DEP BWSC RAO LEVEL 1 AUDIT CHECKLIST

Disclaimer: This checklist is for use by DEP in reviewing Response Action Outcome (RAO) Statements, and may not be relied upon for any other purpose. This checklist is not a comprehensive list of RAO requirements, which are fully set forth in MGL c. 21E and 310 CMR 40.0000. Completion of this checklist by DEP does not constitute a final agency decision, and does not create any legal rights or relieve any party of obligations that exist pursuant to applicable laws.

RTN: 3-0000362 Town: Malden Street Address: Boston Gas Company M

Date RAO Rcvd: 7/2/2007 Date Screened: 4/8/2009

I. SITE CONCERNS

A. Air

1. Applicable GW-2 standard exceeded @ residence/school with no soil gas/indoor air sampling	no
2. Site contaminants impacting indoor air	no

B. Drinking Water/Groundwater

1. More than 0.5" NAPL observed in any monitoring well	no
2. Site within potential drinking water source area (PDWSA)	no
3. Site located within IWPA/mapped Zone II	no
4. Private/Non-municipal public well(s) (i.e. TNC, NTNC) located within 500 feet of site	no
5. Municipal well(s) located within 1000 feet of site	no
6. Private well contaminated as a result of site, still in use (no filter, no public water, etc.)	no
7. Public water supply contaminated as a result of site, no filters or other mitigation.	no

C. Contaminated Soil At a School or Residence

1. EPC in S-1 soil exceeds Method 1 Standard	no
2. Bioaccumulating compounds (i.e. Hg, Pb, PCBs, etc.) detected less than 1 foot dee	no
3. IH compounds (arsenic, cadmium, chrome VI, cyanide) detected less than 1 foot dee	no

D. Environmental Concerns

1. Site within 500 feet of surface water and/or wetlands	yes
2. Endangered species habitat, ACEC and/or certified vernal pool within 500 fee	no
3. Confirmed contamination of surface water, sediments and/or wetlands with site contaminant	yes

E. Site Area Use - Check All That Apply

1. Industrial use or public Right of Way (no children likely to be present)	yes
2. Commercial (limited presence of children)	no
3. School/institution (pre-K through high school, not college/university)	no
4. Residential	no

RTN 3-0000362

F. Released OHM (Primary Contaminant Type[s]

1. Petroleum fuel oils (e.g. #2, #4, #6, JP-4, JP-8, kerosene, lube oil, MODF, etc.	no
2. Gasoline, waste oils, Aviation Fuel (AVGAS, Jet A, etc.)	no
3. Metals, coal tar, PCBs, pesticides/herbicides, asbestos, cyanide	yes
4. Chlorinated solvents, perchlorate, or other organic compounds	yes

G. Site Complexity

1. Co-mingled plumes (i.e., from different sources, one or more releases co-mingled)	yes
2. Bedrock contamination	?

II. TECHNICAL ADEQUACY

A. Remedial Response Actions:

1. Documentation (BOL, HWM, etc.) of removal/treatment of contaminated soil was provide	yes
2. Remediation waste properly managed (Air [95%], GW [permit], SW [NPDES])	yes

B. Source/Extent Investigations:

1. History of OHM use/storage/disposal at the site included	yes
2. Potential source(s) identified, characterized, or abated (septic leach field, floor drain, AST, etc	yes
3. All migration pathways evaluated (soil, groundwater, surface water, air, sediment, food)	yes
4. Extent of contamination defined in all media (including downgradient)	yes
5. Potential or actual OHM analyzed for and/or evaluated (metals, VPH, VOCs, etc.)	yes
6. Proper sample collection technique/preservation//holding times/surrogate recovery, etc.	yes

