January 16, 2015

Mr. Joseph T. Martella II, Senior Engineer
RIDEM Office of Waste Management
Site Remediation Program
235 Promenade Street
Providence, RI 02908

RE: Response to RIDEM Review Comments
December 17, 2014 Risk Memo
Former Gorham Manufacturing Facility
333 Adelaide Avenue, Providence, Rhode Island
AMEC Project No. 3652130029

Dear Mr. Martella:

On behalf of Textron, Inc., this letter provides the response to review comments from Mr. Rich Enander, Rhode Island Department of Environmental Management (RIDEM), on the above referenced document. These comments were as follows:

1. Table A-1. The BaP ingestion and dermal intake/exposure concentration and cancer risk values are shown to be the same. Is this correct?

2. Table B-2. Is the BaP adult ingestion value correct? Is it possible that the adolescent BW and mean sediment concentration of 45 kg and 0.23 mg/kg, respectively, were used in place of the detected concentration/adult values? Do other COPC values in this Table need to be adjusted?

The Risk Memo Toxicity Assessment text has been revised as follows:

"This risk assessment update evaluates adolescents (ages 7-18) and adults (ages 19-30). Typically the CSFs are multiplied by the ADAF to account for the mutagenic MOA. For this risk assessment the ADAF has been included in the intake calculation for the adolescent receptor for carcinogenic chemicals with a mutagenic MOA as shown in Table 4. The ADAF value of 2.5 for the adolescent site visitor receptor represents a weighted average adjustment factor (9 years under age 16 and 3 years at age 16 and above):"

$$\frac{(9\ years \times 3) + (3\ years \times 1)}{12\ years} = 2.5$$

We have also attached the Risk Memo Table 4 supporting calculations (pdf and excel files) to confirm the risk calculation results. The supporting risk calculations shows all inputs to the calculations as well as the equations that are used to do the calculations. The risk results for the supporting risk calculations spreadsheet match the risk results presented in the two Tables A-1 and B-2 that were sent to RIDEM as part of the December 17, 2014 Risk Memo.

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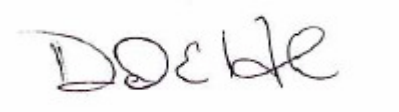
Continued...

This completes the response to comments on the Risk Memo and Final SIR for the Gorham Site. Please contact us if you have any further questions on the SIR. We look forward to working with RIDEM going forward with the Public Meeting for the Program Letter. Feel free to contact either Dave Heislein at (978) 396-5327 or Greg Simpson of Textron at (401) 457-2635 with any questions.

Sincerely,
Amec Foster Wheeler Environment & Infrastructure, Inc.



David E. Heislein
Senior Project Manager

Michael J. Murphy
Principal Scientist

Attachments: Revised Risk Memo dated January 14, 2015
Table A-1 and B-2 Risk Memo
Risk Calculations Check (pdf file)
Risk Calculations Check (excel file)

cc: B. Azar, City of Providence
A. Rose, Groundwork Providence
G. Simpson, Textron, Inc.
Knight Memorial Library Repository
AMEC Project File [projects/3652130029/4.1/SIR/Final SIR/Risk Memo/Risk Memo RTC Ltr 011615.docx]

Memo

To:	**Joseph Martella, Rhode Island Department of Environmental Management**
From:	**Michael Murphy and David Heislein**
Date:	**December 17, 2014** **Revised January 14, 2015**
Subject:	**Risk Assessment – SIR Response to Comments Supporting Information Former Gorham Manufacturing Site, 333 Adelaide Avenue, Providence, Rhode Island**

Introduction

This memo contains supporting and supplemental information for the Response to Comments Letter and the Site Investigation Report Former Gorham Manufacturing Site Phase II Area – Northeast Upland, and Parcel C (SIR) (AMEC, 2014). The Response to Comments Letter responds to comments provided by Rhode Island Department of Environmental Management (RIDEM) dated October 17, 2014 and follows our meeting with RIDEM on November 13, 2014.

Outer Cove Updated Risk Calculations for Exposure to Sediment and Surface Water

As part of the November 12, 2013 *Site Investigation Report, Former Gorham Manufacturing Site, Phase II Area – Mashapaug Pond and Cove, Phase III Area – Northeast Upland and Parcel C, 333 Adelaide Avenue, Providence, Rhode Island* (SIR) (AMEC, 2013) an updated human health risk assessment for the Mashapaug Outer Cove was included in a streamlined manner. On October 17, 2014, RIDEM provided a comment letter concerning the 2013 SIR. In that comment letter, RIDEM requested a brief report that addresses the RIDEM comments on the 2013 risk assessment update and that provides additional documentation of the data used in the risk assessment, the exposure scenarios, and the incorporation of risk assessment procedures and toxicity values that have become available since the preparation of the 2006 risk assessment. This memorandum has been prepared in response to that request.

This memo provides documentation of the human health risk assessment for the Mashapaug Outer Cove sediments and surface water in a traditional Method 3-type risk assessment approach. As previously discussed in the SIR, the Mashapaug Inner Cove sediments will be removed and replaced with clean material. Therefore, with the Inner Cove sediments to be remediated, the risk assessment is focused on the Outer Cove. This risk assessment incorporates updates to scientifically acceptable risk assessment procedures (such as use of age-specific adjustment factors) and toxicity values that have been adopted by USEPA since 2006 (the date of the original Outer Cove risk assessment) as well as analytical data that have been collected since 2006). Based on this revised, conservative risk assessment, the human health risks for a site visitor to the Outer Cove meet the risk limits identified in the Remediation Regulations. With the planned remediation of the Inner Cove sediments, no further remediation of the Mashapaug Outer Cove sediments is necessary.

