples are discussed below in Section 4.1.

### *3.1.3.2 August 2010 Investigation*

Representatives from GZA and Anchor QEA were on site from August 10 to August 17, 2010, to collect and process sediment cores and shallow sediment samples collected with a Ponar sample (Table 3.1.3.2 – 1).

#### *Sediment Cores*

A total of 44 vibracores were collected by TG&B from a workboat. The cores were collected on a grid system, and locations were selected in order to further delineate site-related OHM, assess the PCB concentrations detected in sediment within the Site compared to Local Conditions for disposal purposes, and further assess the concentrations of metals in the Dock Area. Anchor QEA and GZA field technicians processed the cores on shore.

Sediment core information including field sample location coordinates (determined using a vessel-mounted GPS unit), time of collection, water depth (measured with a weighted line), core recovery, and penetration is presented in Table 3.1.3.2 – 1. The core locations are shown on Figure 3.1.3.2 – 1.

Vibracores were collected in the same manner as the 2008 field investigation but only one core was collected at each location. The material from the sample interval was composited before being transferred to laboratory-supplied glassware.

Samples collected from sediment cores were analyzed by Alpha for select metals (arsenic, chromium, copper, lead, mercury, and zinc), PAHs, and TOC (Table 3.1.3.2 – 2). Select samples were submitted for TCLP Metals analysis. Composite samples from select cores were submitted for Waste Characterization analysis SVOCs, VOCs, PCBs, TPH, RCRA 8 Metals, ignitability, reactivity, toxicity, corrosivity, and paint filter test). Sediment from several cores collected near the USCG facility was combined to create a composite sample. A summary of the samples is presented in Table 3.1.4 – 2.

Sediment core logs for cores collected in August 2010 are presented in Appendix 3.1.1 - B. Photographs of sediment cores are included in Appendix 3.1.1 – C.

#### *Ponar Samples*

Samples were also collected from 11 locations with a Ponar sampler and archived for potential analysis of PAHs (Figure 3.1.3.2 – 1).

Sediment samples were collected as follows:

- A total of 79 sediment samples were collected from 40 locations within the grid area, including 31 samples from surface sediment (0.0 – 0.5 feet) and 27 samples from deeper sediment (>0.5 feet) within the grid area. In addition, 12 samples were collected from surface sediment (0.0 – 0.5 feet) and 13 samples were collected from deeper sediment (>0.5 feet) outside of the grid area. Two of the surface sediment samples within the grid area and two of the surface sediment samples from outside the grid area that were analyzed were collected as duplicates for QA/QC purposes in accordance with the QAPP. The total number of samples do not include the archived samples submitted to the laboratory in case additional information was desired as these samples were never analyzed.
- Eleven Ponar samples were collected from locations within the study area grid. Although all 11 samples were submitted to the laboratory and identified as archive samples, only eight samples were submitted for analysis.

Laboratory physical and chemical analyses results for August 2010 sediment samples are discussed below in Section 4.1.

### **3.1.4 2011 Investigation**

Representatives from GZA and Anchor QEA were on site from April 6 to May 6, 2011, to install and sample temporary well points, and collect and process sediment cores and shallow sediment samples collected with a Ponar sample (Table 3.1.4 – 1).

#### *Temporary Well Points*

Well points were installed at a total of 23 locations by TG&B from a workboat. The samples were collected on a grid system and locations were selected to assess porewater for OHM (Figure 3.1.4 – 1). At five of the locations (AQWP1, AQWP10, AQWP12, AQWP17, and AQWP19), well points were installed at multiple depths in order to sample a vertical profile of porewater. A well point was not installed at location AQWP16 due to inclement wind and wave conditions that were considered unsafe for operations by the field crew.

Temporary well point installation methods are presented in the SSOW-3 Data Memorandum included in GZA's Phase II CSA report.

A total of 24 porewater samples including two duplicates were submitted to GZA's laboratory in Hopkinton, Massachusetts, for analysis of EPH, VPH, and total cyanide. Available cyanide samples were submitted to Trace Analytical Laboratories of Muskegon, Michigan. A summary of porewater samples submitted for analysis is presented in Table 3.1.4 – 2. A summary of the analytical data is presented in the SSOW-3 Data Memorandum included in GZA's Phase II CSA report.

#### *Sediment Cores*

A total of 10 vibracores were collected from nine locations by TG&B from a workboat. The cores were collected on a grid system, and locations were selected to further assess the nature and extent of NAPL in the vicinity of AQWP10. Anchor QEA and GZA field technicians processed the cores on shore.

Sediment core information including field sample location coordinates (determined using a vessel-mounted GPS unit), time of collection, water depth (measured with a weighted line), core recovery, and penetration is presented in Table 3.1.4 – 1. The core locations are shown on Figure 3.1.4 – 1.

Vibracores were collected in the same manner as the December 2008/January 2010 field investigation but only one core was collected at each location. The material from the sample interval was composited before being transferred to laboratory-supplied glassware. Samples collected from sediment cores were submitted to Alpha for archiving purposes.

Sediment core logs for cores collected in 2011 are presented in Appendix 3.1.1 - B. Photographs of sediment cores are included in Appendix 3.1.1 - C.

### *Ponar Samples*

Samples were also collected from 20 locations with a Ponar sampler (Figure 3.1.4 - 1). Thirteen samples and one duplicate were submitted for analysis of PAH and TOC and the remaining samples were archived for potential analysis of PAHs. A summary of sediment samples submitted for analysis is presented in Table 3.1.4 - 3.

Temporary well point samples were collected as follows:

- A total of 26 porewater samples were collected from 23 locations within the grid area. Two of the samples within the grid area that were analyzed were collected as duplicates for QA/QC purposes in accordance with the QAPP.

Sediment samples were collected as follows:

- Twenty Ponar samples were collected from locations outside the study area grid. Fourteen samples, which include one duplicate sample per the QAPP, were submitted to the laboratory for analysis and the remainder were identified as archive samples.
- Ten samples were collected from sediment cores from locations within the study area grid. All the samples were submitted to the laboratory and identified as archived samples.

The number of temporary well points installed and sampled was greater than that proposed in the SSOW-3 which was a result of obtaining access to the USCG property during the course of the SSOW-3 field activities. Sediment cores were not included within the SSOW-3 but were added as a direct result of observations made in the field. This is a deviation from the planned scope of work.

Laboratory physical and chemical analyses results for 2011 temporary well point locations are discussed in the SSOW-3 Data Memorandum included as an Appendix in GZA's Phase II CSA report. Laboratory physical and chemical analyses results for 2011 sediment grab samples are discussed below in Section 4.1.

### **3.2 IDW Management**

During sediment coring activities, a spill control kit was available on the workboat. The spill control kit included absorbent materials for managing sheens on surface water. It was not necessary to deploy the spill control kit during the above-described investigation activities.

Sediment cores were opened, photographed, and sampled on the National Grid-owned property adjacent to the pier. The area used for sediment core processing was lined with a plastic tarpaulin to catch spills and drips from the sediment cores. A spill control kit was also available in the sediment processing area, but was not needed. A temporary work table constructed from sawhorses and plywood was constructed in the processing area.

Waste was separated into ordinary solid waste and investigation derived waste (IDW) in the sediment processing area. Ordinary solid waste included cleaned core barrel refuse, paper, plastic, and other disposable materials. Ordinary solid waste was contained in plastic bags or barrels and removed from the Site for appropriate disposal. IDW included sediment removed from the core barrels and other oily materials (e.g., soiled rags and sorbents). All sediment and liners impacted by VOT were stored in 5-gallon buckets and transferred to 55-gallon capacity drums at the end of each work day. IDW was containerized and stored at the National Grid satellite waste storage facility and transported by a licensed waste hauler to a disposal facility. Copies of Bills of Lading and Waste Manifests are included in GZA's Phase II CSA report.



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## 4 PHASE II RESULTS

This section presents the results of the chemical and physical analyses conducted on environmental samples collected from the marine portion of the Site during the Phase II Investigation. Information pertaining to sampling methodology and laboratory analysis were presented in Section 3.0. Laboratory data sheets are included in this report as Appendix 4.0 – D.

### 4.1 Marine

Environmental samples were collected within the Gloucester Inner Harbor between 2005 and 2011. Sediment and surface water samples were collected within the gridded portion of the harbor (see section 3.1) as well as at selected locations outside of the designated grid sampling area (Figure 4.1 – 1). Samples taken outside of the gridded area were collected with the objective of identifying Local Conditions. A detailed discussion of defining and verifying Local Conditions samples is presented in Section 5.1.2. Porewater was also extracted from some of the sediment samples and analyzed for PAHs.

As noted in Section 2.2.1, only the data collected at the Site since EA Engineering’s field investigation in 2005 is included in this site evaluation due to quality control (QC) concerns regarding earlier data. The sampling events and corresponding sample locations discussed in this section are presented in the table below.

	Investigation/Investigator	Date	Figure
2005/2006 Field Work	Sediment Samples/EECS and ARCADIS	2005	2.2.2 - 1
	Surface Water/EECS	2006	2.2.2 - 1
SOW	Cores/EECS and ARCADIS	2007	3.1.1 - 1
	Surface Water/EECS and ARCADIS	2007	3.1.1 - 2
SSOW	Cores/EECS and ARCADIS	2008	3.1.2 - 1
	Surface Water/EECS and ARCADIS	2008	3.1.1 - 2
	Grab Samples/AMEC	2008	3.1.2 – 2
SSOW-2	Cores and Grab Samples/Anchor QEA and GZA	December 2009/ January 2010	3.1.3.1 - 1
	Surface Water/Anchor QEA and GZA	December 2009/ January 2010	3.1.1 - 2
	Cores and Grab Samples/Anchor QEA and GZA	August 2010	3.1.3.2 - 1
SSOW-3	Temporary Well Points/Anchor QEA and GZA	2011	3.1.4 - 1
	Cores and Grab Samples/Anchor QEA and GZA	2011	3.1.4 - 1

Statistics regarding the minimum, maximum, and average values along with number of samples are included in Table 4.1 – 1. The samples are evaluated as two groups: Site Vicinity samples and Local Conditions samples. Site Vicinity and Local Conditions samples were designated based on the analysis as summarized in Section 5.1.2.

A presentation of temporary well point installation methods and a discussion of the analytical results from the temporary well point installations are included in the SSOW-3 Data Memorandum included as an Appendix in GZA's Phase II CSA report and will not be further discussed in this report.

#### **4.1.1 Total PAHs, SVOCs, and EPH**

Environmental samples were collected and analyzed for the EPA 16 priority pollutant PAHs (PAH16). Selected shallow sediment samples were analyzed for PAH16 and for an expanded list that also included PAH16 in addition to alkylated PAHs. Three samples from 2006 (B-1, WB-1, and B-2) were analyzed for EPH. A total PAH16 (TPAH16) concentration was calculated from the results of these analyses. Additional statistics (i.e., minimum, maximum, and average values) were calculated for each environmental matrix on a site-wide basis at particular depth intervals to identify possible trends in the dataset (Table 4.1 – 1).

##### ***Sediment***

Sediment samples were collected from within the sampling grid at 6-inch vertical intervals to evaluate the lateral and vertical extent of OHM in the harbor. A summary of the PAH results in sediment samples is presented in Table 4.1.1 – 1 (PAH16) and Table 4.1.1 – 2 (alkylated PAH [PAH34]). EPH analysis results are presented in Table 4.1.1 – 3. Figure 4.1.1 – 1 shows shallow sediment PAH16 concentrations across the sampled area.

TPAH16 concentrations in samples collected within the grid in the top 6 inches of sediment range from 118 to 4,570,000 micrograms per kilograms ( $\mu\text{g}/\text{kg}$ ) with an average TPAH16 concentration of 229,000  $\mu\text{g}/\text{kg}$  (the total number of samples [n] = 111 samples). The maximum concentration of 4,570,000  $\mu\text{g}/\text{kg}$  reported in the 0 – 0.5 feet depth interval was detected in a sample collected from location N5E21, centrally located within the grid. Visible NAPL was observed in the grab sample collected from this same location, which correlates with the elevated TPAH16 concentration. An average TPAH16 concentration of

96,000 µg/kg (n = 16 samples) was calculated for samples taken within the grid from the 0.5 – 1.0 foot depth interval, which suggests that TPAH16 concentrations in the top 6 inches are greater, on average, than that detected in the 0.5 – 1.0 foot interval (Figure 4.1.1 – 2).

TPAH16 concentrations in the 0.5 – 1.0 interval range from 790 to 450,000 µg/kg. Selected samples were collected at depth (greater than 1.0 foot) within the gridded sample area.

TPAH16 concentrations were calculated for 26 sample locations (i.e., n = 25) from a depth greater than or equal to 1.0 foot and values ranged from 26 to 3,507,200 µg/kg with an average of 210,000 µg/kg for the 25 samples that were collected (Figure 4.1.1 – 3).

Laterally, TPAH16 concentrations were measured in samples in both the Dock Area between docks as well as centrally located within the harbor and the Navigation Channel. Within the top foot of sediment, the individual PAH compounds pyrene, phenanthrene, and anthracene were found in concentrations between 500,000 and 1,000,000 µg/kg and fluoranthene was found at the highest concentration within the gridded area with a concentration in excess of 1,000,000 µg/kg. Naphthalene, chrysene, benzo(a)pyrene, benzo(a)anthracene, anthracene, acenaphthylene, and acenaphthene were also detected in sediment samples at concentrations between 100,000 and 500,000 µg/kg. Including the naphthalene results from the VPH analysis, the highest concentration is 1,700,000 µg/kg (location WB-1).

Naphthalene was detected in the VPH analysis of shallow sediment samples at a range of 5,470 to 1,700,000 µg/kg in the sample set. The maximum concentration was detected in sample WB-1, which was collected near the head of the Harbormaster slip. Naphthalene concentrations greater than 100,000 µg/kg were detected at locations N7E2 (177,000 mg/kg) and N5E11 (270,000 mg/kg).

Sediment samples were also collected at 23 locations outside of the grid in an attempt to characterize Local Conditions. TPAH16 concentrations detected in these sediment samples collected from the top 6 inches ranged from 3,505 to 115,000 µg/kg (29,400 µg/kg average; n = 23). Only one sample was collected outside the designated grid area from below 1.0 foot and analyzed for TPAH16 (LC-SW3; 4.41 µg/kg).

A summary of the minimum, maximum, and average concentrations of TPAH16 and PAH34 is presented in Table 4.1 – 1. A contour map showing TPAH16 concentrations in the surficial sediment (0.0 – 0.5 feet) in the vicinity of the Site as well as Local Conditions is presented in Figure 4.1.1 – 4.

Sediment samples collected from the 0 – 0.5 feet interval at locations B-1 and WB-1 were analyzed for EPH. Detectable concentrations of at least one of the EPH fractions were present in each of the two samples. Concentrations of C11-C22 Aromatics ranged from 24.4 to 53.2 milligrams per kilogram (mg/kg; n = 2); C11-C22 Aromatics, Adjusted ranged from 350 to 4,900 mg/kg (n = 2); C19-C36 Aliphatics were detected at 70 mg/kg in sample WB-1 (n = 1); and C9-C18 Aliphatics ranged from 8.1 to 240 mg/kg (n = 2). A sample was collected from 5 – 7 feet from location B-2. Detectable concentrations of C11-C22 Aromatics and C11-C22 Aromatics, Adjusted were higher than B-1 or WB-1 (308 and 6,910 mg/kg, respectively). C19-C36 Aliphatics and C9-C18 Aliphatics were below detection limits. The PAH16 component of the EPH analysis is discussed above. A summary of the EPH results for these three samples is presented in Table 4.1.1 – 3. EPH analysis was not conducted on samples outside of the sampling grid.

Five composite sediment samples were analyzed for SVOCs for Waste Characterization purposes (Table 4.1.1 – 4). The PAH16 compounds component of SVOCs were detected in some combination in these five samples. In addition, dibenzofuran and 2-methylnaphthalene were detected in four of the five samples. The concentration of TPAH16 ranged from 214 mg/kg (Nearshore – Waste 1) to 1,423 mg/kg (Offshore – Waste 5). This range of concentrations falls within the concentrations of TPAH16 detected in Site samples.