C. Risk Characterization:

1. Correct risk characterization method used (relative to indoor air, surface water, sediment, etc	yes
2. Background identified or characterized	yes
3. All receptors accounted for (human, environmental) or AUL applied	yes
4. Site activities and uses identified (current, future, any limitations that were assume	yes
5. Exposure points identified (GW _soil for all RC Methods, other media for Methods 2 3)	yes
6. All exposure pathways identified and evaluated (inhalation, ingestion, dermal, etc.	yes
7. Hot Spot(s) addressed, identified (as Hot Spot) and not added in to other EPCs	yes
8. EPC calculation(s)/equations provided (including spatial and/or temporal, Hot Spots, etc.)	yes
9. EPC properly calculated (maximum concentration, 75%/10x, upper confidence limit)	yes
10. Soil/groundwater categories properly identified	yes
11. Applicable soil and/or GW standards not exceeded (Method 1 or 2) or AUL applied	yes
12. Characterization of Risk to Safety is included (all methods)	yes
13. Method 3 Public Welfare Risk Characterization is included	yes
14. Method 3 Environmental Risk Characterization – Stage 1 or 2 was completed, if applicab	yes
15. Method 3 Human Health: Non-Cancer Risks < HI of 1, ELCR < than 1x10-5	yes

RTN 3-0000362

III. Preliminary Response Action Type

1. Correct RAO Class was selected	yes
2. RAO boundaries delineated and referenced to permanent landmarks or surveyed boundarie	yes
3. Relationship of this RAO to other RAOs for the property has been defined	no
4. Data Usability Assessment (scien. valid defensible, precise, accurate, complete) is include	yes
5. Data Representativeness Evaluation (adequate spatial and temporal data) is included	yes

A. CLASS A - Permanent Solutions:

1. A background feasibility evaluation is included	yes
2. A Permanent Solution has been achieved	?
3. All sources have been eliminated or controlled	yes
4. Phase IV, Phase V, or Post-RAO OM, where required, were completed	yes

A-1. CLASS A-1:

1. The level of OHM at the site has been reduced to background	NA
2. Threats of Release Only: all TORs were eliminated, and a release of OHM has not occurred	NA

A-2. CLASS A-2:

1. An AUL is not required to maintain a condition of No Significant Risk	yes

A-3. CLASS A-3:

1. An AUL has been implemented to maintain a condition of No Significant Risk	NA
2. Groundwater or Soil OHM concentrations do not exceed UCLs	NA

A-4. CLASS A-4:

1. An AUL has been implemented to maintain a condition of No Significant Risk	NA
2. OHM in soil that exceeds UCLs is beneath engineered barrier or >15 feet below ground surface	NA
3. UCL Feasibility Evaluation conducted and shows that achieving UCLs is not feasible	NA

B. CLASS B - Permanent Solutions: RTN 3-0000362

1. A condition of No Significant Risk exists — NA
2. Remedial actions have not been conducted — NA
3. Where GW-1 applies, groundwater does not exceed an applicable or analogous standard — NA

B-1. CLASS B-1:

1. One or more AULs are not necessary to maintain a level of no significant risk — NA

B-2. CLASS B-2:

1. An AUL has been implemented to maintain a condition of No Significant Risk — NA
2. OHM in groundwater or soil does not exceed UCLs — NA

B-3. CLASS B-3:

1. An AUL has been implemented to maintain a condition of No Significant Risk — NA
2. EPC in soil exceeds UCLs; however:
   a. OHM is located >15 feet below ground surface, AND — NA
   b. UCL Feasibility Evaluation shows that achieving UCLs is not feasible — NA

C. CLASS C - Temporary Solutions:

1. A condition of No Substantial Hazard exists — NA
2. ID, charactization, elimination, and control or mitigation of OHM release has been demonstrated — NA
3. Soil and/or groundwater concentrations exceed applicable or analogous standards or UCLs — NA
4. Phase II and Phase III reports were submitted, or DPS Opinion was submitted — NA
5. A plan with definitive and enterprising steps toward a Permanent Solution has been submitted — NA

C-1. Class C-1:

1. Valid feasibility evaluation - Permanent Solution currently cannot be achieved. — NA

C-2. Class C-2:

1. Site has a valid Tier I Permit, Permit Extension, or Tier 2 status — NA

100 Commercial ST 3

RESPONSE ACTION OUTCOME PARTIAL STATEMENT

Former Malden MGP Site
(Malden River Portion) UIA
Malden, Massachusetts
June 2007