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BRIEF SUMMARY OF NATURE AND EXTENT OF CONTAMINATION AND THE CONCEPTUAL SITE MODEL

The nature and extent of contamination of the Mashapaug Inner Cove and Outer Cove sediments and surface water has been characterized:

- during the surface water and sediment investigations summarized in the 2006 *Supplemental Site Investigation Report*, *Former Gorham Manufacturing Site, 333 Adelaide Avenue, Providence, Rhode Island* (SSIR) [MACTEC, 2006] which included 2005 RIDEM sediment sampling and analysis and 2006 Textron sediment and surface water sampling and analysis,
- during the investigation documented in the April 2010 *Data Summary Report, Mashapaug Cove Groundwater Investigation* (MACTEC, 2010),
- and during the 2011 surface water and sediment investigations described in the 2013 SIR (AMEC, 2013).

As discussed with RIDEM and consistent with the Work Plan *Mashapaug Cove Supplemental Site Investigation, Former Gorham Manufacturing Facility, 333 Adelaide Avenue, Providence, Rhode Island* (AMEC, 2011) approved by RIDEM, the 2011 surface water and sediment investigations included collection of sediment and surface water samples and specific analytical suites to complete the delineation of nature and extent of contamination and to support risk assessment activities (primarily for the Outer Cove). The analytical suite for the 2011 samples was based in large part on the results of the earlier surface water and sediment samples as well as the results of the 2010 groundwater investigation adjacent to and beneath the Cove. If the extent of contamination for a particular analyte group (e.g. VOCs, PAHs, PCBs, dioxins and furans) was determined to be adequately delineated for a given medium, the 2011 Outer Cove samples for that medium were not analyzed for that analyte group. The December 2014 Response to Comments Letter addresses specific RIDEM comments concerning the spatial coverage and numbers of samples of surface water and/or sediment that have been analyzed for various analyte groups.

The available body of information indicates that historical Site impacts to sediment are substantially greater in the Inner Cove than in the Outer Cove and Site-related contaminants in sediment and surface water have been adequately delineated.

The 2010 groundwater investigation concluded that the downgradient extent of the VOC-impacted groundwater plume is located just north of the Inner Cove/Outer Cove boundary. Therefore, VOC impacts to Outer Cove sediments and surface water (shallow groundwater discharging through the sediments and into surface water) are expected to be minimal. In addition, a groundwater pump and treat system is currently operating on Parcel A and it was designed, in part, to interrupt the groundwater migration from the uplands portion of the Site to the Cove. Therefore, with no continuing discharge to the Cove in the near future, VOC concentrations in Cove surface water and sediment are expected to decline over time. Therefore, the available data overestimate future concentrations and potential exposures.

The VOC concentrations reported for surface water samples from the Inner Cove and Outer Cove have been in the low part per billion (ug/L) range. The surface water samples have been collected at the bottom of the water column, within one foot of the sediment/surface water interface. Surface

water samples collected from that close to the sediments (where VOC-impacted groundwater might be discharging and there would be minimal dilution of the groundwater) would represent very conservative estimates of potential exposure concentrations for people wading or swimming in the surface water. It would be expected that locations within the water column that are further away from the sediment/surface water interface would have VOC concentrations that are lower than those very close to the sediment/surface water interface.

A brief discussion of the Conceptual Site Model (CSM), including a discussion of the already completed, the on-going, and the planned remedial activities is useful for providing context for this updated risk assessment. The sources of contaminants and associated migration pathways with respect to the sediment and surface water of the Inner Cove and Outer Cove have been both historical and more recent.

Sources of contamination to surface water and sediment of Mashapaug Cove included reported direct discharge from facility piping (no longer taking place because the facility is no longer operating and the piping has been removed), surface runoff of impacted soil (metals, PAHs, dioxins and furans) from the upland area south of the Cove (also no longer taking place since the upland area south of the Cove has been capped and seeded and most of the remainder of the uplands area is covered by buildings and pavement), discharge of storm water from the on-site storm water settling basin (a more recent site feature) to the Inner Cove (metals and PAHs) and discharge of shallow groundwater impacted with chlorinated VOCs into and through the submerged sediments and into the surface water immediately above the sediments of the Inner Cove (the operating groundwater containment system is interrupting this migration pathway and it is expected that this migration pathway will be eliminated in the near future). Historically, it is probable that during storm events and due to storm water runoff into the Cove, there may have been disturbance and re-suspension of Inner Cove sediments (particulates) into the water column. This would result in transient suspended particulate matter containing metals, PAHs, and dioxins and furans in the surface water of the Inner Cove and possibly, by advective flow, of the Outer Cove. With the planned removal and replacement of sediments of the Inner Cove, there will be no future re-suspension of impacted sediments of the Inner Cove. Concentrations of metals, dioxins and furans, and PAHs in surface water are expected to decrease after the Inner Cove sediment remediation.

The completed, on-going, and planned remedial activities have reduced migration of Site-related contaminants to the Inner Cove and the Outer Cove surface water and sediment. It is expected that the continued operation of the groundwater containment system and the remediation of Inner Cove sediment will eliminate Site-related contaminant exposures in the Inner Cove and further reduce Site-related contaminant exposures for the Outer Cove. In that context, the data used in the risk assessment is conservative, and is likely to overestimate potential surface water and sediment exposures for the future.

RISK ASSESSMENT UPDATE

The following sections are included in this risk assessment update.

- Hazard Identification – identify the Chemicals of Potential Concern (COPCs) that are present in sediment and surface water, and compile the analytical data available for those compounds.

- Exposure Assessment – identify receptors and exposure points, identify exposure scenarios (route of exposure, frequency and duration of exposure), and identify exposure point concentrations for each receptor at each exposure point.
- Toxicity Assessment – identify for each compound evaluated, for direct contact (ingestion and dermal contact) with sediment and surface water, Reference Dose (RfD) and Cancer Slope Factor (CSF) values to be used in calculating hazard quotients (and hazard index values) and cancer risks.
- Risk characterization – calculate cumulative receptor non-cancer risk and cumulative receptor cancer risk for each receptor at each exposure point. Compare calculated risks to cumulative receptor risk limits (Cumulative cancer risk of 1×10^{-5} and Cumulative Non-cancer Hazard Index of 1) and compare cancer risk for each chemical to the single-chemical risk limit of 1×10^{-6}.