### ***Surface Water***

Surface water samples were collected at two locations in 2006 and six locations in 2007 and analyzed for PAHs (see Figure 2.2.1 – 1 and Figure 3.1.1 – 2). Naphthalene was detected ranging from 0.683 µg/L (SW-101-LT) to 3.21 µg/L (SW-101-HT) in the 2006 surface water samples. 2-Methylnaphthalene was also detected in sample SW-101-HT at a concentration of 1.09 µg/L. Samples collected in May 2007 were analyzed for PAHs, and PAHs were not detected in the six samples. Subsequent rounds of surface water sampling did not include PAH analysis because PAHs were not detected in the samples collected in 2007. A summary of surface water analytical data is presented in Table 4.1.1 – 5.

The surface water samples collected in 2006 were analyzed for EPH and no EPH fractions were detected above the detection limits. In addition, five surface water samples were collected around the time of low tide in December 2009 outside of the designated grid area

and analyzed for EPH. EPH compounds and fractions were not detected above the detection limits in the five samples.

### ***Porewater***

Porewater was extracted from sediment samples collected from the 0 – 0.5 feet depth interval at 22 locations within the grid. Sample locations are shown on Figure 3.1.2 – 2. The TPAH16 concentrations in the 22 porewater samples range from 0.027 to 440 µg/L with an average calculated value of 33 µg/L (Table 4.1.1 – 6). Comparatively, the average TPAH16 concentration in the four porewater samples extracted from sediment samples collected from locations outside of the sampling grid is 0.05 µg/L with values ranging from 0.02 to 0.11 µg/L. TPAH16 concentrations of 150 µg/L and 440 µg/L were calculated for the porewater samples extracted from sediment samples collected from locations N5E11 and N5E21, respectively, both centrally located within the sampling grid. The remaining porewater TPAH16 concentrations were less than 10 µg/L with 13 of the 22 sample concentrations being less than 1.0 µg/L.

### **4.1.2 VPH, TPH, and VOC**

Select sediment and surface water samples were analyzed for petroleum hydrocarbons using various analyses including VPH and TPH. In addition, select sediment and surface water samples were analyzed for VOCs (VPH analysis target analytes).

### ***Sediment***

Sixty-two sediment samples from 46 locations within the sampling grid were analyzed for VPH and target analytes. A summary of the sediment sample VPH analysis results is presented in Table 4.1.2 – 1.

Of the 46 sediment samples collected from the 0.0 – 0.5 feet interval within the sampling grid that were analyzed for VPH, only six exhibited detectable concentrations of the VPH fractions or VOC target analytes. The following individual VOC compounds and VPH fractions were detected in some combination in these six samples (B-1 S1, WB-1, N5E2-S1, N5E15-S1, N7E2-S1 and N9E11-S1):

- benzene (1.66 mg/kg; n = 2)
- ethylbenzene (22 mg/kg; n = 3)

- o-xylene (18 mg/kg; n = 3)
- m/p-xylene (22 mg/kg; n = 3)
- C9-C10 Aromatics (460 mg/kg; n = 4)
- C9-C12 Aliphatics (104 mg/kg; n = 3)

Two of these five samples are located within the Dock Area close to the seawall that is located on the Solomon Jacob Park and National Grid properties. Two of the samples are located in the vicinity of the Harbormaster slip. The remaining two samples are located in the central portion of the sampling grid in the Navigation Channel in the vicinity of the Harbormaster dock.

Sediment samples from the 0.5 – 1.0 foot interval were also collected from 14 locations within the sampling grid and analyzed for VPH. VPH fractions or target analyte VOCs were only detected in four (N(-)17E13-S2, N5E2-S2, N5E3-S2, and N5E11-S2) of the fourteen samples. The following individual VOC compounds and VPH fractions were detected in some combination in these four samples:

- benzene (2.16 mg/kg; n = 2)
- ethylbenzene (7.94 mg/kg; n = 2)
- o-xylene (1.4 mg/kg; n = 2)
- m/p-xylene (0.764 mg/kg; n = 1)
- C9-C10 Aromatics (135 mg/kg; n = 2)
- C9-C12 Aliphatics (164 mg/kg; n = 3)
- C9-C12 Aliphatics Adjusted (35.2 mg/kg; n = 1)
- methyl tert butyl ether (MTBE; 0.35 mg/kg; n = 1)

As with the 0-0.5 foot samples, two of the samples with detectable concentrations of VPH fractions and VOCs were located along the seawall and the remaining two samples were located in the central portion of the sampling grid.

Two samples were collected from sediment depths greater than 1 foot below the mudline. Samples at locations N1E37 (1.5 – 2.0 feet) and N(-)7E15 (3.5 - 4.0 feet) were also collected to represent sediment at depths greater than 1 foot. MTBE was the only VPH-related compound detected in these samples (in N1E37 at a concentration of 0.324 mg/kg). MTBE is

not a compound associated with MGPs and is likely from an unassociated gasoline-related release.

Two sediment samples were collected outside of the sampling grid from the 0 – 0.5 foot interval. VPH fractions and VOCs were not detected above the method detection limit in either sample. A summary of the minimum, maximum, and average concentrations of VPH compounds is presented in Table 4.1 – 1.

Thirteen sediment samples were collected and analyzed for TPH (Table 4.1.2 – 2). Of these samples, nine samples were collected in the Site vicinity while four samples were collected from presumed Local Conditions locations. Concentrations ranged from 588 mg/kg (N0E5) to 41,700 mg/kg (N15E4) in the vicinity of the Site and 1,510 mg/kg (LC-SW2) to 2,460 mg/kg (LN-NE1) from locations presumed to represent Local Conditions. A summary of the minimum, maximum, and average concentrations of TPH is presented in Table 4.1 – 1.

Five composite sediment samples were analyzed for TPH for Waste Characterization purposes. TPH was detected in these samples from 1,560 mg/kg (Offshore - Waste 5) to 9,830 mg/kg (Nearshore - Waste 3).

Five composite sediment samples were analyzed for VOCs for Waste Characterization purposes (Table 4.1.2 – 3). The following individual VOC compounds were detected in some combination in these four of the five samples:

- 1,2,4-Trimethylbenzene (28 mg/kg; n = 3)
- 1,3,5-Trimethylbenzene (1 mg/kg; n = 2)
- ethylbenzene (17 mg/kg; n = 3)
- isopropylbenzene (3.9 mg/kg; n = 2)
- n-butylbenzene (1.4 mg/kg; n = 1)
- n-propylbenzene (1 mg/kg; n = 2)
- naphthalene (440 mg/kg; n = 4)
- o-xylene (16 mg/kg; n = 3)
- p-isopropyltoluene (2.1 mg/kg; n = 2)
- p/m-xylene (27 mg/kg; n = 3)

The highest concentrations of VOC compounds were detected in the sample from Nearshore – Waste 3. All reported VOC compounds were below detection limits in the sample from Offshore – Waste 4.

### ***Surface Water***

Two surface water samples from location SW-101, one representing low tide conditions and the other representing high tide conditions, were collected and submitted for VPH analyses (Table 4.1.1 – 3). No VPH fractions were detected in the two samples. In addition, none of the VPH-related VOC target analytes were detected in the two samples.

Five surface water samples were collected around the time of low tide in December 2009 outside of the designated grid area and analyzed for VPH. VPH compounds and fractions were not detected above the detection limits in the five samples.

### **4.1.3 Metals**

Sediment and surface water samples were analyzed for the presence of metals. Tables 4.1.3 – 1 and 4.1.1 - 3 summarize the analytical results for sediment and surface water.

#### ***Sediment***

Select sediment samples were analyzed for RCRA 8 Metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) as well as copper, nickel, and zinc. RCRA 8 Metals analyses were run on sediment samples from 34 locations within the sampling grid. The additional metals analyses were conducted on samples from a 21-location subset of the 34 locations sampled. An additional 22 locations within the sample grid were analyzed for a select combination of metal analyses (arsenic, chromium, copper, lead, mercury, and zinc) based on results from initial sampling rounds. In addition, nine sediment samples were collected from eight locations outside of the sampling grid and submitted for metals analyses.

Forty-seven samples were collected from the 0.0 – 0.5 foot interval within the sampling grid. The following individual metals were detected in some combination in the samples:

- arsenic (28.2 mg/kg; n = 47)
- barium (103 mg/kg; n = 31)
- cadmium (1.2 mg/kg; n = 31)



- chromium (75.5 mg/kg; n = 47)
- copper (697 mg/kg; n = 37)
- lead (689 mg/kg; n = 47)
- mercury (3.4 mg/kg; n = 37)
- nickel (19.3 mg/kg; n = 21)
- selenium (2.7 mg/kg; n = 31)
- silver (0.8 mg/kg; n = 31)
- zinc (594 mg/kg; n = 37)

Eight samples were collected from locations presumed to represent Local Conditions from the 0.0 – 0.5 foot interval and analyzed for metals. The following individual metals were detected in some combination in the Local Conditions samples: arsenic (17.5 mg/kg; n = 8); barium (76 mg/kg; n = 8); cadmium (0.963 mg/kg; n = 8); chromium (71 mg/kg; n = 8); copper (194 mg/kg; n = 4); lead (142 mg/kg; n = 8); mercury (0.59 mg/kg; n = 8); nickel (20.5 mg/kg; n = 4); selenium (2.5 mg/kg; n = 8); silver (0.731 mg/kg; n = 7); and zinc (254 mg/kg; n = 4).

One sample was collected from the 0.5 – 1.0 foot interval from within the sampling grid. The following individual metals were detected in some combination in the sample: arsenic (7.7 mg/kg; n = 1); barium (33.7 mg/kg; n = 1); cadmium (0.4 mg/kg; n = 1); chromium (25.6 mg/kg; n = 1); lead (14.4 mg/kg; n = 1); mercury (0.0215 mg/kg; n = 1); selenium (1.5 mg/kg; n = 1); and silver (ND; n = 1). No samples were collected from locations presumed to represent Local Conditions for metals analysis from the 0.5 – 1.0 foot interval.

Thirteen samples were collected from greater than 1.0 foot below the mudline within the sampling grid. The following individual metals were detected in some combination in the samples:

- arsenic (8.9 mg/kg; n = 13)
- barium (41.8 mg/kg; n = 6)
- cadmium (1.0 mg/kg; n = 6)
- chromium (31.5 mg/kg; n = 13)
- copper (39.9 mg/kg; n = 7)
- lead (32.6 mg/kg; n = 13)
- mercury (0.047 mg/kg; n = 13)
- selenium (2.2 mg/kg; n = 6)

- silver (0.3 mg/kg; n = 2)
- zinc (68.6 mg/kg; n = 7)

One sample was collected from a location presumed to represent Local Conditions from greater than 1.0 foot below the mudline and analyzed for metals. The following individual metals were detected in the Local Conditions sample: arsenic (8.2 mg/kg; n = 1); barium (31 mg/kg; n = 1); cadmium (0.637 mg/kg; n = 1); chromium (34.3 mg/kg; n = 1); lead (7.3 mg/kg; n = 1); mercury (ND; n = 1); selenium (2.75 mg/kg; n = 1); and silver (ND; n = 1).

A summary of the minimum, maximum, and average concentrations of individual metals is presented in Table 4.1 – 1. The spatial distribution of each metal analyzed in the top 6 inches of sediment is presented in Figure 4.1.3 – 1 through Figure 4.1.3 – 11.

Select sediment samples were also submitted for additional TCLP Metals analysis based on the “Rule of 20” (EPA Method 1311) meaning if the total metal concentration was greater than 20 times the TCLP criteria for that metal, then the sample was also analyzed using the TCLP. Based on this criteria, one sample (MR-2-S1) was submitted for TCLP arsenic analysis; two samples (MR-7-S1 and Waste 2) were submitted for TCLP chromium analysis; 23 samples (see Table 4.1.3 – 2 for sample names) were submitted for TCLP lead analysis; and eight samples (see Table 4.1.3 – 2 for sample names) were submitted for TCLP mercury analysis. TCLP metal analysis results are presented in Table 4.1.3 – 2.

AVS/SEM results are presented in Table 4.1.3 – 3. Tributyltin results are presented in Table 4.1.3 – 4. AVS/SEM and butyltin were analyzed solely for the purposes of determining sediment toxicity as part of the ERC.

### ***Surface Water***

Two surface water samples from location SW-101—one representing low tide conditions and the other representing high tide conditions—were collected and submitted for metals analyses (Table 4.1.1 – 3). The following metals and associated concentrations were detected in the low tide conditions surface water sample: barium (7.80 µg/L); lead (0.410 µg/L); nickel (0.420 µg/L); and zinc (12.0 µg/L). The surface water sample collected at the SW-101 location during high tide contained the following metals and corresponding concentrations:

arsenic (1.50 µg/L); barium (7.50 µg/L); lead (0.380 µg/L); nickel (0.420 µg/L); and zinc (12.0 µg/L).

Five surface water samples were collected around the time of low tide in December 2009/January 2010 outside of the designated grid area and analyzed for MCP 14 Metals. The surface water samples contained the following metals and corresponding maximum concentrations:

- antimony (SW-404; 0.53 µg/L)
- arsenic (SW-404; 9.8 µg/L)
- barium (SW-405; 7.7 µg/L)
- beryllium (SW-403; 0.054 µg/L)
- chromium (SW-402; 5.1 µg/L)
- lead (SW-404; 15.4 µg/L)
- mercury (SW-402 and SW-405; 1.4 µg/L)
- selenium (SW-404; 41.1 µg/L)
- silver (SW-401; 0.04 µg/L)
- thallium (SW-402; 0.12 µg/L)
- zinc (SW-405; 18.2 µg/L)

#### **4.1.4 Polychlorinated Biphenyls**

##### ***Sediment***

A total of 106 sediment samples were analyzed for PCBs as part of this investigation. PCB analysis was conducted using the microscale solvent extraction (MSE) extraction process. A subset of seventeen samples was analyzed for PCBs using the Soxhlet extraction process. Similar concentrations of total PCBs by Aroclor were detected using the two extraction processes. For this report, the results from the MSE extraction process are discussed. Only four of the seven Aroclors normally analyzed were detected in at least one sample above the method detection limit. Aroclor 1242 was detected in five of the 106 samples with the highest concentration (1,140 µg/kg) detected at a remote location (LC-HC4). Aroclor 1248 was detected in 17 of the 106 samples with the highest concentration (890 µg/kg) again detected at a remote location (LC-HC5). Aroclor 1254 was detected in 62 of the 106 samples with the highest concentration (12,000 µg/kg) detected at sampling location N5E11A. However, this sample result was from a duplicate sample (DUP6) and the Aroclor 1254

concentration in the parent sample was 266 µg/kg. Due to the disparity between the parent sample and the field duplicate, both samples were re-extracted from sediment archived at the laboratory and re-analyzed for PCBs by EPA Method 8082 as a corrective action. The Aroclor 1254 concentrations in these re-extraction samples were 319 µg/kg and 330 µg/kg, respectively, which are both similar to the original parent sample result. In addition, four samples from locations surrounding sampling location N5E11A from the same depth exhibited Aroclor 1254 concentrations ranging from not detected below a detection limit of 35.5 µg/kg to 535 µg/kg. Therefore, the 12,000 µg/kg concentration appears to be erroneous and not representative of conditions at this sampling location. The next highest Aroclor 1254 concentration (2,610 µg/kg) was detected in MR-7-S1 located on the Maritime Heritage Center property. Aroclor 1260 was detected in 60 of the 106 samples with the highest concentration (4,370 µg/kg) detected on the Maritime Heritage Center property (MR-3).

Of the 106 samples analyzed for PCBs, 45 were shallow sediment samples (from 0.0 – 0.5 feet) collected from within the sampling grid. Total PCBs by Aroclor were calculated by Anchor QEA as the sum of the detected values and one-half the reporting limit for non-detects (NDs) only for Aroclors that were detected at least one time from the collected samples, which excluded Aroclors 1016, 1221, and 1232. Sediment PCB concentrations, measured as total Aroclors, ranged from below method reporting limits (ND) to 12,000 µg/kg (Figure 4.1.4 – 1) in these 45 samples. As explained previously, the 12,000 µg/kg concentration was measured in a field duplicate sample (DUP6). In the parent sample (N5E11A), the total PCB concentration was 483 µg/kg. The next highest detected concentration was 4,940 µg/kg (MR-3).