3-362

RECEIVED

JUL 02 2007

DEP
NORTHEAST REGIONAL OFFICE

BROWN AND CALDWELL

1 Corporate Drive
Andover, MA 01810

Tel: (978) 794-0336
Fax: (978) 794-0534

BROWN AND CALDWELL

June 29, 2007

Massachusetts Department of Environmental Protection
Northeast Regional Office
205B Lowell Street
Wilmington, MA 01887

36-25469

Subject: Submittal of Response Action Outcome Partial Statement
Former Malden Manufactured Gas Plant (MGP) Site – Malden River Portion
(RTN 3-0362)

Dear Sir or Madam:

Enclosed please find a copy of the Response Action Outcome Partial Statement for the Malden River Portion of the Former Malden Manufactured Gas Plant (MGP) Site. Please call me or Michele Leone at National Grid (508-389-4296) if you have any questions.

Sincerely,

BROWN AND CALDWELL

Donald W. Podsen
Licensed Site Professional

cc: Michele Leone – National Grid

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC104

RESPONSE ACTION OUTCOME (RAO) STATEMENT

Pursuant to 310 CMR 40.1000 (Subpart J)

Release Tracking Number: 3 - 362

For sites with multiple RTNs, enter the Primary RTN above.

A. SITE LOCATION:

1. Site Name/Location Aid: BOSTON GAS COMPANY MALDEN PLANT

2. Street Address: 100 COMMERCIAL ST

3. City/Town: MALDEN 4. ZIP Code: 021480000

☑ 5. Check here if a Tier Classification Submittal has been provided to DEP for this disposal site.

☐ a. Tier IA ☑ b. Tier IB ☐ c. Tier IC ☐ d. Tier II

6. If a Tier I Permit has been issued, provide Permit Number: 7378

B. THIS FORM IS BEING USED TO: (check all that apply)

1. List Submittal Date of RAO Statement (if previously submitted): _____ mm/dd/yyyy

☐ 2. Submit a **Response Action Outcome (RAO) Statement**

☐ a. Check here if this RAO Statement covers additional Release Tracking Numbers (RTNs). RTNs that have been previously linked to a Tier Classified Primary RTN do not need to be listed here.

b. Provide additional Release Tracking Number(s) covered by this RAO Statement. ☐ - _____ ☐ - _____

☐ 3. Submit a **Revised Response Action Outcome Statement**

☐ a. Check here if this Revised RAO Statement covers additional Release Tracking Numbers (RTNs), not listed on the RAO Statement or previously submitted Revised RAO Statements. RTNs that have been previously linked to a Tier Classified Primary RTN do not need to be listed here.

b. Provide additional Release Tracking Number(s) covered by this RAO Statement. ☐ - _____ ☐ - _____

☑ 4. Submit a **Response Action Outcome Partial (RAO-P) Statement**

Check above box, if any Response Actions remain to be taken to address conditions associated with this disposal site having the Primary RTN listed in the header section of this transmittal form. This RAO Statement will record only an RAO-Partial Statement for that RTN. A final RAO Statement will need to be submitted that references all RAO-Partial Statements and, if applicable, covers any remaining conditions not covered by the RAO-Partial Statements.

Also, specify if you are an Eligible Person or Tenant pursuant to M.G.L. c. 21E s. and have no further obligation to conduct response actions on the remaining portion(s) of the disposal site:

☐ a. Eligible Person ☐ b. Eligible Tenant

RECEIVED
JUL 02 2007
DEP
NORTHEAST REGIONAL OFFICE

☐ 5. Submit an optional **Phase I Completion Statement** supporting an RAO Statement

☐ 6. Submit a **Periodic Review Opinion evaluating the status of a Temporary Solution** for a Class C-1 RAO Statement, as specified in 310 CMR 40.1051 (Section F is optional)

☐ 7. Submit a **Retraction** of a previously submitted **Response Action Outcome Statement** (Sections E & F are not required)

(All sections of this transmittal form must be filled out unless otherwise noted above)