Hazard Identification

The sediment samples used in the risk assessment are identified in Table 1. The sediment samples selected for use in the risk assessment are from near-shore locations, representative of areas where sediment contact would be more likely. The samples selected were collected at locations with depth of water approximately 6 feet or less. In order to include as much of the available sediment data to characterize near-shore exposures, some sediment samples collected at locations with slightly more than 6 feet of water were selected for use in the risk assessment. Sediment sample locations in the deeper water of the interior of the Outer Cove were not selected, since the deeper water would minimize the likelihood of sediment contact. Locations of sediment sample used in the risk assessment are shown in Figure 1. Table 2 presents the sediment analytical data used in the risk assessment for sediment COPCs detected from the Outer Cove. COPCs were selected for sediment as part of the human health risk assessment completed in 2006 (Appendix H of the SIR).

Surface water samples used in the risk assessment are identified in Table 1. Locations of surface water samples used in the risk assessment are shown on Figure 1. In contrast to sediments, it is assumed that all of the surface water samples (not just the near-shore samples) would represent surface water that could be contacted, particularly during potential swimming activity. Table 3 presents the surface water analytical data used in the risk assessment for surface water COPCs detected in the Outer Cove. As shown in Table 3, only 3 Outer Cove surface water samples were analyzed for VOCs. The uncertainty analysis addresses this small number of samples and presents some worst-case scenarios to evaluate risks associated with VOCs in surface water. COPCs were selected for surface water as part of the human health risk assessment completed in 2006 (Appendix H of the SIR).

Exposure Assessment

The current and future site uses and exposure pathways were previously described in the 2006 HHRA (MACTEC, 2006). Previously the HHRA evaluated risks to a trespasser. However, in the future the fence surrounding the site will be removed, most of the soil in the area around the Inner and Outer Cove will have been capped and seeded, and the sediments of the Inner Cove will have been replaced. Therefore the future receptor evaluated in the risk assessment update is a site visitor. This update to the risk assessment assumes that a site visitor could potentially contact surface water and aquatic (submerged) sediment by incidental ingestion and dermal contact

during wading and/or swimming. The exposure parameters for the site visitor remain the same as the exposure parameters used for the future trespasser in the 2006 HHRA (AMEC, 2014).

It is assumed that a site visitor would include older children (ages 7 through 18) and adults (assumed ages 19 through 30). It is assumed that a site visitor may visit the Outer Cove for wading and swimming mid-May through mid-September. The exposure frequency for sediment and surface water assumes 51 days (3 times weekly for 17 weeks) of wading per year and swimming on 17 (once weekly) of those 51 days for adults/older children. The risk assessment does not evaluate children younger than 7 years of age. Given the physical environment including a steep slope down to the water, a wooded shoreline, lack of a beach and steep banks along much of the shoreline, young children are not expected to be wading or swimming in the Outer Cove. It should also be noted that the City of Providence maintains 5 public swimming pools and 11 water parks open during the summer. These would be a more attractive option for public swimming than the Outer Cove, further supporting the conservatism of the assumed exposure scenarios to the surface water and sediment. Tables 4 and 5 present the exposure parameters used for sediment and surface water for the site visitor.

The exposure frequency for wading (51 days per year) and swimming (17 days per year) are reasonable for this urban pond. As a point of reference, the Maine Department of Environmental Protection (DEP) has a default exposure frequency for wading of 78 days per year and swimming of 40 days per year (4 days per week for 10 weeks during the summer). The Maine DEP Park Visitor exposure scenario (Maine DEP, 2013) is a more intensive land use (an active recreational park scenario that likely includes a formal, supervised wading/swimming beach area) than the Outer Cove scenario. The Maine DEP exposure parameters are located at:

http://www.maine.gov/dep/ftp/RAGS-Background-Documents/Human%20Health%20Risk%20Assessment%20Manual/

Previously, in the risk assessment competed in 2006, two scenarios were evaluated, the Reasonable Maximum Exposure (RME) scenario and the Central Tendency (CT) scenario. The CT exposure is the typical or average exposure that would be expected in a population. The RME is the highest exposure that is reasonably expected to occur at a site. The more conservative (health-protective) RME scenario is included in this risk assessment update.

Consistent with USEPA guidance, a single concentration is selected as representative of the exposures for each COPC in a given medium for a given exposure point. This value, called the Exposure Point Concentration (EPC), is used in the estimates of health risks for the Outer Cove. The EPC has been identified as the lower of the 95% Upper Confidence Limit (UCL) on the mean and the maximum detected concentration. If there is an insufficient number of samples for calculation of the 95% UCL, the maximum detected concentration is used as the EPC. Table 6 presents the EPCs for COPCs in the Outer Cove sediments. Table 7 presents the EPCs for COPCs in Outer Cove surface water.

Toxicity Assessment

The purpose of the toxicity assessment is to characterize the relationship between the dose of COPCs received and the likelihood or risk of adverse health effects in the exposed population. Based on this quantitative dose-response relationship, toxicity values (e.g., slope factors, reference dose values, or reference concentrations) are derived that can be used to characterize

the risk of adverse effects as a function of human exposure to an agent. These toxicity values are used in the risk characterization process to estimate the cancer risk and non-cancer hazard at different exposure levels.

The dose-response relationship(s) for each chemical that has been selected as a COPC is presented in this section. The dose-response information may be divided into two major categories:

- Toxicity information associated with threshold (non-carcinogenic) health effects.
- Toxicity information concerning carcinogenicity, either from human epidemiologic data or from laboratory studies.