Excluding the original DUP6 concentration, the average total PCB concentration for the shallow sediment samples within the sampling grid is 773 µg/kg. Without including the initial DUP6 result, the two samples with the highest concentrations (4,530 and 4,940 µg/kg) were collected adjacent to the former Marine Railway located in the northern portion of the Dock Area. PCB results are presented in Table 4.1.4 – 1, PCB concentrations from surficial sediment (0.0 – 0.5 feet) are presented in Figure 4.1.4 – 1.

Samples were collected from sediment deeper than 1.0 foot in 24 locations within the sampling grid and analyzed for PCBs. PCBs were not detected above the method reporting limits in 21 of these 24 samples. Detected PCB concentrations in the remaining three

samples ranged from 105 µg/kg to 111 µg/kg with an average total PCB concentration of 107 µg/kg. PCB concentrations from samples deeper than 1.0 foot are presented in Figure 4.1.4 – 2.

Samples were collected outside of the gridded area from both shallow sediment (n = 13) and sediment deeper than 1.0 foot (n = 13) and analyzed for PCBs. PCBs were not detected above the method reporting limits in two of the thirteen shallow sediment samples and six of the thirteen deeper sediment samples. Total detected PCB concentrations in shallow sediment (0.0 – 0.5 feet) ranged from 163 µg/kg to 682 µg/kg. The average total PCB concentration detected in shallow sediment is 441 µg/kg. Total detected PCB concentrations in sediment deeper than 1.0 foot ranged from 379 µg/kg to 2,577 µg/kg. The average total PCB concentration detected in deeper sediment is 1,212 µg/kg.

### ***Surface Water***

An analysis of PCBs in surface water was conducted on samples from location SW-101 at both high tide and low tide conditions. PCBs were not detected above the method reporting limits in the samples. A summary of surface water data is presented in Table 4.1.1 – 3.

## **4.1.5 Cyanide**

### ***Sediment***

Shallow sediment samples (from 0.0 – 0.5 feet below the mud line) were collected at 24 sample locations within the sampling grid and submitted for analysis of total cyanide. Concentrations of total cyanide above the method reporting limits were not detected in the samples with the exception of the sample collected from location N2E2 (0.42 mg/kg), located close to the shoreline and proximate to the Gloucester Coast Guard Station dock. Sediment samples from five Local Conditions locations were also collected and submitted for total cyanide analysis. Total cyanide was not detected above the method reporting limits in the five samples. Cyanide results are presented in Table 4.1.5 – 1.

### ***Surface Water***

Surface water samples from location SW-101 were collected at both high tide and low tide conditions and analyzed for physiologically available cyanide (PAC). PAC was not detected

above the method reporting limit in either sample. A summary of surface water data is presented in Table 4.1.1 – 3.

Surface water samples collected at both high and low tide from within the vicinity of the Site as well as from Local Conditions locations were analyzed for available cyanide in 2008. Surface water samples collected at low tide from locations representing Local Conditions were also collected in 2009/2010 and analyzed for available cyanide. Available cyanide was not detected above the method reporting limit in any of these samples.

#### **4.1.6 Ammonia/Nitrogen**

Twenty-two samples from the 0.0 – 0.5 foot interval within the sampling grid were analyzed for ammonia/nitrogen (Table 4.1.6 – 1). The detected concentrations ranged from 21 mg/kg (N0E5) to 40 mg/kg (N11E33). The average concentration was 28 mg/kg. Ammonia/nitrogen was below detection limits in 14 of the samples. Ammonia/nitrogen was also analyzed in five samples collected from the 0.0 – 0.5 foot interval and presumed to represent Local Conditions. Ammonia/nitrogen concentrations were below detection limits in all five samples.

#### **4.1.7 pH**

Twenty-two samples from the 0.0 – 0.5 foot interval within the sampling grid were analyzed for pH (Table 4.1.6 – 1). The detected concentrations ranged from 7.2 (N(-)6E15) to 8.1 (N11E33). The average concentration was 7.6. pH was also analyzed in four samples collected from the 0.0 – 0.5 foot interval and presumed to represent Local Conditions. The detected concentrations ranged from 7.1 (LC-NE2) to 7.5 (LC-NE1). The average concentration was 7.3.

#### **4.1.8 Additional Waste Characterization Analyses**

The five composite samples were analyzed for reactive sulfide and reactive cyanide (reactivity), pH (corrosivity), ignitability, and a paint filter test for Waste Characterization purposes (Table 4.1.6 – 1).

Reactivity is assessed by analysis of reactive sulfide and reactive cyanide. Reactive sulfide ranged from 19 mg/kg (Nearshore – Waste 3) to 340 mg/kg (Offshore – Waste 5). The

average concentration was 135 mg/kg. Reactive cyanide was below detection limits in all five samples.

Corrosivity is assessed by analysis of pH. pH values ranged from 7.8 (Nearshore – Waste 3) to 8.4 (Nearshore – Waste 1 and Marine Railway – Waste 2). The average concentration was 8.1.

All five samples were identified as non-ignitable. All the samples passed the paint filter test except for Nearshore – Waste 1.

#### **4.1.9 Total Organic Carbon**

TOC concentrations are relatively consistent over the extent of the harbor that was sampled (both within and outside of the sampling grid). Similar TOC concentrations were also reported with depth over these samples. A summary of the TOC analysis is presented in Table 4.1.9 – 1.

TOC in sediment samples collected from within the sampling grid in the 0 – 0.5 foot depth interval ranged from 0.99% to 11% with an average TOC of 3.7% over 107 samples. The 15 samples taken outside of the sampling grid over this depth interval had an average TOC concentration of 5.2%.

The average TOC reported for 52 samples collected from depths deeper than 0.5 feet below the mudline was 2.2% with concentrations ranging between 0.43% and 8.1%. Five samples were collected from depths deeper than 0.5 feet below the mudline outside of the sampling grid. These five samples had an average TOC concentration of 3.8%.

Organic carbon was also analyzed as Soot Organic Carbon (SOC) for sediment samples collected within and outside of the sampling grid. SOC results are presented in Table 4.1.9 – 2. The samples were all collected from the top 0.5 feet of sediment. Like the TOC results, SOC results were similar within (maximum concentration = 1.82%; average concentration = 0.72%; n = 20) and outside the grid (maximum concentration = 0.7%; average concentration = 0.55%; n = 5).

#### **4.1.10 Grain Size and Stratigraphy**

##### ***Grain Size***

Fifty sediment samples were collected and analyzed by GeoTesting Express for grain size from within the gridded study area, and 12 samples were collected and analyzed from areas presumed to represent Local Conditions. An additional 43 samples were submitted to Alpha for grain size analysis in 2007; the grain size data received from Alpha were not consistent with field observations and subsequent grain size analyses of similar sediment. Due to these reasons, the grain size data from Alpha was not included in the grain size sediment assessment.

Grain size analysis was performed on 41 sediment samples collected from within the sampling grid from a depth interval of 0 – 0.5 feet. Generally, the sediment samples analyzed were composed of sand and silt/clay fractions at average percentages over the entire 41-sample dataset of 21% and 73%, respectively. Thirteen of the 41 samples were found to have a gravel component ranging from 0.3% to 67%. The maximum value (67% gravel) was reported in sample N17E6, which is located in the vicinity of the marine railway. In addition, samples N7E7 and N8E30 both had gravel fractions greater than 33%.

The ten samples collected from a depth greater than 0.5 feet show that the percentage of silt/clay increases with depth at least within the shallower sediment. The average silt/clay fraction in these eight samples is 90%. Only one sample had a measureable fraction of gravel of 0.2%, which was collected at location N10E23 from a depth interval of 1.0 – 1.5 feet below the mudline.

Samples collected from locations outside of the sampling grid from the 0 - 0.5 foot depth interval have similar grain size fractions from those collected within the grid. For the 11 samples analyzed, the average grain size distribution was approximately 80% silt/clay, 17% sand, and 3% gravel. Samples collected at a depth outside of the sampling grid at two locations—LC-SW3 and LC-NE1—from 2.5 to 3.0 feet below the mudline were found to have a lower percentage of silt/clay and a higher percentage of sand and gravel.

A summary of the grain size analysis results are presented in Table 4.1.10 – 1. A comparison between surficial grain size distributions was conducted for sediment cores located within



and outside the Navigation Channel (Table 4.1.10 – 2). A comparison between different stratigraphic units was also conducted and included on Table 4.1.10 – 2.

### *Stratigraphy*

Based on visual characterization and grain size analysis of the cores, the surficial sediment in the vicinity of the Site includes a very soft to soft, black to dark gray organic silt with trace shell fragments and organic fibers. This unit transitions with depth to a more stiff olive-gray organic silt with trace shells and organic fibers.

At 41 locations, an olive-gray to bluish-gray, lean clay or silty clay was observed within the sediment core. Five of these cores are located in areas that represent Local Conditions (LC-1 and LC-NE1: North Channel; LC-HC1, LC-HC3, and LC-HC4: Harbor Cove). The remaining cores are located within the Dock Area and on the northwest side of the Navigation Channel. The clay was observed at the base of 32 of the sediment cores. In eight of the cores, an orange-brown to tan, silty sand unit was observed beneath the clay unit. These cores are located within the Harbormaster slip and between the USCG docks and the Harbormaster dock. The depth to the top of the clay ranged from 0.0 feet (LC-HC3) to 7.3 feet (N10E1A) below the mudline. The elevation to the clay unit decreases from northwest to southeast (approximately -9 feet at N5E1, N8E3, and N10E1A to approximately -28 feet at N15E15; elevation is in relation to MLLW). Based on a comparison of the elevation to the top of the gray clay layer in cores and the elevation of the bottom of adjacent cores that did not contain gray clay, it appears that the clay layer is non-uniform across the Site (Figure 4.1.10 – 1). The subsurface gray clay layer appears the most continuous within the Harbormaster slip.

Surficial sediment from cores located outside of the Navigation Channel was compared to surficial sediment from cores located within the Navigation Channel (Table 4.1.10 – 2). The average amount of silt/clay was higher in cores located within the Navigation Channel compared to cores located outside the Channel (approximately 80% compared to 60%). The percentage of gravel and sand was also higher in the surficial sediment for cores collected outside of the Navigation Channel. This difference in grain size distributions could be due to the deeper water depth within the Navigation Channel that allows it to act as a depositional environment. Sediment outside of the channel is located in more shallow water where prop scour and wind/wake generated waves can scour away fine surficial sediment. On a smaller geographic scale, surficial sediment in the vicinity of the Coast Guard docks (N0E5, N2E2,

and N5E2) appears to be coarser than other Dock Area sediment, which could be due to the frequent prop wash from USCG vessels or the presence of the seawall and the impact of reflected waves on the sediment. The surficial sediment at N17E6 is also very coarse, potentially due to the proximity of the core to the location where boats are loaded with shells from the adjacent seafood processing facility for disposal.

Three cross-sections were selected to compare the upland subsurface conditions with the in-water stratigraphy (Figure 4.1.10 – 2). The cross-sections run perpendicular to the Navigational Channel and display a similar stratigraphy of black silt overlying olive gray silt. Cross-section A-A' runs parallel to and through the Harbormaster slip (Figure 4.1.10 – 3). On the western end of cross section A-A' is a deposit of clay underlying both the black silt and the olive gray silt (Figure 4.1.10 – 3). As the cross-section extends to the east, the stratigraphy becomes black silt overlying gray silt. Although clay is not detected in cores east of N10E13, it potentially extends further to the east; limitations on sediment core penetration and recovery may be the reason for not observing clay in cores further out in the Navigation Channel.

Cross-section B-B' runs parallel to the Harbormaster dock (Figure 4.1.10 – 4). This cross-section line includes two of the borings drilled in 2005 as part of the Phase I ISI. On the western end of the cross-section, granite was apparently encountered at approximately 17.5 and 18 feet below the mudline in borings B-1 and B-2, respectively, although the presence of rock at these locations and the Site in general are discussed in GZA's Phase II CSA report in more detail. As the cross-section extends to the east, the stratigraphy becomes black silt overlying gray silt. As with cross-section A-A', clay is not observed east of N9E11, but it may potentially extend further to the east.

Cross-section C-C' runs parallel to the USCG floating dock (Figure 4.1.10 – 5). On the western end of cross-section C-C' is a more varied stratigraphy of black silt, gray silt, gray sandy silt, black sandy silt, orange/brown silt, orange/brown sandy silt, gray sand, black sand clay, and orange brown silt. As the cross-section extends to the east, the stratigraphy becomes black silt overlying gray silt. Again, clay is not observed east of N5E4, but it may potentially extend further to the east.

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## 5 NATURE AND EXTENT

This section of the Phase II CSA provides the information required in Section 40.0835(4)(f) of the MCP, including characterization of source(s), nature, and vertical and horizontal extent of OHM at the disposal Site, presence and distribution of any NAPL, tabulation of analytical testing results, and characterization of Local Conditions for OHM material in the Site vicinity.

During investigations implemented through 2011, samples of sediment and surface water were collected from the marine portion of the Site to assess the potential for OHM that originated at the Site to have migrated, or to migrate in the future, to other areas in Gloucester Inner Harbor. Additionally, Local Conditions were evaluated to assess other potential OHM sources.

OHM that originated at the Site may have come to be located in the harbor sediment either by historical releases directly into Gloucester Inner Harbor, or via migration of OHM released to upland soil and groundwater during MGP operation and subsequent migration through the subsurface into the Inner Harbor.

Assessment of the potential for OHM migration from the MGP to Gloucester Inner Harbor was based on assessing distribution of sediment and surface water laboratory analysis results as well as visual observations of Site media (e.g., sediment) and general Site observations (e.g., seawalls and surface water). Additional factors related to OHM migration, including general surface water hydraulics, sediment transport, and Local Conditions are considered in this assessment. A site-specific investigation of upland subsurface-marine environment interaction is included in the Phase II CSA report prepared by GZA.

The OHM considered in this CSA report includes visible NAPL, OHM dissolved in groundwater, and OHM associated with shallow sediment and surface water. Site investigations, discussed previously, included the collection of sediment samples and surface water samples. The analysis of the nature and extent of OHM is based on consideration of potential OHM sources, migration pathways, field observations, and laboratory chemical analysis of OHM in environmental media samples.

## 5.1 Marine

### 5.1.1 Other Potential OHM Sources

#### *Historical Spills*

The MassDEP Spills database is summarized in Table 5.1.1 – 1 and displayed on Figure 5.1.1 – 1. Typically, there is not adequate information in the MassDEP Spills database to evaluate the potential impacts of the spills on the Site. Limited information regarding a spill at the former Tarr and Wonson Paint Factory in March 2010 and more detailed information regarding a diesel spill on November 25, 2007, at 11-13 Harbor Loop was available from the database and discussed below. The files for several sites, such as the Maritime Heritage Center, have been reviewed at the MassDEP due to their proximity to the Site and the potential for impacts to the Site.

An additional database search was conducted at the National Response Center (NRC). The NRC receives reports of oil, chemical, radiological, biological, and etiological discharges into the environment. From 1999 through July of 2011, approximately 176 discharges have been reported in the vicinity of Gloucester (Table 5.1.1 – 2). Although not all of these discharges may have been directly to the harbor, if the frequency of discharges remained relatively constant over time at the rate reported by NRC, there is a probability that the accumulation of releases to the environment has impacted the harbor.

An Environmental Data Resources, Inc. (EDR) report was produced for the Phase I ISI, which identifies properties or facilities located in the vicinity of the property with reported environmental actions and/or operations that have potential to affect environmental conditions at the property. Two adjacent sites were identified that have the potential to impact the Site: Gloucester Marine Railway Site and USCG Gloucester Station Site, which are discussed below. A complete summary of the EDR report can be found in the Phase I ISI (EECS 2006).

#### ***Release Tracking Number (RTN) 3–0029886 Former Tarr and Wonson Paint Factory, 32 Horton Street, Gloucester, Massachusetts***

Available information for this release was included in a March 2010 report in the MassDEP database and indicates an unknown volume, location, and type of OHM were released at this facility. Based on the information provided, it appears metals were the primary OHM

included in the release. This is consistent with the historical use of the facility for paint manufacture and also with the historical and current harbor industrial uses that involve metals.