C. DESCRIPTION OF RESPONSE ACTIONS: (check all that apply; for volumes, list cumulative amounts)

- [x] 1. Assessment and/or Monitoring Only
- [ ] 2. Temporary Covers or Caps
- [ ] 3. Deployment of Absorbent or Containment Materials
- [ ] 4. Treatment of Water Supplies
- [ ] 5. Structure Venting System
- [ ] 6. Engineered Barrier
- [ ] 7. Product or NAPL Recovery
- [ ] 8. Fencing and Sign Posting
- [ ] 9. Groundwater Treatment Systems
- [ ] 10. Soil Vapor Extraction
- [ ] 11. Bioremediation
- [ ] 12. Air Sparging
- [ ] 13. Monitored Natural Attenuation
- [ ] 14. In-situ Chemical Oxidation

- [ ] 15. Removal of Contaminated Soils
  - [ ] a. Re-use, Recycling or Treatment
    - [ ] i. On Site Estimated volume in cubic yards
    - [ ] ii. Off Site Estimated volume in cubic yards

    iia. Facility Name: Town: State:

    iib. Facility Name: Town: State:

    iii. Describe:
  - [ ] b. Landfill
    - [ ] i. Cover Estimated volume in cubic yards

      Facility Name: Town: State:
    - [ ] ii. Disposal Estimated volume in cubic yards

      Facility Name: Town: State:
- [ ] 16. Removal of Drums, Tanks or Containers:

  a. Describe Quantity and Amount:

  b. Facility Name: Town: State:

  c. Facility Name: Town : State:
- [ ] 17. Removal of Other Contaminated Media:

  a. Specify Type and Volume:

  b. Facility Name: Town: State:

  c. Facility Name: Town: State:

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC104

RESPONSE ACTION OUTCOME (RAO) STATEMENT

Pursuant to 310 CMR 40.1000 (Subpart J)

Release Tracking Number: 3 - 362

C. DESCRIPTION OF RESPONSE ACTIONS (cont.): (check all that apply; for volumes, list cumulative amounts)

☑ 18. Other Response Actions:

Describe: **ACTIONS ON UPLAND PORTION OF SITE THAT AFFECT MALDEN RIVER INCLUDE SEALING OF CULVERTS, RE-LINING OF STORM DRAIN PIPES/CATCH BASINS, INJECTION OF GROUT IN BEDDING OF CULVERTS, AND REMOVAL OF DNAPL**

☐ 19. Use of Innovative Technologies:

Describe:

D. SITE USE:

1. Are the response actions that are the subject of this submittal associated with the *redevelopment, reuse* or the *major expansion of the current use* of property(ies) impacted by the presence of oil and/or hazardous materials?

☐ a. Yes ☑ b. No ☐ c. Don't know

2. Is the property a *vacant or under-utilized commercial or industrial* property ("a brownfield property")?

☐ a. Yes ☑ b. No ☐ c. Don't know

3. Will funds from a state or federal brownfield incentive program be used on one or more of the property(ies) within the disposal site?

☐ a. Yes ☑ b. No ☐ c. Don't know If Yes, identify program(s):

4. Has a Covenant Not to Sue been obtained or sought?

☐ a. Yes ☑ b. No ☐ c. Don't know

5. Check all applicable categories that apply to the person making this submittal: ☐ a. Redevelopment Agency or Authority

☐ b. Community Development Corporation ☐ c. Economic Development and Industrial Corporation

☐ d. Private Developer ☐ e. Fiduciary ☐ f. Secured Lender ☐ g. Municipality

☐ h. Potential Buyer (non-owner) ☑ i. Other, describe: **FORMER OWNER/OPERATOR**

This data will be used by MassDEP for information purposes only, and does not represent or create any legal commitment, obligation or liability on the part of the party or person providing this data to MassDEP.

E. RESPONSE ACTION OUTCOME CLASS:

Specify the Class of Response Action Outcome that applies to the disposal site, or site of the Threat of Release. Select **ONLY** one Class.