All the chemicals selected as COPCs are evaluated for potential non-carcinogenic health effects. In addition, any substance identified by USEPA as a known, probable, or possible human carcinogen is also evaluated for its potential carcinogenic effects. The classification of a chemical as a carcinogen does not preclude an evaluation of that same chemical for potential non-carcinogenic health risks, as all potentially carcinogenic chemicals may also exert non-carcinogenic health effects.

The following hierarchy of sources for dose-response values has been utilized in identifying dose-response values for this HHRA.

Tier 1- IRIS (http://www.epa.gov/iris/). In accordance with USEPA guidance, the main source of dose-response values is the USEPA Integrated Risk Information System (IRIS), which is a database established by USEPA containing all validated data on many toxic substances found at hazardous waste Sites. This database was used to identify the CSFs and RfDs applied in this risk assessment (USEPA, 2014).

Tier 2- National Center for Environmental Assessment's (NCEA's) provisional peer reviewed toxicity values (PPRTVs). NCEA's PPRTVs are developed by the Superfund Technical Support Center (STSC) for the EPA Superfund program. STSC's reassessment of HEAST toxicity values, as well as development of PPRTVs in response to Regional or Headquarters Superfund program requests, are consistent with Agency practices on toxicity value development, use the most recent scientific literature, and are supported by both internal and external peer review, providing a high level of confidence in the use of these values in the Superfund Program.

Tier 3 - Other toxicity values

- Cal EPA's toxicity values. Cal EPA develops toxicity values for both cancer and non-cancer effects. Cal EPA toxicity values are obtained on the Cal EPA website at http://www.oehha.ca.gov/risk/chemicalDB//index.asp.
- Toxicity values remaining in current versions of HEAST (1997a).

In this HHRA, most of dose-response values used are published in IRIS. For some COPCs, the required dose-response data are only available as NCEA provisional values or from CAL-EPA. These dose-response values were used in this HHRA in order to provide a more complete evaluation of potential risks. Tables 8 and 9 present the Cancer Slope Factors and Reference Doses used in the risk calculations.

USEPA has developed guidance for characterizing cancer susceptibility associated with early life exposures (e.g., young children) to potentially carcinogenic chemicals (USEPA, 2005). The approach developed by USEPA to characterize cancer risks for early life stages includes consideration of differences in physiology and exposure potential between children and adults, as well as differences in susceptibility to tumor development between children and adults. Physiological and behavioral differences are accounted for in the exposure assessment, whereby age-specific exposure parameters (e.g., body weights, ingestion rates, inhalation rates, contact frequencies) are applied to the various age groups evaluated in the risk assessment. Differences in susceptibility to tumor development are accounted for by considering the carcinogenic mode of action in accordance with the mode of action framework developed by USEPA (USEPA, 2005). CSFs for carcinogens that act with a mutagenic mode of action are assigned Age-Dependent Adjustment Factors (ADAFs) to account for early life stage susceptibility. A 10 fold adjustment is used for the first two years of life (ages 0-2). A 3 fold adjustment is used after two year through <16 years of ages. After 16 years of age no adjustment is made to the CSFs (USEPA, 2005).

This risk assessment update evaluates adolescents (ages 7-18) and adults (ages 19-30). Typically the CSFs are multiplied by the ADAF to account for the mutagenic MOA. For this risk assessment the ADAF has been included in the intake calculation for the adolescent receptor for carcinogenic chemicals with a mutagenic MOA as shown in Table 4. The ADAF value of 2.5 for the adolescent site visitor receptor represents a weighted average adjustment factor (9 years under age 16 and 3 years at age 16 and above):

$$\frac{(9\ years \times 3) + (3\ years \times 1)}{12\ years} = 2.5$$

As stated previously no CSF adjustment is necessary for the adult receptor.

Carcinogenic COPCs (for sediment and/or surface water) with a mutagenic mode of action identified by USEPA include: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, vinyl chloride and trichloroethene. Therefore, the CSFs for each of those COPCs (except vinyl chloride) have been adjusted for the 7 – 18 age group to account for the mutagenic mode of action. The time-weighted ADAF of 2.5 has been applied to the oral and dermal CSFs for the COPCs identified above for sediment and surface water exposures for the adolescent site visitor. The vinyl chloride CSF does not require adjustment, since the CSF incorporates the adjustment.

The oral CSF and RfD for arsenic (USEPA, IRIS) are based on exposure to arsenic in water. For most chemicals is it assumed that the bioavailability in the exposure medium used to derive the toxicity values is the same as the bioavailability in the exposure medium evaluated at the Site. However, USEPA has determined that arsenic in soil is less bioavailable than arsenic in drinking water. The Relative Bioavailability (RBA) for soil compared to drinking water is the ratio of bioavailability from soil and the bioavailability in drinking water. USEPA has compiled available estimates of the RBA of arsenic in soil. Based on the available data an upper percentile from the arsenic RBA dataset was determined to be 0.60 (USEPA, 2012). Therefore, this risk assessment will use a RBA of 60% for exposure to arsenic in sediment (analogous to soil) for both carcinogenic and non-carcinogenic endpoints.

Risk Characterization

Cancer risk and non-cancer hazard index was calculated for the site visitor (adolescent and adult separately) using the same standard EPA risk calculation equations that were used in the original 2006 risk assessment. The receptor cancer risk was calculated as the sum of the cancer risks for the two age groups. The receptor hazard index for each age group have been considered separately (by convention, they are not additive). Risk calculations for sediment are presented in the spreadsheets in Attachments A (Tables A-1 and A-2) and B (Tables B-1 and B-2). Tables A-3, A-4, B-3, and B-4 present risks for surface water using Outer Cove surface water EPCs. Attachment A includes spreadsheets in a USEPA RAGS Part D Table 7 format and Attachment B includes risk calculation spreadsheets in the USEPA RAGS Part D Table 9 format. The risk summary for the RME scenario for the site visitor is presented in Table 10.