***RTN 3-0027277 – Western Venture Release – 11-13 Harbor Loop***

A significant release of oil was reported in the MassDEP database on November 25, 2007. Three hundred gallons of diesel oil was released to surface water at 11-13 Harbor Loop from the fishing vessel Western Venture. The sudden release occurred due to the overfilling of an onboard above-ground storage tank (AST) during a tank-to-tank fuel transfer necessary for maintenance activities. Due to tide and wind conditions, the majority of the spill was contained in the “canal” located between 11-13 Harbor Loop and the adjacent USCG facility. Hard booms and sorbents were deployed to contain the spill, and product recovery was via a vacuum truck. Based on observations during and after the spill, the majority of the product was contained between 11-13 Harbor Loop and the USCG property. Little to no product was reported to have migrated further out into Harbor Cove or Gloucester Inner Harbor, and the potential for this release to have significantly impacted the Site is low. However, intermittent sheens associated with this release were observed at select locations along the perimeter of the USCG property, which demonstrates that sheens observed along the shoreline can be from a multitude of sources.

***RTN 3-3341 – Gloucester Marine Railway Site – 23 Harbor Loop***

The Gloucester Marine Railway site is located at 23 Harbor Loop and abuts the Site to the north. The marine railway property, which was once identified as 9 Harbor Loop and later 27 Harbor Loop, is currently owned by the Gloucester Maritime Heritage Center, Inc. Historically, the site was used as a marine railway yard where boats could be hauled from the water and repaired and refinished. One of the two railways that exist on the site is still in active use.

The site was listed as a Location to be Investigated (LTBI) on October 15, 1990, because of elevated concentrations of contaminants in sediments. The site was classified by the MassDEP as a non-priority disposal site and granted a waiver on August 28, 1991. Pursuant to the 1993 MCP, the site was classified as a Tier II disposal site on October 1, 1993.

Subsequent investigations on the site have detected metals, particularly tin, lead, copper, nickel, and zinc, the VOCs benzene, toluene, and xylenes, PAHs, and petroleum hydrocarbons in soil, groundwater, and/or sediments. According to reports prepared for this site, PAH concentrations in sediment samples were primarily attributed to releases from the former MGP even though PAHs were detected in site upland soils adjacent to Gloucester Inner Harbor, and the MGP did not operate on this property. Note that PAHs were not detected in surface water samples collected adjacent to the Marine Railway site. In addition, PCBs were detected in one sediment sample located near the pier situated on the National Grid property.

Based on the results of the site investigations, a risk to human health and the environment existed for both site soil and sediments, primarily due to the presence of metals but also PAHs. Remedial actions implemented at this site have included the capping of exposed surface soils and implementing an AUL. Remediation of site sediments was deemed technically infeasible and not cost effective due to the potential re-contamination of sediments from nearby areas containing sediments with elevated levels of PAHs. A Class C RAO Statement was submitted to the MassDEP for this site in January 2004. Given the proximity of this site to the Site and the presence of contamination potentially attributable to this site in sediments, conditions at this site have the potential to adversely affect environmental conditions (i.e., sediments) at the Site, whereas releases from the former MGP are likely to have impacted sediment at this site as well.

### ***RTN 3-23063 – USCG Gloucester Station Site – 17 Harbor Loop***

The USCG Gloucester Station Site is located at 17 Harbor Loop and abuts the Site to the southwest. The USCG property is currently owned by the U.S. and is used as an active station for the USCG. Historically, prior to USCG occupancy, a portion of the USCG property was used as a marine railway yard where boats could be hauled from the water and repaired and refinished. The marine railway yard was owned and operated by the Gloucester Marine Railways Corporation, which is the same entity that owned and operated the marine railway located on the 23 Harbor Loop site, beginning in 1953. The U.S. purchased the marine railway portion of the property from the Gloucester Marine Railways Corporation in 1970. Based on a 1972 Sanborn Map, these marine railway areas appear to have been filled in during the redevelopment of the property in the early 1970s but after 1972.

On August 5, 2003, during the driving of piles for a new USCG dock, a release of an unknown quantity of a substance identified subsequently as “creosote oil” occurred to the surface water and sediments in the vicinity of the new dock. According to reports for this site, the release was immediately contained with absorbent booms. Absorbent booms and pads were then used to remove the material from the water surface of Gloucester Inner Harbor. Subsequent remedial actions included the cleaning of equipment and the seawall located adjacent to the dock to remove the visible oily material. Samples of the product were first identified by one laboratory as #2 fuel oil and later identified as creosote oil with minor amounts of #2 and #6 fuel oil.

The creosote oil was reportedly released during drilling operations at a depth of 16 feet to 23 feet below the bedrock surface. The depth at which bedrock was encountered was not indicated in the available reports.

The USCG submitted a Downgradient Property Status (DPS) Submittal to the MassDEP for the release in August 2004. The source of the “creosote oil” was identified in the DPS Submittal as potential releases from the former MGP. An IRA Completion Report was also submitted to the MassDEP for this release in June 2006. Based on a comparison of sediment sample analytical results to coal tar standards, the findings documented in the IRA Completion Report reported that the source of the product released on the USCG property was the former MGP.

Analytical results for sediment samples in the immediate vicinity of the release area appeared to have significantly higher PAH concentrations than sediment samples located farther from the drilling operations. The IRA Completion Report did state that the PAH concentrations in the sediment did not constitute an Imminent Hazard to human health or the environment. Subsequent investigations conducted as part of Phase II, potentially indicate that the former marine railway operations may have impacted the sediments within this area of the Site. In addition, the creosote oil does appear to be related to coal tar releases that have migrated into bedrock on this site.

### *Combined Sewer Outfalls*

Gloucester Inner Harbor is an active industrial harbor with various potential OHM sources. Historically, there were six combined sewer outfalls (CSOs) located in Gloucester Harbor. Stormwater discharged from four of the CSOs. The remaining two CSOs were only active during extreme conditions. Approximately 80% of the total discharge was from the CSO on Pavillion Beach (MCZM 2004). The City of Gloucester is currently in an abatement program to upgrade its sewer system and convert the existing five CSOs into sanitary sewers.

Data developed during extensive research on stormwater chemistry and reported in scientific and engineering literature indicates PAHs and cyanide compounds, particularly in urban areas like the area surrounding Gloucester Inner Harbor, are typically measured in stormwater runoff. Researchers believe that PAHs enter stormwater primarily via vehicle emissions that accumulate on roadways, and releases of petroleum to roadways (Menzie-Cura & Associates, Inc. 1995; Galvin and Moore 1982; VanMetre et al. 2000; Pitt and Barron 1989; Stenstrom et al. 1998; EPA 1983; Masterson and Bannerman 1994; Burton and Pitt 2001). Cyanide is a component of stormwater because it is typically used as a de-caking agent in road salt (Paschka et al., 1999). As ice and snow on the road melts, the dissolved and particulate-sorbed cyanide compounds runoff to storm drains.

The storm drains discharge to Gloucester Inner Harbor. Near the time of low tide, the stormwater discharges may contact sediment directly. During the time of high tide, the storm drains may discharge to surface water, where some fraction of the dissolved- and particulate-sorbed OHM are deposited in the sediment. Based on this information, storm drain discharges are a likely OHM source for the marine portion of the Site.

### *Historical Filling*

As discussed in GZA's Phase II CSA report, areas of the Site and in the vicinity of the Site have been historically altered by filling. The origin of the majority of the fill and its potential to act as a source for OHM is unknown.

### *Harbor Activities*

Gloucester Harbor has historically been and still is a heavily used and industrialized waterbody. The harbor is used for a mixture of activities, including one of the largest commercial fishing fleets in New England, industrial, commercial, and recreational uses. To access the wharves and moorings within the Inner Harbor, many vessels frequently pass



through the marine portion of the Site. Discharges from vessels likely impact the surface water and sediment associated with the Site. The following are potential sources of sheen and OHM within Gloucester Harbor: discharges to the harbor from nearshore industry; fueling operations, bilge releases, various boating and marine operations in the harbor; and, releases from sunken vessels. Dredging around docks and within slips may also have released OHM through possible residual sediment remaining after dredging has been completed.

### **5.1.2 Local Conditions**

The MCP differentiates OHM that has originated at the disposal Site and OHM that has originated from other locations. OHM that originates at other locations may be attributed to one of two categories, according to the MCP: 1) Local Conditions; and, 2) those that would be attributable to Background. As discussed below, it is our experience that attribution of OHM to specific sources is often not practical, particularly in waterways with the industrial history and numerous OHM sources in Gloucester Harbor.

Local Conditions, as defined by MassDEP's Guidance for Disposal Site Risk Characterization Section 9.4, "are concentrations of OHM that are higher than Background levels, but nevertheless ubiquitous throughout the vicinity of the Site and are attributable to sources other than the site in question." Local Conditions around the Site are associated with levels of OHM present in Gloucester Harbor sediment and surface waters that are attributable to other industrial sources, permitted discharges, and non-point sources. These sources are distributed throughout Gloucester Harbor and have had a complex industrial history. In order to evaluate Local Conditions sediment OHM concentrations, detailed information is required for OHM source locations, the variability in OHM releases over time, and the migration and deposition of the OHM released from those sources based on hydraulic flows and sedimentation rates. This information is seldom available.

Background is defined in section 310 CMR 40.0006 of the MCP as those levels of OHM that would exist in the absence of the disposal site of concern that are any of the following:

- Ubiquitous and consistently present in the environment at and in the vicinity of the disposal site of concern; and attributable to the geologic or ecological conditions, or atmospheric deposition of industrial process or engine emissions
- Attributable to coal ash or wood ash associated with fill material

- Releases to groundwater from a public water supply system
- Petroleum residues that are incidental to the normal operation of motor vehicles

Local Conditions and/or Background may also be characterized by first identifying OHM attributable to a disposal site and then differentiating that OHM from outlying OHM, which can then be presumed to represent Local Conditions or Background. The MCP definition of a disposal site, listed in Section 40.0006(b) is “a place or area where an uncontrolled release of oil and/or hazardous material from or at a site or vessel has come to be located.” OHM attributable to a disposal site would by definition be located within the disposal site boundary.

In our experience this definition is not as practical for defining a disposal site boundary in the urban marine environment as it may be for an upland disposal site. The combined effects of historical OHM discharges from multiple facilities in Gloucester since the start of industrial era in the mid-1800s, the variable hydraulic conditions that influence OHM migration and deposition, and the modifications to the environment due to storms, dredging, and nearshore activities can sufficiently alter the distribution and nature of OHM in the marine environment making association with the site unclear.

Our experience also has identified a line-of-evidence approach that is useful for attempting to map a site boundary. These lines of evidence include the following:

- OHM that are specific to the site and do not have other nearby sources. If OHM specific to the site do not have other nearby sources, the OHM can be attributed to the site. This line of evidence does not work for the Site—the OHM associated with the Site has other potential sources within Gloucester Harbor.
- Examine OHM for differences in chemical fingerprint. As discussed below, this represents a line of evidence for defining the marine Site boundary. An uncertainty associated with this line of evidence is the modification of the OHM in the environment—differential weathering can affect the chemistry within a sample and change the fingerprint, resulting in varying fingerprint for the same compound at different locations. However, when a large dataset is considered (as is the case for this Site), the uncertainty associated with this variability is reduced.
- Evaluate the distribution of OHM attributable to the Site and compare to the OHM distribution in areas that are remote from the Site, where the term “remote” is used

relative to the size of the waterway. Typical OHM distribution is highest near the point of discharge and decreases moving away. This results in an OHM concentration gradient. The concentration gradient is generally steepest near a site and flattens moving away from the site, particularly for OHM discharged from former MGP sites, based on our experience. This OHM distribution presumes the site effects decrease with distance from the Site where, except for support from other lines of evidence, the OHM is not discernible from OHM attributable to Local Conditions. This line of evidence is, therefore, not generally conclusive alone, and requires support from other lines of evidence. As discussed below, this line of evidence is applied to the Site with support from chemical fingerprinting to define the marine Site boundary.

This line of evidence approach is typically more useful when applied to sediment than to surface water. Sediment exposed to OHM is more likely than surface water to retain OHM and thereby preserve a record of historical OHM discharges. OHM discharges to surface water that do not attenuate by dilution or otherwise degrade are likely to be deposited in sediment.

Our evaluation of sediment OHM concentrations in Gloucester Inner Harbor, near the Site, and from more distant locations indicated that it is not possible to attribute some sediment OHM concentrations (i.e., metals) to particular sources, nor to determine Background concentrations because of the ubiquity and variability in concentrations of the sediment metals. Additionally, in our experience elevated sediment metals concentrations are not typically associated with MGP sites. Accordingly, we did not consider the sediment metals to be useful for differentiating between OHM that originated at the Site and OHM that originated from other sources. However, locally, relatively higher concentrations of metals within the Site boundary can be attributed to specific sources, such as the adjacent marine railway, as discussed in Section 5.1.3.

The evaluation of Local Conditions, Background, and marine Site boundary was based on the distribution of OHM in sediment and sediment porewater samples collected at the Site. Surface water OHM is discussed below to be complete, but does not provide useful information in defining Local Conditions, Background, or the marine Site boundary.

Additionally, the analysis focuses on Local Conditions and the marine Site boundary. Based on the MCP definition of Background, organic OHM (e.g., PAHs and petroleum hydrocarbons) included in the Background OHM category would be in Gloucester Harbor likely due to road runoff and atmospheric deposition. PAHs were detected in all samples at concentrations that exceed the typical concentration associated with those Background sources. Accordingly, OHM concentrations in the samples collected in the Inner Harbor are attributable to the Site and/or Local Conditions.

OHM considered in this evaluation included EPHs (particularly PAHs), petroleum hydrocarbons, metals, PCBs, and cyanide. As described below, PAHs provide the most information for this analysis, likely because the distribution (often expressed as a ratio of two or more PAHs) of individual PAHs in a sample varies depending on OHM source.

Sediment and porewater PAHs were more useful in differentiating between Site-related OHM and OHM from other sources because PAH concentrations in Gloucester Inner Harbor were relatively elevated near the upland portion of the Site compared to other locations within Gloucester Harbor, and PAHs are associated with former MGP operations as well as other sources (e.g., petroleum and combustion byproducts).

Sediment cores were collected in 2007 and 2008 from ten locations within Gloucester Inner Harbor to evaluate Local Conditions concentrations (Sediment sample series: LC, LC-SW, LC-NE, and LC-HC). An additional 13 sediment samples were collected in 2011 (sediment sample series AQSG) to supplement the samples collected in 2007 and 2008, comprising a total of 23 samples used in the analysis of Local Conditions/marine Site boundary.

Sample locations were selected based on distance from the Site relative to the size of the waterway and similar environmental conditions compared to the Site environmental conditions. The samples were collected from locations sufficiently distant from the Site to be presumably minimally impacted, if at all, by Site OHM based on the relatively low energy flow/transport conditions within the Inner Harbor.

Sediment type appeared to be more varied in the Local Conditions cores than cores collected within the Site grid. There was no visual observation of MGP impacted sediment in Local Conditions cores. As indicated on Table 4.1.5 – 1 and Table 4.1.6 – 1, physical sediment

properties (i.e., total solids, TOC, and percent fines) that influence sediment capacity to sorb OHM are similar for sediment samples that were collected from within the Site grid and for presumed Local Conditions samples.

Data from the 2007 and 2008 investigations were used in the ERC to assess the concentrations of PAHs in sediment and porewater that are attributable to regional OHM sources in the development of the ERC. The 2010 and 2011 sediment investigations were conducted after the development of the ERC. The chemical data are discussed in section 4.1. The locations of the samples used to evaluate Local Conditions sediment OHM concentrations are presented on Figure 3.1.1 – 1 and Figure 3.1.2 – 1. Subsequent sampling in 2011 to supplement Local Conditions data are presented on Figure 3.1.4 – 1.