Calculated risks for each receptor are compared to the remedial objectives as outlined in the Remediation Regulations (RIDEM, 2011):

1. The excess lifetime cancer risk for each carcinogenic substance does not exceed 1×10^{-6} and the cumulative excess lifetime cancer risk (ELCR) posed by the site does not exceed 1×10^{-5};
2. The hazard index for each substance does not exceed a hazard index of 1 and the cumulative hazard index posed by the contaminated-site does not exceed 1 for any target organ.

The risk characterization results for the site visitor for the Outer Cove are summarized below:

- The cumulative HI (0.012) for the site visitor for exposures to surface water and sediment in the Outer Cove is below the target risk level.
- The individual chemical HI values for the site visitor for exposures to surface water and sediment in the Outer Cove are below the target risk level.
- The cumulative ELCR (4×10^{-6}) for the site visitor for exposures to surface water and sediment in the Outer Cover are below the target risk.
- The individual chemical cancer risk for all COPCs except benzo(a)pyrene (BaP) is below the individual chemical risk limit of 1×10^{-6}. For BaP in sediment (not detected in the three surface water samples tested for SVOCs), the calculated cancer risk (2×10^{-6}) in sediment is greater than the individual chemical risk limit of 1×10^{-6}. That estimated risk is based on one detection of BaP (0.862 mg/kg) in a sediment sample collected from sampling location SED/SW-12 (located just outside the northeast boundary of the Outer Cove). BaP was not detected in the other 3 sediment samples (SED/SW-10, SED/SW-13, and SED/SW-15) analyzed for BaP. The risk estimate is biased high as the result of using the single detection of BaP as the exposure point concentration. This typically applied, conservative approach does not incorporate the fact that there are three of four samples with no detected BaP. <u>This artifact of the data distribution and the conservative assumptions about frequency of exposure indicate that this cancer risk is overestimated and that the risk is below 1×10^{-6}.</u>

Uncertainty Analysis

Unlike some other assessments, risk assessments rely not just on measured or certain facts, but also on assumptions and estimates, and also policy decisions, in the face of limited or nonexistent data. Historically, many risk assessments have used highly conservative assumptions in the place of unavailable data, with the net result often being a substantial overestimation of potential risks. It is important, however, to evaluate the assumptions and choices made in any risk assessment to evaluate their impact on the results and conclusions.

Benzo(a)pyrene

The calculated BaP individual cancer risk (using the maximum detected sediment concentration) of 2×10^{-6} exceeds the individual chemical risk limit of 1×10^{-6}. BaP was not detected in the only surface water sample analyzed for BaP from the Outer Cove area. Therefore the cancer risk of 2×10^{-6} is entirely from exposure to sediments. There were four sediment samples analyzed for BaP and BaP was detected in one of the four samples. The EPC for BaP in sediment is the maximum concentration (0.862 mg/kg) since a 95% UCL cannot be calculated with only one detection. The average concentration of BaP in sediment, using half the detection limit for non-detects, is 0.23 mg/kg. The use of the maximum concentration of BaP in sediment as the EPC results in an overestimation of the cancer risk. Using the average concentration as the EPC for BaP the individual cancer risk for a site visitor for exposure to sediment is 5×10^{-7}.

Volatile Organics in Surface Water

The surface water data set used in the risk assessment for the Outer Cove consists of 21 samples collected in 2006 and 2011. All surface water samples were analyzed for metals, however only three surface water samples were analyzed for volatile organic compounds (VOCs) (SW10, SW11, and SW21). To address RIDEM comments concerning the limited data set for VOCs three additional conservative risk calculations were completed for surface water using different EPCs for VOCs.

The following three data sets were used to determine EPC for VOCs:

- Maximum detected concentration for VOCs for all surface water samples collected in the Inner and Outer Cove. This includes sample data from locations closer to the groundwater source area for VOCs than the Outer Cove.
- Maximum detected concentration for VOCs collected from the temporary shallow (0-5 feet bgs) groundwater location DP-I (at the downgradient end of the groundwater VOC plume and located just north of the boundary between the Inner Cove and Outer Cove). The plume does not extend throughout the Outer Cove. Shallow groundwater at that location would be the impacted groundwater that could discharge directly to sediments and surface water. This is a worst case scenario for VOC concentrations in surface water of the Outer Cove for the shallow groundwater discharge (assuming the groundwater concentrations would be unchanged (not diluted) when the groundwater discharges to surface water).
- Maximum detected concentration for VOCs collected from the temporary groundwater location DP-I using all depths sampled. This approach is a worst-case scenario for discharge of VOC impacted groundwater to sediment and surface water at the downgradient end of the groundwater VOC plume and for the entire Outer Cove.

It should be noted that these conservative and worst case scenarios utilize data that were collected prior to operation of the groundwater containment system. That system will eliminate migration of VOC-impacted groundwater to the Mashapaug Cove. Therefore, these worst case scenarios represent groundwater and surface water conditions from the 2006 to 2011 time period. VOC concentrations have likely decreased since then (groundwater containment system operating) and are expected to decrease further and the migration pathway to the Inner Cove will be eliminated.

The EPCs for the three different scenarios are presented in Table 12. The use of the maximum VOC concentrations detected in Inner and Outer Cove surface water represents a conservative estimate of the VOC concentrations a site visitor could be exposed to in the Outer Cove prior to installation of the groundwater containment system. Also the use of the shallow groundwater concentration at DP-I for the surface water EPC represents a conservative approach. This groundwater sampling point is located at the boundary of the Inner Cove and Outer Cove, and represents the boundary of VOC-impacted groundwater beneath Mashapaug Pond. This sample point also represents a conservative estimate of possible Outer Cove surface water VOC concentrations by not incorporating the biodegradation of the VOCs as they discharge up through the sediment and dilution with the Pond water once the groundwater is above the sediment/surface water interface.

Risk calculations were completed for a site visitor exposed to surface water using the three different EPCs for VOCs as listed above. The exposure scenario for the site visitor assumed the same exposure parameters used in the 2006 risk assessment. Risk calculations are documented in Tables A-5 through A-10 and B-5 through B-10. The risk summary for the different scenarios is presented in Table 10. For all three scenarios (and EPCs), the cumulative HI and cumulative cancer risk for the site visitor exposed to VOCs surface water are below the target risk limits. In addition the individual chemical HI and individual chemical cancer risk are below the risk limits for the three different EPC scenarios (Table 11).

Conclusions

In summary, the cumulative ELCR and HI values for the site visitor for the Mashapaug Outer Cove meet the Remediation Regulations risk limits. There are no individual HIs greater than the Remediation Regulations risk limit. One chemical (benzo(a)pyrene) has a calculated individual cancer risk greater that the Remediation Regulations risk limit for individual chemicals (1×10^{-6}). However, the risk calculation for BaP is biased high by a single detection in one sediment sample and the exposure frequency is very conservative. The cancer risk for BaP is overestimated, and the risk associated with the average concentration within the Outer Cove (a better representation of potential exposure) is below the individual chemical risk limit.

Based on this conservative risk assessment, the human health risks for a site visitor to the Mashapaug Outer Cove meet the risk limits identified in the Remediation Regulations. With the planned remediation of the Inner Cove sediments, no further remediation of the Outer Cove should be necessary.

References

AMEC, 2011. Mashapaug Cove Supplemental Site Investigation, Former Gorham Manufacturing Facility, 333 Adelaide Avenue, Providence, Rhode Island (Work Plan).

AMEC, 2013. Site Investigation Report Former Gorham Manufacturing Site Phase II Area – Mashapaug Pond and Cove, Phase III Area – Northeast Upland, and Parcel C. 333 Adelaide Avenue Providence, Rhode Island. November.

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TABLE A-1
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS -- REASONABLE MAXIMUM EXPOSURE - CURRENT/FUTURE - SITE VISITOR - ADOLESCENT/CHILD
RISK ASSESSMENT MEMORANDUM - SIR RESPONSE TO COMMENTS
GORHAM
PROVIDENCE, RHODE ISLAND