### *PAHs*

In the ERC assessment of locations representative of Local Conditions and Site conditions, it was concluded that nine of ten sediment samples had similar PAH distribution and chemical characteristics based on analysis of sediment and sediment porewater chemistry. One of the ten sediment cores initially proposed as a Local Conditions location, LC-SW1, had PAH characteristics more similar to Site samples than other Local Conditions samples. The concentration of TPAH16 in porewater was higher than for the other presumed Local Conditions samples, and the PAH distribution also differed. The PAH concentration and distribution in sample LC-SW1 were more similar to samples collected from Site grid locations. Therefore, LC-SW1 was not considered a sample representative of Local Conditions and included as part of the Site samples.

The ERC also concluded that even though the TPAH16 concentration detected in LC-NE3 was more than a factor of two greater than the next highest presumed Local Conditions sample concentration, the PAH distribution for LC-NE3 was more similar to other Local Conditions samples than to Site samples. Therefore, LC-NE3 was still considered a sample representative of Local Conditions.

Thirteen additional sediment samples presumed to represent Local Conditions were collected and analyzed for PAHs as part of the SSOW-3 in 2011. Using a similar approach to that used in the ERC, a lines-of-evidence approach was used to evaluate the combined dataset of 23 sediment samples for inclusion in the Local Conditions dataset.

The distribution of the PAH compounds was compared to Site sample distributions. The distributions appeared to be more similar to Local Conditions (higher relative percentages of fluoranthene and pyrene and lower percentages of 2-methylnaphthalene, acenaphthalene, and naphthalene).

Additionally, the chemical fingerprint of the samples was evaluated by comparing ratios of selected PAH compounds. The ratio of fluoranthene to pyrene was plotted against the ratio of anthracene to phenanthrene (Figure 5.1.2 – 1). In addition, the ratio of fluoranthene to pyrene was plotted against the ratio of benz(a)anthracene to chrysene (Figure 5.1.2 – 2). On both graphs, samples presumed to represent Local Conditions are clustered in two groups.

As a final line of evidence, the sediment TPAH concentration gradient was conducted on the TPAH concentrations. Local Conditions samples are located beyond where the TPAH16 gradient flattens (Figure 4.1.1 – 4). Based on these lines of evidence, the 13 additional sediment samples are considered to represent Local Conditions.

TPAH16 concentrations in the upper 6 inches of sediment from the 23 presumed Local Conditions samples ranged from 3,505 to 115,000  $\mu\text{g}/\text{kg}$ . As stated previously, the highest concentration (115,000  $\mu\text{g}/\text{kg}$ ) was detected in a sample collected from core LC-NE3. This core is located in the mouth of Smith Cove and in the vicinity of the Gloucester Marine Railway Corporation located at the northern end of Rocky Neck across the Inner Harbor from the Site. The relatively high concentration of TPAH16 in surficial sediment at this location is likely attributable to the proximity of this location to marine industrial activities. The next highest Local Conditions TPAH16 concentration of 105,000  $\mu\text{g}/\text{kg}$  was detected at AQSG2, which is located along the northern shoreline of Harbor Cove and was collected next to a dock used by commercial fishing vessels.

As discussed in Section 4.2.1, the average concentration of TPAH16 within the upper 6 inches of sediment within the gridded area is 229,000  $\mu\text{g}/\text{kg}$ , and the concentrations ranged from 118 to 4,570,000  $\mu\text{g}/\text{kg}$ . The average concentration for Local Conditions samples is 29,400  $\mu\text{g}/\text{kg}$ . The average concentration for the Local Conditions samples is within an order of magnitude of the concentration of the gridded samples. The average Local Conditions TPAH16 concentration is lower than the average from the CLE Engineering (2009) samples,

which is 40,693 µg/kg. The CLE samples were collected for another project with the purpose of characterizing Inner Harbor sediment for dredging and disposal options. The average concentration of the CLE samples may be higher than the average concentration of the Local Conditions samples because several of the CLE Engineering samples were located within the Site boundary, and some samples were collected close to docking facilities where relatively higher vessel traffic and usage could have resulted in increased PAH concentrations.

### ***Total Petroleum Hydrocarbons***

TPHs were analyzed in nine samples collected from the Site and four locations presumed to represent Local Conditions. TPH concentrations detected in Site samples ranged from 588 mg/kg to 41,700 mg/kg with an average value of 7,852 mg/kg. Concentrations detected in Local Conditions samples ranged from 1,510 mg/kg to 2,460 mg/kg with an average value of 1,835 mg/kg. Other TPH sources include fuel and various types of oil (e.g., hydraulic oil and lubricating oil), which can be attributed to general industrial and recreational marine activities. In general, TPH concentrations are higher in Site sediment samples than in Local Conditions samples. TPH impacts in sediment defined as Site sediment by PAH analysis described above are considered attributed to the Site, and are similarly considered attributed to Local Conditions in Local Conditions samples. Many of the compounds in TPH have sources common to PAHs and also have similar transport and fate properties that indicate TPH and PAHs would be expected to coincide.

### ***Volatile Petroleum Hydrocarbons***

As discussed in Section 4.1.2, VPH compounds were detected within the vicinity of the upland Site; however, VPH compounds were not detected in the presumed Local Conditions samples. Concentrations of benzene, ethylbenzene, xylenes, one or more VPH compounds, and MTBE were detected in sediment samples collected from the Site. While the aromatic VOCs within this VPH group may be associated with historical operations at the former MGP facility, they may also be attributed to sources such as marina activities, boat traffic, and stormwater runoff. Additionally, MTBE is typically not related to MGP operations but was a common gasoline additive and is, therefore, more likely associated with vessel operation and roadway runoff.

Although the VPH compounds are likely not solely attributable to the former MGP, they are elevated compared to Local Conditions samples and are conservatively being attributed to the Site.

### ***Metals***

Sediment metal concentration data were analyzed to evaluate regional sediment OHM concentrations. To assess metals concentrations in Site samples compared to Local Conditions samples, the Site was divided along property lines into five separate areas: the USCG property, the City of Gloucester property (south of the Harbormaster dock), the National Grid property (the combined area of the Harbormaster dock and Harbormaster's slip), the Maritime Heritage Center property, and the Navigation Channel. This division was based on assessing potential sources for elevated metals in Inner Harbor sediment. In our experience, MGP sites are typically not a source of elevated metals concentrations in sediment; however, historical operations in the area including vessel construction, operation, and maintenance are potential sources of metals.

Sediment metals concentrations in samples collected on each of the properties were compared to the overall Site minimum, maximum, and average metal concentrations, and to the Local Conditions samples concentrations to assess the properties as potential sources of the metals. Within the six areas, the sediment samples were separated into those collected from 0.0 – 0.5 feet and those collected from sediment deeper than 0.5 feet below mudline. A statistical analysis was then carried out to calculate the minimum, maximum, average, and median of the sample subsets (Table 5.1.2 – 1).

Overall, the highest maximum and average concentrations of metals were detected within the Maritime Heritage Center property with the following exceptions:

- barium (>0.5 feet)
- cadmium (>0.5 feet)
- chromium (>0.5 feet)
- mercury (>0.5 feet)
- nickel (0.0 – 0.5 feet and >0.5 feet)
- selenium (>0.5 feet)
- silver (>0.5 feet)



These metals are located either at Local Conditions locations or within the Navigation Channel, indicating there were historical discharges of metals to the Inner Harbor, but these historical discharges were not likely from the upland portion of the Site based on location of the metals (i.e., more distant from the Site) and historical operations at the Site.

Based on the average concentration of metals calculated for the Site samples and excluding the Maritime Heritage Center samples, all metals are within 10% of Local Conditions concentrations except barium (exceeds Local Conditions on average by 20%), copper (34%), lead (59%), and mercury (48%). The ERC includes a statistical analysis of the metals data to assess which, if any, metals may be attributable to the Site. The ERC concluded that Site concentrations were not statistically higher than Local Conditions samples for arsenic, copper, and zinc. In addition, the ERC concluded that both concentrations at the Site and Maritime Heritage Center were not statistically higher than Local Conditions for cadmium, chromium, nickel, selenium, and silver. Furthermore, the ERC concluded that concentrations of barium, lead, and mercury in both Site samples and samples from the Maritime Heritage Center were statistically higher than Local Conditions and; therefore, these three compounds were conservatively carried through the ERC process even though these metals are unlikely to be attributable to the Site.

In general, excluding the Maritime Heritage Center samples, the metal concentrations in the surface sediments within the Site boundary are comparable to the metal concentrations in the surface sediment in the presumed Local Conditions samples. The similarity between the metal concentrations indicates that the Site was not a significant source of metals to the area sediments. As discussed in section 5.1.3, a potential source for localized high concentrations of metals within the Site boundary could be the adjacent marine railway.

### ***PCBs***

As discussed in Section 4.1.4, total PCBs were identified in sediment in the vicinity of the Site ranging from ND to 4,940 µg/kg from 0 - 0.5 feet (average = 774 µg/kg) and from ND to 146 µg/kg in sediment greater than 1.0 foot (average = 119 µg/kg). Concentrations of total PCBs higher than 1,000 µg/kg were detected in seven sediment samples in the vicinity of the Site. Six of seven samples are located within the vicinity of the marine railway on the current Maritime Heritage Center property and the seventh located in the Navigation Channel.

Total PCBs concentrations decrease with depth in the vicinity of the Site. Of the 24 sediment samples collected from intervals deeper than 1 foot, only three samples had detected concentration of total PCBs above the method detection limit (N7E14-S4: 105 µg/kg; N10E24-S4: 146 µg/kg; and N12E18-S4: 105 µg/kg).

Total PCBs were identified in sediment from locations representing Local Conditions ranging from ND to 682 µg/kg from 0.0 - 0.5 feet (average = 441 µg/kg) and from ND to 2,577 µg/kg in sediment greater than 1.0 foot (average = 1,212 µg/kg). Concentrations of total PCBs were detected above method detection limits in seven samples collected from sediment deeper than 1.0 foot in locations representing Local Conditions. Total PCBs were detected above 1,000 µg/kg in sediment deeper than 1.0 foot in three Local Conditions locations (Harbor Cove: LC-HC4-3 and LC-HC5-S3; North Channel: LC-NC2-S3).

Concentrations of PCBs detected in Local Conditions samples from the 0.0 – 0.5 foot sediment interval and sediment deeper than 0.5 feet were compared to similar samples collected from similar sediment intervals from the five Site properties. Concentrations of total PCBs by Aroclor were significantly higher in the 0.0 – 0.5 foot interval from the marine railway area of the Maritime Heritage Center property than any of the other four Site properties or the Local Conditions samples (Table 5.1.2 – 1). Excluding the Maritime Heritage Center, the average concentration of total PCBs by Aroclor is higher in Local Conditions samples from the 0.0 – 0.5 foot interval (441 µg/kg) than Site samples (417 µg/kg). Concentrations of total PCBs by Aroclor are significantly higher in Local Conditions samples collected deeper than 0.5 feet below mudline (1,130 µg/kg) than Site samples, including the Maritime Heritage Center (107 µg/kg). Three deeper samples (>0.5 feet) collected from locations representing Local Conditions have detected concentrations of total PCBs by Aroclor above 1,000 µg/kg, and two of the samples are above 2,000 µg/kg (LC-HC4 and LC-HC5).

In general, the total PCBs by Aroclor concentrations in the surface sediments within the Site boundary are comparable to or lower than the total PCBs by Aroclor concentrations in the surface sediment in the presumed Local Conditions samples. The similarity between the total PCBs by Aroclor concentrations indicates that the Site (with the exception of the Maritime Heritage Center) is not a source of total PCBs by Aroclor to the area sediments.

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Based on these results, PCBs are not attributable to the Site and are consistent with Local Conditions (excluding the Maritime Heritage Center property).

### *Cyanide*

Total cyanide was not detected above detection limits in the majority of the 24 Local Conditions and Site sediment samples collected for analysis of total cyanide. Total cyanide was only detected at location N2E2 (0.42 mg/kg). Total cyanide is considered a Constituent of Potential Ecological Concern (COPEC) because it was detected in one sample collected from Site sediment but not detected in any of the samples collected from Local Conditions locations.

### *Surface Water*

Surface water samples were collected from four locations within the Site boundary and eight locations presumed to represent Local Conditions from 2006 to 2010. A total of 31 samples were collected from the 12 locations at both high and low tide and analyzed for a combination of EPH, VPH, PAH, PAC, available cyanide, and metals.

Low concentrations of two PAHs and metals were detected in sample SW-101 collected in 2006; EPH fractions, VPH fractions and the associated target analytes, styrene, and PAC were not detected in the SW-101 surface water series of samples. For samples collected from the Site from subsequent years, PAHs and available cyanide were not detected. Because PAHs compounds were only detected in 2006 and were not detected in subsequent samples, PAHs do not appear to consistently impact surface water in the vicinity of the Site.

Low concentrations of select metals were detected in samples presumed to represent Local Conditions. EPH and VPH fractions and the associated target analytes detected with these methods were not detected in Local Conditions surface water samples. Available cyanide was also not detected in all surface water samples collected from Local Conditions locations.

Arsenic, mercury, and zinc were detected at slightly higher concentrations in the Local Conditions samples than respective naturally occurring seawater concentrations identified in available literature. Zinc was also detected at a higher concentration in the Site sample than the natural seawater concentration while arsenic was lower, and mercury was not detected, but the detection limit was higher than the naturally occurring concentration. In general,

the concentrations of metals detected in the Local Conditions samples are higher than those detected in the Site sample SW-101, but they are lower than Massachusetts Surface Water Quality Standards. Therefore, metals concentrations detected in surface water do not appear to be attributable to the Site.

### ***Site Boundary***

As discussed above, sediment samples within the harbor were either attributed to the Site or were presumed to represent Local Conditions. Concentrations of PAHs, petroleum hydrocarbons, metals, total cyanide, and PCBs were compared in Site samples and Local Conditions samples. Due to the additional sources of OHM that are unrelated to the Site (Section 5.1.1) but can impact harbor sediment and mix with sediment impacted by the Site, the delineation of the marine Site boundary is a complex process. The marine Site boundary was delineated by taking the following factors into account:

- Potential OHM sources
- OHM transport and fate characteristics
- Existing or potential migration pathways
- Nature and extent of OHM
- Local Conditions evaluation

Based on the above assessment, the distribution and type of PAHs in sediment appeared to be the best indicator of Site conditions. The marine Site boundary was developed by grouping sediment samples together by PAH type, as described above in the Local Conditions analysis. This was combined with mapping the PAH concentration contour for all sediment samples. The average PAH concentration for the 23 samples that were grouped in the Local Conditions sample set was determined, and the PAH concentration contour line that represents this concentration was evaluated relative to the general sediment PAH concentration gradient. The marine Site boundary was then adjusted to account for the sediment samples that were identified as representing Local Conditions based on PAH distribution in sediment and/or sediment porewater but had a higher concentration than the average Local Conditions PAH concentration.

The PAH concentration gradient “flattens” (i.e., the sediment PAH concentrations in the area where the concentration gradient flattens are likely not significantly affected, if affected at all, by the Site) at concentrations higher than the Local Conditions concentration of 29.4

mg/kg, except for the area near Smith's Cove where OHM inputs from marine operations likely contribute to PAH concentrations locally. This means the sediment PAH concentration gradient is steeper in areas near the Site than in the area of the marine Site boundary (except for the Smith's Cove area as explained above). A steeper PAH concentration gradient indicates the area is closer to the PAH source, in this case, the upland portion of the Site. PAHs from the Site may be present at relatively low concentrations (compared to Local Conditions) in this area. However, those PAHs cannot be practically differentiated from PAHs attributable to other PAH sources (i.e., Local Conditions).

The marine Site boundary is, therefore, drawn conservatively. The marine Site boundary could have been based on the higher end of the Local Conditions sample set, but the average was selected because this is considered to account for uncertainty inherent to the process of drawing the marine Site boundary.

The marine Site boundary is shown on Figure 5.1.2 – 3. All samples impacted by VOT and all samples that pose a Significant Risk are included within the marine Site boundary.