SCENARIO TIMEFRAME: CURRENT/FUTURE
RECEPTOR POPULATION: SITE VISITOR
RECEPTOR AGE: ADOLESCENT/CHILD

MEDIUM	EXPOSURE MEDIUM	EXPOSURE POINT	EXPOSURE ROUTE	CHEMICAL	EPC		CANCER RISK CALCULATIONS					NON-CANCER HAZARD CALCULATIONS				
					VALUE	UNITS	INTAKE/EXPOSURE CONCENTRATION		CSF/UNIT RISK		CANCER RISK	INTAKE/EXPOSURE CONCENTRATION		RfD/RfC (1)		HAZARD QUOTIENT
							VALUE	UNITS	VALUE	UNITS		VALUE	UNITS	VALUE	UNITS	
SEDIMENT	SEDIMENT	OUTER COVE	INGESTION	cis-1,2-Dichloroethene	0.296	mg/kg	NC		NC			9.2E-08	mg/kg/day	2.0E-03	mg/kg/day	5.E-05
				Tetrachloroethene	0.0161	mg/kg	8.6E-10	mg/kg/day	2.1E-03	(mg/kg/day)-1	2.E-12	5.0E-09	mg/kg/day	6.0E-03	mg/kg/day	8.E-07
				Trichloroethene	1.47	mg/kg	2.0E-07	mg/kg/day	4.6E-02	(mg/kg/day)-1	9.E-09	4.6E-07	mg/kg/day	5.0E-04	mg/kg/day	9.E-04
				Benzo(a)anthracene	0.685	mg/kg	9.1E-08	mg/kg/day	7.3E-01	(mg/kg/day)-1	7.E-08	2.1E-07	mg/kg/day	3.0E-02	mg/kg/day	7.E-06
				Benzo(a)pyrene	0.862	mg/kg	1.1E-07	mg/kg/day	7.3E+00	(mg/kg/day)-1	8.E-07	2.7E-07	mg/kg/day	3.0E-02	mg/kg/day	9.E-06
				Benzo(b)fluoranthene	1.41	mg/kg	1.9E-07	mg/kg/day	7.3E-01	(mg/kg/day)-1	1.E-07	4.4E-07	mg/kg/day	3.0E-02	mg/kg/day	1.E-05
				Dibenzo(a,h)anthracene	0.0807	mg/kg	1.1E-08	mg/kg/day	7.3E+00	(mg/kg/day)-1	8.E-08	2.5E-08	mg/kg/day	3.0E-02	mg/kg/day	8.E-07
				Indeno(1,2,3-cd)pyrene	0.259	mg/kg	3.4E-08	mg/kg/day	7.3E-01	(mg/kg/day)-1	3.E-08	8.0E-08	mg/kg/day	3.0E-02	mg/kg/day	3.E-06
				Dioxin TEQ (USEPA, 2010)	0.000001	mg/kg	5.3E-14	mg/kg/day	1.3E+05	(mg/kg/day)-1	7.E-09	3.1E-13	mg/kg/day	7.0E-10	mg/kg/day	4.E-04
				Arsenic	10.11	mg/kg	3.2E-07	mg/kg/day	1.5E+00	(mg/kg/day)-1	5.E-07	1.9E-06	mg/kg/day	3.0E-04	mg/kg/day	6.E-03
				Chromium	5.361	mg/kg	NC		NC			1.7E-06	mg/kg/day	1.5E+00	mg/kg/day	1.E-06
				Copper	7.167	mg/kg	NC		NC			2.2E-06	mg/kg/day	4.0E-02	mg/kg/day	6.E-05
				Lead	10.54	mg/kg	NC		NC			3.3E-06	mg/kg/day	NA		
				Nickel	10.3	mg/kg	NC		NC			3.2E-06	mg/kg/day	2.0E-02	mg/kg/day	2.E-04
			EXPOSURE ROUTE TOTAL								2.E-06					8.E-03
			DERMAL	cis-1,2-Dichloroethene	0.296	mg/kg	NC		NC			--		2.0E-03	mg/kg/day	
				Tetrachloroethene	0.0161	mg/kg	--		2.1E-03	(mg/kg/day)-1		--		6.0E-03	mg/kg/day	
				Trichloroethene	1.47	mg/kg	--		4.6E-02	(mg/kg/day)-1		--		5.0E-04	mg/kg/day	
				Benzo(a)anthracene	0.685	mg/kg	8.5E-08	mg/kg/day	7.3E-01	(mg/kg/day)-1	6.E-08	2.0E-07	mg/kg/day	3.0E-02	mg/kg/day	7.E-06
				Benzo(a)pyrene	0.862	mg/kg	1.1E-07	mg/kg/day	7.3E+00	(mg/kg/day)-1	8.E-07	2.5E-07	mg/kg/day	3.0E-02	mg/kg/day	8.E-06
				Benzo(b)fluoranthene	1.41	mg/kg	1.7E-07	mg/kg/day	7.3E-01	(mg/kg/day)-1	1.E-07	4.1E-07	mg/kg/day	3.0E-02	mg/kg/day	1.E-05
				Dibenzo(a,h)anthracene	0.0807	mg/kg	1.0E-08	mg/kg/day	7.3E+00	(mg/kg/day)-1	7.E-08	2.3E-08	mg/kg/day	3.0E-02	mg/kg/day	8.E-07
				Indeno(1,2,3-cd)pyrene	0.259	mg/kg	3.2E-08	mg/kg/day	7.3E-01	(mg/kg/day)-1	2.E-08	7.5E-08	mg/kg/day	3.0E-02	mg/kg/day	2.E-06
				Dioxin TEQ (USEPA, 2010)	0.000001	mg/kg	1.1E-14	mg/kg/day	1.3E+05	(mg/kg/day)-1	1.E-09	6.7E-14	mg/kg/day	7.0E-10	mg/kg/day	1.E-04
				Arsenic	10.11	mg/kg	1.2E-07	mg/kg/day	1.5E+00	(mg/kg/day)-1	2.E-07	6.7E-07	mg/kg/day	3.0E-04	mg/kg/day	2.E-03
				Chromium	5.361	mg/kg	NC		NC			--		2.0E-02	mg/kg/day	
				Copper	7.167	mg/kg	NC		NC			--		4.0E-02	mg/kg/day	
				Lead	10.54	mg/kg	NC		NC			--		NA		
				Nickel	10.3	mg/kg	NC		NC			--		8.0E-04	mg/kg/day	
			EXPOSURE ROUTE TOTAL								1.E-06					2.E-03
		EXPOSURE POINT TOTAL									3.E-06					1.E-02
	EXPOSURE MEDIUM TOTAL										3.E-06					1.E-02
											TOTAL RECEPTOR RISK ACROSS ALL MEDIA					**TOTAL RECEPTOR HAZARD ACROSS ALL MEDIA**
											3.E-06					**1.E-02**

NOTES:
NA - indicates that an RfD or RfC is not avalailable from the sources used to obtain dose-response data for this risk assessment.
NC - Not carcinogenic by this exposure route.
-- - Not calculated; dose-response data and/or dermal absorption values are not available.

Prepared by: LCG 12/2/2014
Checked by: BJR 12/7/2014

TABLE B-2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - REASONABLE MAXIMUM EXPOSURE - CURRENT/FUTURE - SITE VISITOR - ADULT
RISK ASSESSMENT MEMORANDUM - SIR RESPONSE TO COMMENTS
GORHAM
PROVIDENCE, RHODE ISLAND