### **5.1.3 Site Conditions**

Section 310 CMR 40.1003(5) of the MCP includes OHM sources that are located within the marine portion of the Site and include the following:

- Contaminated fill, soil, sediment, and waste deposits
- NAPLs

Accordingly, potential OHM sources include OHM in: nearshore soil because groundwater and surface water may dissolve OHM and transport the OHM via groundwater flow to the marine environment; nearshore NAPL in surface sediment; and nearshore NAPL in deeper sediment. Surface sediment NAPL has been observed to migrate to surface water and form sheens. Deeper NAPL deposits likely contribute dissolved phase OHM to groundwater.

During investigations implemented through 2011, samples of sediment, porewater, and surface water were collected from Gloucester Inner Harbor to assess the potential for OHM that originated at the Site to have migrated, or to migrate in the future, to other areas in Gloucester Harbor.

OHM that originated at the Site may have migrated from the Site either by historical discharges directly into Gloucester Harbor and/or through subsurface migration pathways. Based on investigation data included in this report, it is possible OHM was released to upland soil and groundwater during MGP operation, and the OHM has subsequently migrated through the subsurface to Gloucester Harbor. During upland drilling investigations, NAPL has been observed in the openings between the granite blocks that comprise the seawall, possibly indicating the NAPL also migrated through the granite block seawall in the past (recent observations indicate no significant NAPL or sheens are observed to migrate through the openings between granite blocks).

Based on the visual assessment of sediment samples (and supported by laboratory chemical analysis of organics) the volumetric percentage of NAPL, or VOT, is higher in near-surface sediment than in deeper sediment. This observation indicates the NAPL observed in the surficial sediment was likely discharged to the waterway and was deposited in near-surface sediment rather than migrated through the upland subsurface to marine sediment. A file review of historical documents was conducted to determine if a direct discharge of OHM to Gloucester Harbor was reported. No direct discharges were confirmed, although the characteristics of the coal tar detected in some sediment cores as discussed below suggests that such a release may have occurred in the past.

### ***Visible Oil and/or Tar in Sediment***

VOT was observed in 98 of the 315 vibracores and push cores collected from the marine portion of the Site. Depth to, and a description of sheen, staining, and VOT observed in each core is included in Table 5.1.3 – 1. The VOT observed in sediment ranged from trace droplets of VOT to sediment saturated with VOT. VOT in saturated sediment was present in a liquid that ranged from very dark brown to black and appeared to be of low viscosity based on observations of associated NAPL movement in cores. What appeared to be homogeneous, taffy-like black VOT was observed from about 2.3 to 2.5 feet below mudline in core N10E7A and from 2.7 to 2.8 feet below mudline in core AQSC2A, both located within the Harbormaster slip. Four feet of liquid VOT containing little to no sediment was observed from 0.0 to 4.0 feet below mudline at location AQSC2, located within the Harbormaster slip. This volume of VOT was the highest observed in any exploration performed in the Harbor and based on the additional cores in the vicinity, appears to be a discrete volume of material

(Figure 5.1.3 – 1). VOT observed in surficial subsurface sediment in two areas of the Site could potentially equate to greater than ½” of NAPL in a media: the area in the vicinity of cores AQSC1A, AQSC2, AQSC2A, and N10E7A; and the area in the vicinity of core N7E2 (2010).

A strong coal-tar-like odor was generally associated with intervals containing VOT. In addition, sheens and stained sediment were also observed in sediment. Sheens were present as silver-blue to multi-colored iridescent coating on sediment solids, porewater, and standing water in core barrels shortly after core collection. Stained sediment appeared as discolored black sediment with no apparent immiscible liquid or NAPL.

VOT was observed laterally from gridline N(-)2 to N24 and E0 to E31 (Figure 5.1.3 – 1). Vertically, VOT was observed from the sediment-water interface (36 locations; see Table 5.1.3 – 1) to a maximum depth of 5.5 feet below mudline (AQSC2). (Note that this depth range is for relatively surficial sediment; deeper sediment is discussed in GZA’s Phase II CSA report.) In general, VOT was observed deeper in the sediment closer to the seawall. As the distance from the seawall increased, the depth of VOT observed in the samples generally decreased. Between E0 and E11, the apparent depth to the bottom of the VOT-impacted interval ranges from about 0.4 feet below mudline (N10E9) to 5.5 feet below mudline (AQSC2). In comparison, east of N11 the apparent depth to the bottom of the VOT impacted interval ranges from less than 0.1 feet below mudline (N10E17) to 1.9 feet below mudline (N3E27). An anomaly is N24E22 where VOT was detected from about 2.1 to 2.6 feet below mudline. VOT was only observed vertically in half of the core. This was the only observance of this type of VOT distribution and could have been caused by a subsurface disturbance such as historic dredging or other penetration into the sediment surface such as a barge spud, anchor, or mooring. A second core was collected at N24E22 in December 2009/January 2010 to confirm the observation but the anomalous VOT distribution was not observed.

The deepest observation of VOT in the sediment cores was observed in the vicinity of the southeast end of the Harbormaster slip. VOT-impacted sediment was observed from the mudline to 5.5 feet below mudline in core AQSC2. Unlike other sediment cores collected from the Site, the core appeared to contain liquid VOT with little to no sediment. This

interval was underlain by sand and silt saturated with VOT. An apparent vertical limit of VOT was observed in several of the sediment cores located within the slip area:

- N10E7A where the VOT-impacted interval was underlain by clay at approximately 3.2 feet below mudline
- N10E1A where the VOT-impacted interval was underlain by brown silt at about 2.5 feet below mudline
- N11E7 where the VOT-impacted interval was underlain by dark gray grading to olive gray silt at about 1.6 feet below mudline
- N9E6 where the VOT-impacted interval was underlain by black sandy silt at about 1.2 feet below mudline

In several of the cores in the Dock Area, the depth to the base of the VOT-impacted interval was not determined because “clean” sediment was not observed at the bottom of the cores. The bottom of the interval impacted by VOT was not identified in 21 of the 27 cores located within the Harbormaster slip. Of these 21 cores, 12 cores had recoveries less than 2.0 feet, and nine of the cores had recoveries less than 1.2 feet. Based on the five cores where the apparent depth to the bottom of the VOT interval was identified, the depth to the bottom of the VOT impacted interval ranged from about 1.2 to 3.2 feet below the mudline. By comparing the length of recovery to the observed depth to the bottom of the VOT-impacted interval, it is possible that clean material was not observed at the bottom of the nine cores based on their limited recoveries. The recovery in the remaining four cores ranged from approximately 2.3 feet (N11E0) to 5.5 feet (AQSC2).

The VOT-impacted interval to the south of the Harbormaster dock appeared to be more variable. Unlike the Harbormaster slip, many of the cores to the south of the Harbormaster dock and in the vicinity of the USCG did not include a VOT-impacted interval (Figure 5.1.3 – 1). Cores that contained VOT-impacted sediment were located along the seawall (N5E1, N6E2, and N7E2) and along the south side of the Harbormaster dock (N7E2, N7E4, and N8E6). A line of impacted cores trending northeast-southwest is located near the offshore end of the Harbormaster dock (N8E6, N7E7, N7E6, N6E7, N6E6, and N4E7). This lateral variability could be the result of removal of VOT-impacted sediment during historical dredging in the area (DEQE 1984; Coneco 1996).



The depth of the interval impacted by VOT appeared to be shallower in the area south of the Harbormaster dock. Depth to the bottom of the VOT-impacted interval ranged from about 0.8 feet (N7E7) to 4.5 feet (N7E2). The bottom of the interval impacted by VOT was identified in eight cores (N3E2, N6E2, N6E7, N7E2, N7E6 [07], N7E6 [10], N7E7, and N8E7) and it ranged from approximately 0.1 feet to 4.5 feet. These cores are located near the seawall and offshore end of the Harbormaster dock. The bottom of the VOT-impacted interval was not identified in six of the cores. The recoveries for these cores ranged from about 1.1 feet (N7E2) to 2.6 feet (N8E6).

The lateral and vertical variability of VOT-impacted intervals increases to the east of E11. Many of the sediment cores had no visual observation of VOT-impacted intervals (Figure 5.2.3 – 1). The depth to the bottom of the unit impacted by VOT ranged from less than 0.1 foot (N10E17) to about 1.9 feet (N3E27). The depth to the bottom of the unit impacted by VOT was identified in all the cores located to the east of E11. The lateral and vertical variability of VOT-impacted intervals observed within the sediment cores east of E11 could be caused by sediment removal during historical dredging activities within the Navigation Channel and/or the variable nature of migration of VOT from the expected sources located closer to the upland area of the Site.

VOT in shallow sediment was observed within both the surficial black to dark gray organic silt, the deeper olive gray organic silt, and the gray clay (Figure 4.1.10 – 3 through 4.1.10 – 5). Overall, however, the majority of the VOT was observed within the upper black silt unit. VOT was only observed within the clay unit within two cores—N10E4 and AQSC3. Unlike other observations that indicated the clay unit was generally homogeneous, desiccation cracks were observed in the clay in core N10E4. The VOT was observed within these cracks but not within the homogeneous clay around the cracks. Trace droplets of VOT were observed within the clay in core AQSC3.

Since the VOT was observed at variable depths within the sediment cores and not observed within a specific stratigraphic unit or along a stratigraphic interface, it does not appear that the majority of the VOT migrated along pathways at depth from the upland portion of the Site offshore into Gloucester Harbor sediment. Had the VOT migrated through the seawall, more staining would be expected in sediment near the base of the seawall. Subsurface migration under the seawall would have resulted in increasing VOT with depth rather than

an increasing VOT percentage in shallow sediment; VOT-impacted intervals appeared to be located within shallow sediment (i.e., the upper 4 feet of sediment), except for deeper NAPL observed in the USCG dock construction and in the GZA offshore borings. As explained in GZA's Phase II CSA report, the NAPL observed in the USCG dock/offshore borings is located in nearshore deeper sediment and rock, and there is no clear migration pathway for the VOT to migrate, particularly in the quantities observed in shallow sediment, from those deeper locations to the shallow sediment.

Although some cores contained a visually unimpacted surficial layer, which could have been deposited subsequent to VOT surface water releases, the degree of VOT impacts to sediment within cores appeared to generally decrease with depth. This is consistent with the PAH concentration trend measured in sediment samples that indicated sediment PAH concentrations generally decreased with depth in shallow sediment. No cores appeared to contain evidence of upward migration of VOT; that is, none of the cores were observed to have a higher volumetric VOT percentage, or pooled VOT, near the bottom of the sediment core. The variable deposition of VOT within the sediment and the lack of a significant migration pathway through the seawall indicate that the deposition of VOT within the shallow sediment may have been caused by a release or releases into the harbor from the former MGP.

#### ***Site Observation of Sheen on Surface Water***

Sheen observations have been informally conducted during field investigations from 2005 to 2011, a seawall survey was conducted as part of the SSOW-3 field event, and a temporary time-lapse camera has been installed at the Site to document surface water conditions in the Harbormaster's slip. On several occasions while conducting field investigations, sheens have been observed discharging from the exposed sediment located adjacent to the Harbormaster building within the slip near the Harbormaster's dock. In addition, blebs of NAPL have been observed during Site visits and in the photographs from the time-lapse camera to apparently be released from the sediment and float to the water surface resulting in a patchy sheen. The majority of these observations have been made near the time of low tide, particularly during periods of extreme low tides, and during the warmer months of the year. The presence of these sheens is not consistent during each tidal cycle, generally sporadic, and highly variable as to size and duration. These sheen blossoms appear most frequently at several locations within the Harbormaster slip. At least during the 2010 to 2011 time period, these blossoms

appear to be generating the largest volume of sheen compared to sheen originating from the exposed sediment at the head of the Harbormaster slip.

A seawall inspection was conducted to assess the potential migration of groundwater and NAPL through the seawall at the head of the Harbormaster slip. Based on observations from April 21, 2011, groundwater may be discharging through the seawall, but NAPL does not appear to be discharging in an amount sufficient to generate obvious NAPL droplets or significant sheens. This assessment is supported by the lack of significant sheens or discoloration on the face of the seawall or in the visible opening between the stone blocks that comprise the seawall.

No sheens have been observed during any tidal stage discharging from the seawalls adjacent to the Site except during drilling activities conducted along the seawall. On those occasions, IRAs were initiated to address the sheens and then closed after the sheens were addressed.

If mobile NAPL or OHM was located on the upland portion of the Site, it is possible that groundwater flow or drainage of seawater as the tide ebbs could lead to mobilization of product and the appearance of sheen on the surface water in the Dock Area. The apparent lack of sheen emanating from the seawall could be a result of long-term groundwater flushing of the area immediately behind the seawall (based on observed rapid response of groundwater elevations to the tidal changes in surface water elevation that are consistent with groundwater intrusion in this area). NAPL or OHM that migrates with groundwater may be limited to discharging with deeper groundwater into sediment located near the base of the seawall.

### ***Analytical Results***

Laboratory chemical analysis results for samples of sediment and surface water are used in combination with field investigation observations to assess the nature and extent of OHM. Samples included in the nature and extent assessment include samples collected from 2005 through 2011.

### ***PAH***

As discussed in Section 4.1.1, PAH16 was identified in sediment in the vicinity of the Site ranging from 118 to 4,570,000 µg/kg from 0 - 0.5 feet (average = 229,000 µg/kg), 796 to

450,000 µg/kg from 0.5 - 1.0 feet (average = 95,800 µg/kg), and 26 to 3,507,200 µg/kg from samples deeper than 1.0 foot (average = 210,000µg/kg). Laterally, the highest concentrations of PAH were detected along the shoreline between the USCG and Maritime Heritage Center and then extend to the southeast into the Navigation Channel (Figure 4.1.1 – 4). Two PAHs were detected in Site surface water in 2006, but PAH compounds were not detected in Site or Local Conditions samples in 2007.

As part of the ERC, AMEC assessed the impact of Site sediment on benthic organisms. Through this analysis, they identified the concentration of PAH that did not pose a Significant Risk to benthic organisms. AMEC identified areas that did not pose No Significant Risk as those that had a PAH16 concentration above 135,000 µg/kg. Laterally, this area extends from the shoreline east to approximately gridline E31. It extends north and south from approximately gridline N(-)8 to N13.

Stratigraphically, the highest concentrations of PAH16 are generally located within the 0 - 0.5 foot interval that generally corresponds to the surficial, very soft, black organic silt stratigraphic unit. Elevated concentrations of PAH appear to coincide with VOT-impacted intervals in sediment cores. Vertically, only four locations (of a total of 16 sample locations) had concentrations of PAH16 above 135 parts per million (ppm) from the depth interval of 0.5-1.0 foot. These cores include N5E2, N5E7, N5E11, and N6E18. They extend along a line parallel to the Harbormaster's dock. Only one core (of a total of 28 sample locations) contained PAH16 concentrations above 135 ppm deeper than 1.0 foot. The sample taken from 1.0 to 1.5 feet at N12E15 contained a PAH16 concentration of 1,320,000 µg/kg. This sample is both stained and saturated with VOT.

The following four areas are identified within the Inner Harbor based on VOT and PAH 16 distribution:

- The area containing VOT within the upper 12 inches of sediment, which represents RAH as defined by Section 40.0995 (3)(b)1.(c) of the MCP (see Section 4.2)
- The area with PAH16 concentrations above 135 ppm within the upper 6 inches for which a condition of No Significant Risk is not achieved, as defined in the ERC
- The area bounded by the marine Site boundary (29.4 mg/kg) but not contained within the RAH area or the Significant Risk area
- The area outside the marine Site boundary (29.4 mg/kg), which represents Local

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## Conditions

### ***VPH and TPH***

As discussed in Section 4.1.2, the highest concentrations of VPH and TPH appear to be located between the USCG and Maritime Heritage Center in the Dock Area. In general, concentrations of VPH appear to decrease with depth in the sediment column with the highest concentrations located in the 0.0 – 0.5 foot interval (except for benzene, which is slightly elevated at depth). These elevated concentrations appear to be collocated with elevated PAH concentrations within the Site boundary.