SCENARIO TIMEFRAME: CURRENT/FUTURE
RECEPTOR POPULATION: SITE VISITOR
RECEPTOR AGE: ADULT

MEDIUM	EXPOSURE MEDIUM	EXPOSURE POINT	CHEMICAL	CARCINOGENIC RISK (1)					NON-CARCINOGENIC HAZARD QUOTIENT (1)				
				INGESTION	INHALATION	DERMAL	EXTERNAL (RADIATION)	EXPOSURE ROUTES TOTAL	PRIMARY TARGET ORGAN	INGESTION	INHALATION	DERMAL	EXPOSURE ROUTES TOTAL
SEDIMENT	SEDIMENT	OUTER COVE	cis-1,2-Dichloroethene	NC	NA	NC	NA		Undetermined	3.0E-05	NA	--	3.0E-05
			Tetrachloroethene	1.2E-12	NA	--	NA	1.2E-12	Liver	5.4E-07	NA	--	5.4E-07
			Trichloroethene	2.3E-09	NA	--	NA	2.3E-09	Liver / Kidney	5.9E-04	NA	--	5.9E-04
			Benzo(a)anthracene	1.7E-08	NA	7.6E-09	NA	2.5E-08	Kidney	4.6E-06	NA	2.0E-06	6.6E-06
			Benzo(a)pyrene	2.2E-07	NA	9.5E-08	NA	3.1E-07	Kidney	5.7E-06	NA	2.5E-06	8.3E-06
			Benzo(b)fluoranthene	3.5E-08	NA	1.6E-08	NA	5.1E-08	Kidney	9.4E-06	NA	4.1E-06	1.4E-05
			Dibenzo(a,h)anthracene	2.0E-08	NA	8.9E-09	NA	2.9E-08	Kidney	5.4E-07	NA	2.4E-07	7.7E-07
			Indeno(1,2,3-cd)pyrene	6.5E-09	NA	2.9E-09	NA	9.3E-09	Kidney	1.7E-06	NA	7.6E-07	2.5E-06
			Dioxin TEQ (USEPA, 2010)	4.4E-09	NA	4.5E-10	NA	4.9E-09	Reproductive / Endocrine	2.9E-04	NA	2.9E-05	3.1E-04
			Arsenic	3.1E-07	NA	5.3E-08	NA	3.6E-07	Skin / Hematological	4.0E-03	NA	6.9E-04	4.7E-03
			Chromium	NC	NA	NC	NA		NOAEL	7.1E-07	NA	--	7.1E-07
			Copper	NC	NA	NC	NA		Undetermined	3.6E-05	NA	--	3.6E-05
			Lead	NC	NA	NC	NA			--	NA	--	
			Nickel	NC	NA	NC	NA		General Toxicity	1.0E-04	NA	--	1.0E-04
												--	
			CHEMICAL TOTAL	6.1E-07	--	1.8E-07	--	8E-07		5.1E-03	--	7.3E-04	6E-03
			RADIONUCLIDE TOTAL										
		EXPOSURE POINT TOTAL						8E-07					6E-03
	EXPOSURE MEDIUM TOTAL							8E-07					6E-03
RECEPTOR TOTAL								**8E-07**					**6E-03**
							TOTAL RISK ACROSS ALL MEDIA	**8E-07**	**TOTAL HAZARD ACROSS ALL MEDIA**				**6E-03**

NOTES:
NC - Not carcinogenic by this exposure route.
NA - Not applicable; exposure route not applicable for this chemical/exposure medium.
-- - Not calculated; dose-response data and/or dermal absorption values are not available.

Prepared by: LCG 12/2/2014
Checked by: BJR 12/7/2014

TOTAL GENERAL TOXICITY HI =	**1.0E-04**
	--
	--
	--
	--
	--
	--
	--
TOTAL KIDNEY HI =	**6.2E-04**
TOTAL LIVER HI =	**5.9E-04**
	--
	--
TOTAL NOAEL HI =	**6.6E-05**
	--
	--
	--

Calculations Check - Sediment - Outer Cove

Adolescent BaP Intake Sediment Ingestion

BaP CONCENTRATION IN SEDIMENT	CS	0.862	mg/kg	BaP INTAKE cancer-INGESTION =		
INGESTION RATE OF SEDIMENT	IR-S	100	mg/day	CS x IR-S x FI x EF x ED x CF x ADAF x 1/BW x 1/AT	=	1.14708E-07
FRACTION INGESTED	FI	1	unitless			
EXPOSURE FREQUENCY	EF	51	day/yr			
EXPOSURE DURATION	ED	12	yr	***ROUNDS TO 1.1E-07***		
BODY WEIGHT	BW	45	kg			
AVERAGING TIME (CANCER)	AT-C	25550	day			
AVERAGING TIME (NONCANCER)	AT-N	4380	day			
CONVERSION FACTOR	CF	0.000001	kg/mg			
AGE DEPENDENT ADJUSTMENT FACTOR	ADAF	2.5	unitless			

Adolescent BaP Intake Sediment Dermal

BaP CONCENTRATION IN SEDIMENT	CS	0.862	mg/kg	BaP INTAKE-DERMAL =		
ADHERENCE FACTOR	AF	0.2	mg/cm2	DAevent x SA x EV x EF x ED x ADAF x 1/BW x 1/AT	=	1.06592E-07
ABSORPTION FACTOR	AbF	0.13	unitless			
SKIN SURFACE AREA AVAILABLE FOR CONTACT	SA	3574	cm2/day	Where DAevent =		
EVENT DAY	EV	1	unitless	CS x AF x AbF x CF		
EXPOSURE FREQUENCY	EF	51	day/yr	***ROUNDS TO 1.1E-07***		
EXPOSURE DURATION	ED	12	yr			
BODY WEIGHT	BW	45	kg			
AVERAGING TIME (CANCER)	AT-C	25550	day			
AVERAGING TIME (NONCANCER)	AT-N	4380	day			
CONVERSION FACTOR	CF	0.000001	kg/mg			
AGE DEPENDENT ADJUSTMENT FACTOR	ADAF	2.5	unitless			

Adult BaP Intake Sediment Ingestion

BaP CONCENTRATION IN SEDIMENT	CS	0.862	mg/kg	BaP INTAKE-cancer INGESTION =		
INGESTION RATE OF SEDIMENT	IR-S	100	mg/day	CS x IR-S x FI x EF x ED x CF x 1/BW x 1/AT	=	2.94964E-08
FRACTION INGESTED	FI	1	unitless			
EXPOSURE FREQUENCY	EF	51	day/yr	BaP INTAKE-noncancer INGESTION =		
EXPOSURE DURATION	ED	12	yr	CS x IR-S x FI x EF x ED x CF x 1/BW x 1/AT	=	1.72063E-07
BODY WEIGHT	BW	70	kg			
AVERAGING TIME (CANCER)	AT-C	25550	day	Cancer risk BaP Ingestion =		
AVERAGING TIME (NONCANCER)	AT-N	4380	day	INTAKE -cancer x CSF	=	2.15324E-07
CONVERSION FACTOR	CF	0.000001	kg/mg	***ROUNDS TO 2.2E-07***		
CANCER SLOPE FACTOR	CSF	7.3	$(mg/kg/day)^{-1}$	Hazard Quotient BaP Ingestion =		
REFERENCE DOSE	RfD	0.03	mg/kg/day	INTAKE- noncaner / RfD	=	5.73542E-06
				ROUNDS TO 5.7E-06		