### ***Metals***

Individual metals concentrations are discussed in Section 4.1.3. Overall, the highest concentrations of metals appear to be located in the surficial sediment (0.0 to 0.5 feet) in both Site and Local Conditions sediment and concentrations of detected metals decrease with depth. Laterally, there does not appear to be a clear pattern to the concentration of most metals within Gloucester Inner Harbor because Site concentrations do not appear statistically higher than Local Conditions concentrations (excluding the Maritime Heritage Center property) except for barium, lead, and mercury. In addition, when the concentrations of metals within sediment are compared per property, sediment on the Maritime Heritage Center property appears to have elevated concentrations of arsenic, barium, copper, lead, mercury, and zinc compared to both Site sediment and Local Conditions sediment (Table 5.1.2 – 3). In general, concentrations of metals within the surficial sediment (0.0 – 0.5 feet) in the vicinity of the Site are similar to those detected in Local Conditions locations.

An area with consistently high concentrations of detected metals is the Maritime Heritage Center, located to the north of the Harbormaster slip. Relatively elevated concentrations of arsenic, barium, copper, lead, mercury, and zinc were identified in surficial sediment samples (0.0 – 0.5 feet). The marine railway has been in operation since 1853. Over that time, many vessels have been serviced and wastes could have been deposited within the railway. The historical use of metals, such as copper, lead, mercury, and zinc, in ship construction and repair could have contributed to the high concentrations of metals within the railway. Historically, these metals were also used in antifouling paints and wood preservation. Mercury could also be found in ballistic compasses and barometers.

High metal concentrations have generally not been attributed to sediment at former MGP sites. However, the heavy industrial and commercial use of Gloucester Harbor could be the source for the relatively high concentrations of metals in the surficial sediment of the Inner Harbor.

On average, concentrations of metals within Gloucester Harbor appear to be elevated in surficial samples as compared to other harbors within the Northeast. Site results were compared to the results from the NOAA National Status and Trends Mussel Watch Program. Sediment samples have been collected from harbors around the country starting in 1986 and continuing to present and analyzed for several constituents, including select metals. Site grid and Local Conditions samples at the surface and at depth had concentrations generally higher than those reported in the Mussel Watch Program for arsenic, cadmium, copper, nickel, selenium, and zinc. Surface concentrations were higher but concentrations in deeper sediment were lower for lead and silver. Concentrations of chromium were lower in both Site grid and Local Conditions samples than those reported in the Mussel Watch Program. Concentrations of mercury were higher in both the shallow and deeper sediment samples within the Site grid but were higher for surficial samples and lower for deeper samples at Local Conditions locations.

The overall relatively higher metal concentrations in Gloucester Harbor are likely due to the heavy industrial use of the port. Barium, copper, and lead can be found in hull paint for boats. Zinc plates are attached to hulls of ships to combat corrosion. In particular, the highest concentrations of several metals appear to be located within the marine railway.

### *Cyanide*

As discussed in Section 4.1.5, total cyanide was detected in only one sample in either Site or Local Conditions sediment. This sample was located near the seawall within the USCG property. Since total cyanide was detected in only one sample, it is not possible to assess the lateral or vertical distribution of total cyanide in sediment.

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## 6 ENVIRONMENTAL FATE AND TRANSPORT OF OHM

### 6.1 Marine Environmental Fate and Transport of OHM

Environmental fate and transport characteristics were assessed for Site-related OHM. Existing and potential OHM migration pathways were identified and characterized, including air, sediment, groundwater, soil, surface water, food web, subsurface utilities (including storm drains), and surface water runoff during rainfall and snow melt.

#### 6.1.1 Identification of Site-related OHM in the Marine Environment

The rationale for identifying Site-related OHM and COPEC from the list of analytes detected in sediment, porewater, and surface water during Site investigations is presented in the ERC.

Selected as COPECs were PAHs, other SVOCs, metals, VOCs, and petroleum hydrocarbon fractions quantified in the EPH/VPH analysis. Not all compounds are considered COPECs in each of the marine environmental media tested (sediment, porewater, and surface water). A summary of the COPECs by media is presented in the ERC (Table 6.1.1 – 1). Additionally, not all COPECs are necessarily attributable to the Site.

Not all marine environmental samples were analyzed for all the compounds identified as COPECs. Some compounds were not analyzed in all media because results from previous sampling found undetected or low levels of these compounds. Tables 3.1.1 – 2 and 3.1.1 – 3 (2007) and Tables 3.1.2 – 2 through 5 (2008), Table 3.1.3.1 – 2 (2009/2010), Table 3.1.3.2 – 2 (August 2010), and Table 3.1.4 – 2 (2011) summarize the laboratory chemical analyses performed on the Phase II CSA marine environmental samples.

Seven constituents (i.e., arsenic, barium, lead, nickel, zinc, 2-methylnaphthalene, and naphthalene) were identified in surface water collected within the Site Vicinity. Of those seven, four were detected at or below concentrations for the same OHM measured in Local Conditions samples (arsenic, lead, nickel, and zinc). Therefore, the constituents are not considered attributable to the Site. The remaining three constituents, barium, 2-methylnaphthalene, and naphthalene, were detected during the initial round of surface water sampling in one surface water sample (SW-101) at low concentrations, which were below Massachusetts Surface Water Quality Criteria (314 CMR 4.00). Although barium was detected at similar concentrations in December 2009/January 2010, 2-methylnaphthalene

and naphthalene were not detected in subsequent sampling rounds. Because concentrations of barium, 2-methylnaphthalene, and naphthalene concentrations in sample SW-101 were below surface water standards, they are not considered COPECs. Therefore, these constituents are not carried through the ERC as COPECs, and surface water is not considered an impacted media.

### **6.1.2 Characteristics of Marine Site COPECs**

The characteristics of the Site-related OHM discussed in this section of the report include type of compound, chemical composition, physical and chemical properties, toxicological characteristics, and environmental fate and transport characteristics. Environmental fate and transport characteristics include mobility, stability, volatility, and bioaccumulation potential.

The primary chemical and physical properties of the contaminants that affect their fate and transport in Site media are molecular weight, vapor pressure, water solubility, Henry's Law constant, specific gravity, water-carbon partition coefficient, and octanol-water partition coefficient. Sources of chemical, physical, and fate and transport characteristics were obtained from the literature, including the Agency for Toxic Substances and Disease Registry website ([www.atsdr.org](http://www.atsdr.org)). Table 6.1.2 – 1 summarizes the chemical and physical properties of the COPECs discussed below.

The COPECs are typically found in environmental media in groups, based on common sources and environmental fate and transport characteristics. PAHs, EPH, and VPH compounds are examples of these groups. Accordingly, the OHM are grouped together for the discussion of environmental fate and transport characteristics.

#### **6.1.2.1 SVOCs (including PAHs)**

In general, SVOCs have high molecular weights, low water solubilities, low vapor pressures, low Henry's Law constants, high carbon-water partition coefficients, and moderate to high octanol-water partition coefficients. These chemicals have a tendency to sorb to soil or sediment rather than dissolve into groundwater, porewater, or surface water, and tend not to volatilize into soil gas or the atmosphere. The tendency to sorb to sediment increases with an increase in the number of aromatic rings in the compound. This tendency is evident at the Site where SVOCs detected in porewater are typically the lower molecular weight



compounds such as naphthalene, and the higher molecular weight compounds such as pyrene are dominant in weathered soil and sediment.

PAHs are a subgroup of SVOCs at the Site because they can comprise up to 80 percent of coal tar, the most voluminous byproduct of MGP processes. PAHs are compounds with two or more fused benzene rings. Some PAHs can be carcinogenic as well as toxic to organisms. PAH sources can be generalized into two groups: 1) petrogenic; and 2) pyrogenic. Petrogenic sources include petroleum product manufacturing, storage, and use. Pyrogenic sources include combustion byproducts, including MGP operations.

Coal tar is comprised primarily of PAHs, with lesser concentrations of other organic compounds and metals. Coal tar has a wide range of physical properties, although it has generally high viscosity and interfacial tension. Coal tar is relatively insoluble in water, is not very volatile, tends to sorb to organic carbon and solids, and does not biodegrade rapidly. These properties indicate coal tar is not very mobile in the environment and tends generally to resist degradation mechanisms.

Although PAHs are discussed as a group and their concentrations are often expressed as TPAH16 and TPAH34, individual PAH compounds exhibit a wide range of physical and chemical properties that influence their distribution, mobility, and availability in environmental media. Lower molecular weight PAHs (i.e., the 2- to 4-carbon ring PAHs) tend to degrade biologically (in most media) or photochemically (in surface water) and are more available to partition to porewater. These properties generally decrease with increasing molecular weight.

Sediment characteristics also influence the distribution of PAHs. PAHs preferentially sorb to the low-density fraction and partition to the more recently deposited detrital material present in sediment. Sediment characteristics together with PAH properties can predict the ability of PAHs to desorb from sediment and the potential availability of PAHs to benthic organisms.

### 6.1.2.2 EPH/VPH

EPH/VPH fractions include groups of petroleum hydrocarbons, classified by MassDEP to include compounds with five to 36 carbon atoms. EPH compounds include aliphatic and aromatic hydrocarbons, TPAH16, and 2-methylnaphthalene. Different types of petroleum hydrocarbons are detected and quantified using EPH analyses, including diesel/No. 2 oil, No. 3 to No. 6 fuel oil, kerosene, aviation fuel, mineral oil dielectric fluid (MODF), and waste oil. Certain coal tar compounds are also detected and quantified using EPH analyses.

VPH compounds consist of lighter molecular weight petroleum hydrocarbons often associated with gasoline; however, other sources of VPH exist. Sources include petroleum product manufacturing, storage, and use. Additionally, many aromatic VPH compounds are used as solvents. Coal tar contains aromatic VPH compounds.

EPH compounds generally include heavier petroleum hydrocarbons than VPH compounds (nine to 36 carbon atoms compared to five to 12 carbon atoms). Petroleum products characterized by EPH include: No. 6 fuel oil (similar to “Bunker C” oil); coal tar (a byproduct at the former MGP); and gasoline and motor oil discharges (potentially associated with boat traffic and storm drain outfalls that discharge to Gloucester Harbor).

EPH compounds are divided into two aliphatic fractions ( $C_9$ - $C_{18}$  and  $C_{19}$ - $C_{36}$ ) and one aromatic fraction ( $C_{11}$ - $C_{22}$ ). In general, EPH compounds have a low solubility in water and a lower specific gravity than water. The  $C_9$ - $C_{18}$  EPH aliphatic fractions that tend to occur in diesel fuel have a low to moderate viscosity, moderate interfacial tension, are relatively insoluble in water, are slightly volatile, will sorb to sediment organic carbon and solids, and are moderately to highly biodegradable. In contrast, the  $C_{19}$ - $C_{36}$  aliphatic fraction and the  $C_{11}$ - $C_{22}$  aromatic fraction have higher viscosities, are insoluble, and are less biodegradable.

VPH compounds are divided into an aliphatic fraction ( $C_5$ - $C_8$ ) and an aromatic fraction ( $C_9$ - $C_{10}$ ). The VPH target analytes are benzene, toluene, ethylbenzene, and xylene (BTEX) compounds, which are discussed subsequently in the section for VOCs, and naphthalene, which was also discussed previously in the section for PAHs.

When VPH is analyzed without EPH, a third VPH fraction ( $C_9$ - $C_{12}$  aliphatics) is included in the VPH analysis. However, the  $C_9$ - $C_{12}$  aliphatics VPH fraction is a portion of the  $C_9$ -

C<sub>18</sub> aliphatics EPH fraction, and when both EPH and VPH analyses are performed only the C<sub>9</sub>-C<sub>18</sub> aliphatics fraction in EPH should be considered.

VPH compounds have low to moderate molecular weights, high water solubilities, high vapor pressures, moderate to high Henry's Law constants, low water-carbon partition coefficients, low water-carbon partition coefficients, and low to moderate octanol-water partition coefficients. These factors indicate VPH compounds are mobile in the environment; they will dissolve in water and tend to migrate from water to air via vaporization. VPH compounds are typically not present in shallow sediment or surface soil and most VPH compounds do not build up to high levels in plants or animals.

#### 6.1.2.3 VOCs

VOCs detected in environmental media at the Site include constituents of the BTEX group (e.g., benzene, ethylbenzene, and xylenes) and MTBE. These compounds are less dense than water and have low to moderate solubilities in water. VOCs tend to volatilize readily into the atmosphere. BTEX are aromatic VOCs and have a tendency to adsorb to organic soil, and this adsorption slows the rate at which these compounds migrate in sediment and porewater. MTBE is a gasoline additive, is highly soluble, and is a common groundwater contaminant in urban/industrialized areas.

#### 6.1.2.4 Metals

Metals are naturally occurring elements. Sources of metals in the environment include erosion of geologic materials, and use and storage of refined metals for paints, poisons, gasoline manufacturing and use, and other manufacturing processes. Because metals are conservative elements, they are also combustion byproducts.

Metals tend to be immobile in the environment because they have low solubilities and low soil/water partition coefficients, indicating that they prefer to stay in solid forms or sorbed to sediment. Metals are not degradable in the environment though they may undergo changes in valence state that can change their mobility and bioavailability. The physical and chemical conditions present at the Site influence how metals will migrate in the environment. The behavior of metals is influenced by environmental factors such as pH, oxidation/reduction potential (Eh), temperature, hydrostatic pressure, salinity, and the

presence of complexing agents. For example, the presence of sediment organic matter, as measured by TOC represents a physical condition that may sorb heavy metals and prevent them from migrating. Metals with a greater affinity to bind with organic carbon or AVS in sediment tend to exhibit the least toxicity to benthic organisms. Metals that tend to partition to porewater exhibit the greatest sediment toxicity.

#### **6.1.2.5 Acid Volatile Sulfides/Simultaneously Extracted Metals (AVS/SEM)**

Metals that are simultaneously extracted (SEM) when acid volatile sulfides (AVS) are released by laboratory acidification of sediments are a potential indicator of the toxicity of the metals in sediment. Because heavy metals bind with sulfide, it has been proposed that the SEM:AVS ratio can serve as an indicator of sediment toxicity. Metals in sediment porewater combine with sulfide to form insoluble metal-sulfide complexes. The metal sulfide complexes are insoluble and are, therefore, not bioavailable. However, the SEM:AVS ratio (based on the molar concentrations of divalent metals and sulfides) must be less than 1 for all metals to be complexed with sulfides. Otherwise, excess metals are dissolved in water (bioavailable) or may be bound to other ligands such as organic carbon (not bioavailable).

## **6.2 Existing and Potential OHM Migration Pathways**

### **6.2.1 Marine Potential OHM Migration Pathways**

The existing or potential migration pathways for OHM detected in environmental media in the marine portion of the Site include the nearshore subsurface, porewater, sediment, surface water, and the food chain. The nearshore subsurface includes the granite block seawall, pervious soils located behind and beneath the seawall, bedrock located beneath the soil in the nearshore area, and sediment located near the base of the seawall.

OHM migrates along these potential migration pathways from the OHM sources described above. OHM includes dissolved phase contaminants in the aqueous pathways (groundwater that migrates through the nearshore subsurface, surface water, and porewater) and contaminants sorbed to solid particles in the sediment pathway. Additionally, NAPL potentially migrates along these same migration pathways.

The nearshore subsurface migration pathway includes potential migration of dissolved OHM with groundwater and NAPL through the seawall, and through pervious soil/sediment and

bedrock near the seawall, to porewater. As discussed in the SSOW-3 Appendix in GZA's Phase II report, the migration of dissolved phase OHM through the seawall is likely not significant due to the low flow of groundwater near the time of low tide, indicating the area behind the seawall is flushed, and as seen by the very limited detection of OHM in surface water samples. Significant and/or consistent sheens have not been observed migrating through the seawall either. Accordingly, the seawall is not considered to be a significant migration pathway for OHM or NAPL migration.

Sediment, soil, and bedrock near the seawall are also potential migration pathways for OHM dissolved in groundwater and NAPL. As described in GZA's Phase II report, NAPL has been observed in rock during USCG dock construction and in GZA offshore borings. The NAPL likely migrated to bedrock through overlying soil/sediment and in permeable zones in bedrock. Dissolved phase OHM in porewater is likely attributable at least in part to NAPL in bedrock. Additionally, dissolved phase OHM likely migrates with nearshore groundwater through nearshore soil/sediment and bedrock based on the presence of OHM in porewater samples collected offshore (see GZA's Phase II CSA report). Based on the presence of dissolved phase OHM and NAPL in the nearshore subsurface migration pathway, the nearshore subsurface is considered a potentially significant OHM migration pathway.

Sediment porewater is considered a potential OHM migration pathway because OHM dissolved in the porewater migrates via advection to overlying surface water. The rate at which porewater advects to surface water is dependent on nearshore groundwater/surface water interaction, and the permeability of the sediment to porewater flow. OHM dissolved in sediment porewater will typically dilute significantly upon entry into surface water. OHM including TPAH16 and TPAH34 was detected in shallow sediment porewater in samples collected from the Site grid area and from Local Conditions samples. Additional data and discussion on deep sediment porewater associated with the April-May 2011 SSOW-3 investigation is included in GZA's Phase II report.

Potential surface water migration pathways include two potential modes of OHM migration: 1) migration of OHM dissolved in surface water; and 2) transport of OHM sorbed to sediment solids via erosion, suspension, transport, and redeposition of sediment solids.

Evaluation of the surface water dissolved phase OHM potential migration pathway includes review of the surface water laboratory chemical analyses results. Only the TPAH16 compounds naphthalene and 2-methylnaphthalene were detected in surface water samples collected during the 2006 ISI field event. Subsequent surface water analyses for PAHs in 2007 did not detect these, or other PAH compounds, in surface water. Additionally, other OHM including metals are generally of low solubility and are not expected to dissolve and partition from the sediment solid phase to the water phase. Metals were detected in the 2006 surface water samples but in concentrations consistent with Background (i.e., naturally occurring seawater concentrations of these metals). Accordingly, dissolved OHM migration in surface water is not considered a significant migration pathway.

Evaluation of the sediment transport potential migration pathway includes evaluation of the potential for sediment transport in Gloucester Inner Harbor. Sediment transport potential is dependent on sediment stability. Sediment stability is a function of grain size characteristics, bed morphology, and the hydrodynamic environment. In general, for sediment transport to occur via erosion/resuspension/transport, hydrodynamic flows need to be of sufficient magnitude to erode sediment from the bed, maintain the sediment particles in suspension, and transport the sediment to a redeposition location. Hydrodynamic flows of this magnitude are typically associated with coastal waterways open to storm waves and flows, and/or subjected to significant tidal currents. In these waterways, sediments typically consist of coarse-grained sediment (e.g., coarse sand, gravel, and cobbles). Gloucester Inner Harbor is sheltered from storm flows, does not have predicted high tidal currents, and sediments are typically fine-grained, all indicating a relatively stable sediment bed subject to deposition rather than erosion. This is further supported by the dredging records for the harbor, which indicate a periodic need for maintenance dredging of the Inner Harbor, consistent with a depositional environment.

Heavy vessel use of the Inner Harbor, however, does expose sediment to local propeller-induced sediment erosion. The eroded sediment may be briefly suspended in surface water in low-flow conditions and transported to a nearby redeposition location. Accordingly, propeller scour and associated sediment OHM suspension and redeposition is expected to be confined to localized, shallow water areas near the shoreline where OHM concentrations are relatively elevated.

Sediment transport of particle-sorbed OHM is not considered to be a significant large-scale migration pathway, but the potential for localized migration of OHM via propeller-induced erosion/suspension and transport/redeposition is considered a potential migration pathway. Although this migration pathway is considered likely, it is not considered to be a significant OHM migration pathway because of the expected small scale of OHM transport.

Based on the ERC, the food chain that includes the link between benthic macroinvertebrates and benthivorous fish poses a Significant Risk only in localized areas for TPAH. Mercury is the only COPEC assumed to biomagnify in the food web and is not present at sediment concentrations that exceed toxicity reference values (TRV) for benthivorous fish or piscivorous birds considered in the ERC included with GZA's Phase II CSA report. Accordingly, the food chain is not considered a significant OHM migration pathway.

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## 7 EXPOSURE ASSESSMENT/RISK CHARACTERIZATION

### 7.1 Marine Exposure Assessment/Risk Characterization

A Stage II Method 3 ERC was prepared by AMEC for the marine portion of the Site. A Stage I Environmental Screening was not performed due to the identification of conditions consistent with Readily Apparent Harm, as defined by 310 CMR 40.0995(3)(b)(1), at the Site. Therefore, a Stage II ERC was conducted in accordance with 310 CMR 40.0995 and the MassDEP's Guidance for Disposal Site Characterization (MassDEP 1995, 1996).

The ERC evaluated potential exposures of benthic macroinvertebrates possibly exposed to MGP-related constituents in harbor sediment and porewater and upper trophic level aquatic receptors potentially exposed to MGP-related constituents in sediment and surface water. Samples used in the sediment toxicity testing and benthic community survey were collected during the Supplemental Phase II CSA field investigation in 2008.

AMEC evaluated three assessment endpoints in the ERC: the benthic macroinvertebrate community, benthivorous fish, and piscivorous fish.

The ERC indicated the following:

- The Site does not achieve a condition of No Significant Risk with respect to macroinvertebrates and benthivorous fish since average concentrations of TPAH16 in sediment at the Site exceeded the TRV and may pose an unacceptable potential risk to macroinvertebrates and benthivorous fish.
- The Site achieves a condition of No Significant Risk with respect to piscivorous birds.



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## 8 CONCEPTUAL SITE MODEL – SHALLOW MARINE SEDIMENT

A conceptual site model (CSM) was developed based on the findings from the Phase II marine investigations. In this section of the report, the CSM applicable only to the shallow sediment is presented; therefore, potential OHM sources, migration pathways, and receptors for shallow sediment are assessed. A comprehensive CSM is presented in GZA's Phase II CSA report that combines potential OHM sources, migration pathways, and receptors for the Site upland subsurface, nearshore subsurface, deeper sediment, and shallow sediment.

The significance of potential OHM migration pathways was assessed based on the combined site environmental conditions, OHM transport and fate characteristics, and OHM nature and extent in shallow sediment. This analysis was also used to further evaluate the possible location and relative OHM contribution from potential OHM sources.

Shallow sediment generally includes the uppermost dark-gray to black organic silt and underlying olive gray silt. As indicated in the cross-sections included as Figure 4.1.10 – 3 through Figure 4.1.10 – 5, the thickness of these sediment layers varies.

Potential sources for NAPL, PAHs, SVOCs, and EPH/VPH include the former MGP that occupied the upland portion of the property. This OHM has been detected in upland soil and/or groundwater samples. Potential sources for PCBs and metals include general historical industrial and commercial uses of the harbor and shoreline land. During the Site history research performed for this report, there was no information found that indicated PCBs or metals were used or stored at the Site. Additionally, our experience working on former waterfront MGP sites is that PCBs and metals are generally not associated with former MGP operations.

The primary OHM source for shallow sediment is likely historical release(s) from the former MGP to surface water and deposition in sediment. Other OHM sources and migration pathways from the upland and nearshore subsurface to marine sediment are addressed in more detail in GZA's Phase II CSA report.

As described in Section 4.1 of this report, OHM detected in samples of shallow sediment in the marine portion of the Site includes NAPL, PAHs, other SVOCs, EPH/VPH, PCBs, and

metals. A total of 51 compounds were identified as COPECs. COPECs were found in sediment, porewater, and surface water samples collected from the Site. Not all compounds are considered COPECs in each of the environmental media tested.

During the Site history research performed for this report, no significant OHM releases or discharges to the waterway were reported that would be consistent with the presence of OHM in shallow sediment within the marine Site boundary.

NAPL has been observed in the marine portion of the Site in numerous sediment cores. Although NAPL does not appear to be confined to a stratigraphic unit because it was observed within both the soft surficial black to dark gray silt and the deeper, stiffer olive-gray silt, the majority of the visually contaminated intervals are located within the surficial silt. The sediment located within the vicinity of the Harbormaster slip appears to be the most impacted, both quantity-wise and thickness of the impacted interval. The depth to the bottom of the impacted interval and the degree of visual impacts decrease with distance from the slip, likely indicating the NAPL source was in the vicinity of the former MGP (i.e., near the Harbormaster's slip). PAHs and EPH/VPH concentrations generally correlate with the presence of NAPL; that is, they are higher in locations where NAPL was observed.

For shallow sediment, the most plausible scenario that explains the presence of OHM including EPH, VPH, and NAPL in Site shallow sediment is historical discharge of NAPL to the surface water, and subsequent deposition of NAPL in sediment. In general, the observations of NAPL and the concentrations of PAHs and VPH/EPH were higher in sediment samples collected near the top of the sediment cores; OHM concentrations generally decrease with depth in the sediment cores. In 25 of 29 sediment cores where shallow and deeper sediment samples were collected, the OHM concentration decreased in deeper samples compared to shallow samples. This OHM distribution is consistent with an OHM discharge to surface water and deposition of OHM in the shallow sediment. Over time, the OHM in shallow sediment would be expected to migrate down through the shallow sediment (MGP NAPLs are usually more dense than water) to underlying sediment, decreasing in concentration by attenuation and dilution with less impacted porewater and sediment solids as the OHM migrates downward.

Other Site OHM sources and migration pathways are discussed in GZA's Phase II CSA report and are related to the marine portion of the Site and shallow sediment. Dissolved phase OHM and NAPL that migrate through the upland and nearshore shallow subsurface may migrate to sediment porewater and surface water. OHM may migrate from the subsurface either in dissolved form in groundwater through the seawall to surface water, or to sediment porewater, or as NAPL present in sufficient volume to migrate through soil pore space to sediment pore space. Although NAPL was observed on surfaces between the stone blocks that make up the seawall, sheens have not been observed originating from the stone seawall joints during numerous visits to the Site and work at the Site. Accordingly, it is likely that NAPL is not migrating through the seawall joints in significant quantities or the NAPL observed between the stone blocks is no longer mobile. If NAPL were migrating through the seawall joints in significant quantities, sheens would likely be observed in surface water and/or sediment at the point where the NAPL exits the seawall (when the seawall face is submerged), or at the base of the seawall (when the surface water elevation is below the base of the seawall). Significant and/or consistent sheens have not been observed near the seawall.

OHM dissolved in groundwater and/or NAPL also likely migrates through deeper upland subsurface soil, nearshore soil, bedrock, and nearshore sediment beneath the seawall to deeper marine sediment.

Additionally, surface water is a potential migration pathway for localized transport of sediment solids and associated OHM sorbed to the sediment solids and NAPL that may be within the surficial sediments. Sediment solids/sorbed OHM may be re-suspended in surface water through natural erosive flows (including waves and currents) and/or propeller scour. NAPL may be mobilized with gas bubbles through the water column or in droplet form along the sediment surface during sediment disruption events.

Receptors of concern are benthic macroinvertebrates and benthivorous fish. These organisms can be impacted through the food chain due to elevated OHM concentrations in sediment and in lesser amounts in surface water in the vicinity of the Site. These receptors are addressed in the ERC.

Based on the nature and extent of Site COPECs and the Local Conditions analysis for COPECs presented in Section 5.1.3, the lateral extent of impacted shallow sediment in the marine portion of the site includes the area bound by the 29.4 ppm TPAH16 contour. The marine Site boundary is delineated on Figure 5.1.2 – 3.

The vertical extent of OHM in the marine portion of the Site is addressed in GZA's Phase II CSA report.

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## 9 CONCLUSIONS

This Phase II CSA meets the standards presented in the MCP for a Phase II Report (310 CMR 40.0830) and a Risk Characterization (310 CMR 40.0900). The Site consists of an upland portion where the former MGP was located and an in-water portion (see GZA's Phase II CSA and Figure 5.1.2 – 3 for Site boundaries). Anchor QEA's conclusions based on the results of the Phase II CSA and Method 3 Risk Characterization are listed below.

### 9.1 Marine

- The lateral extent of VOT in the in-water portion of the Site extends generally from grid line N(-)2 southwest to grid line N24 and to the northeast-southwest from E31 to E0. The probable OHM sources include historical direct release(s) or spill(s) of OHM/NAPL to the harbor from the former MGP. The vertical extent of VOT in shallow sediment is dependent on distance from the shoreline—near the shore VOT extends to approximately 5.5 feet below the mudline. As the distance from the shoreline increases, the depth of VOT decreases to less than 2 feet below the mudline at the far eastern portion of the Site.
- VOT appears to be mostly located within the upper black silt stratigraphic unit. In isolated locations, VOT was observed within the underlying olive gray silt and clay units. Based on visual observations of cores, the largest volume of VOT appears to be located in the vicinity of the Harbormaster's slip.
- Comparison of metals concentrations in the vicinity of the Site to Local Conditions and no documented use or storage of metals on the Site upland area indicates that metals are not likely to be related to the Site. The heavy industrial use of the harbor most likely contributed to the elevated metals in Gloucester Inner Harbor sediment while local hotspots may be attributable to known sources, including historical marine industrial operations adjacent to the Site.
- Because TPAH16 spatial distribution and fingerprint within shallow sediment appear to differentiate Site conditions from Local Conditions, the Site boundary was estimated by averaging the TPAH16 concentrations for Local Conditions samples (about 29.4 mg/kg).
- Additional OHM sources likely contribute OHM to Gloucester Harbor, and it is not possible with available information to assess the impact of these OHM discharges to the Site.

- Based on visual observations of sediment cores and PAH concentrations measured in sediment samples collected from the sediment cores, the primary OHM source and migration pathway for shallow sediment are historical release(s) of OHM/NAPL from the vicinity of the former MGP to surface water, and subsequent deposition of OHM/NAPL in shallow sediment.
- Additional OHM migration sources and pathways that affect environmental media within the marine Site boundary are upland and nearshore subsurface OHM including NAPL in upland subsurface soil and bedrock; migration of OHM in nearshore sediment and bedrock with nearshore groundwater and porewater, and as NAPL; OHM dissolved in groundwater and sediment porewater; and localized migration of shallow sediment OHM in surface water by erosion, suspension, and redeposition of sediment associated with navigation.
- Four areas have been identified within Gloucester Inner Harbor: 1) the RAH area, which is defined by VOT observed within the upper 12 inches of sediment; 2) the area bound by the 135 ppm TPAH16 contour, which represents the area for which a condition of No Significant Risk is not present according to the ERC; 3) the area bound by the 29.4 ppm marine Site Boundary contour but not located within the two previously noted areas; and 4) the area outside the 29.4 ppm contour, which represents Local Conditions. A condition of RAH exists in Area 1. Area 2 includes the area within the 135 ppm TPAH16 contour. Accordingly, a condition of No Significant Risk was not present for the entirety of Area 2. In general, the majority of Area 1 and Area 2 overlap. Area 3 includes shallow sediment that was likely impacted by OHM attributable to the former MGP site, but for which a condition of No Significant Risk is present. Area 4 includes shallow sediment that contains OHM consistent with Local Conditions and is, therefore, not included within the site boundary.
- The Method 3 Risk Characterization concluded that there is a Significant Risk of environmental harm in shallow sediments that have a TPAH16 concentration above 135 ppm. Where VOT has been observed in sediment within the upper 12 inches, a condition of RAH exists because VOT is present in the surface sediment over an area greater than 1,000 square feet.
- Because a condition of No Significant Risk to human health, public welfare, and the environment has not been achieved for all areas of the Site, a RAO cannot be achieved for the Site at this time. Additional Comprehensive Response Actions are

needed to achieve a RAO; therefore, a Phase III – Identification, Evaluation, and Selection of Comprehensive Remedial Action Alternatives report will be prepared in order to select the appropriate remedial measures for the Site.

- The objectives of the Phase II Supplemental CSA have been met because the source, nature, extent, and potential impacts of the releases at the Site have been identified; the risk of harm posed by the Site to human health, safety, public welfare, and the environment have been evaluated; and the need to conduct remedial actions at the Site have been identified. A copy of the Phase II Completion Statement is presented in GZA’s Phase II CSA report.

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## **10 LIMITATIONS**

This Phase II CSA report was prepared for National Grid, exclusively. The conclusions provided by Anchor QEA in this report are based solely on the information reported in this document. Additional quantitative information regarding the Site, which was not available to Anchor QEA, may result in a modification of the conclusions stated above. This report has been prepared in accordance with generally accepted geohydrological practices. No warranty, expressed or implied, is made.



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