☐ **1. Class A-1 RAO**: Specify one of the following:

☐ a. Contamination has been reduced to background levels. ☐ b. A Threat of Release has been eliminated.

☑ **2. Class A-2 RAO:** You **MUST** provide justification that reducing contamination to or approaching background levels is infeasible.

☐ **3. Class A-3 RAO**: You **MUST** provide an implemented Activity and Use Limitation (AUL) and justification that reducing contamination to or approaching background levels is infeasible.

☐ **4. Class A-4 RAO**: You **MUST** provide an implemented AUL, justification that reducing contamination to or approaching background levels is infeasible, and justification that reducing contamination to less than Upper Concentration Limits (UCLs) 15 feet below ground surface or below an Engineered Barrier is infeasible. If the Permanent Solution relies upon an Engineered Barrier, you must provide or have previously provided a Phase III Remedial Action Plan that justifies the selection of the Engineered Barrier.

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC104

RESPONSE ACTION OUTCOME (RAO) STATEMENT

Pursuant to 310 CMR 40.1000 (Subpart J)

Release Tracking Number
3 - 362

E. RESPONSE ACTION OUTCOME CLASS (cont.):

☐ **5. Class B-1 RAO: Specify one of the following:**

☐ a. Contamination is consistent with background levels ☐ b. Contamination is **NOT** consistent with background levels.

☐ **6. Class B-2 RAO**: You **MUST** provide an implemented AUL.

☐ **7. Class B-3 RAO**: You **MUST** provide an implemented AUL and justification that reducing contamination to less than Upper Concentration Limits (UCLs) 15 feet below ground surface is infeasible.

☐ **8. Class C-1 RAO**: You must submit a plan as specified at 310 CMR 40.0861(2)(h). Indicate type of ongoing response actions.

☐ a. Active Remedial System ☐ b. Active Remedial Monitoring Program ☐ c. None

☐ d. Other Specify: _____

☐ **9. Class C-2 RAO**: You must hold a valid Tier I Permit or Tier II Classification to continue response actions toward a Permanent Solution.

F. RESPONSE ACTION OUTCOME INFORMATION:

1. Specify the Risk Characterization Method(s) used to achieve the RAO described above:

☐ a. Method 1 ☐ b. Method 2 ☑ c. Method 3

☐ d. Method Not Applicable-Contamination reduced to or consistent with background, or Threat of Release abated

2. Specify all Soil Category(ies) applicable. More than one Soil Category may apply at a Site. Be sure to check off all **APPLICABLE** categories:

☐ a. S-1/GW-1 ☐ d. S-2/GW-1 ☐ g. S-3/GW-1

☐ b. S-1/GW-2 ☐ e. S-2/GW-2 ☐ h. S-3/GW-2

☐ c. S-1/GW-3 ☐ f. S-2/GW-3 ☑ i. S-3/GW-3

3. Specify all Groundwater Category(ies) impacted. A site may impact more than one Groundwater Category. Be sure to check off all **IMPACTED** categories:

☐ a. GW-1 ☐ b. GW-2 ☑ c. GW-3 ☐ d. No Groundwater Impacted

4. Specify remediation conducted:

☐ a. Check here if soil remediation was conducted.

☐ b. Check here if groundwater remediation was conducted.

5. Specify whether the analytical data used to support the Response Action Outcome was generated pursuant to the Department's Compendium of Analytical Methods (CAM) and 310 CMR 40.1056:

☐ a. CAM used to support all analytical data. ☑ b. CAM used to support some of the analytical data.

☐ c. CAM not used.

☑ 6. Check here to certify that the Class A, B or C Response Action Outcome includes a Data Usability Assessment and Data Representativeness Evaluation pursuant to 310 CMR 40.1056.

7. Estimate the number of acres this RAO Statement applies to: 1

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC104

RESPONSE ACTION OUTCOME (RAO) STATEMENT

Pursuant to 310 CMR 40.1000 (Subpart J)

Release Tracking Number: 3 - 362

G. LSP SIGNATURE AND STAMP:

I attest under the pains and penalties of perjury that I have personally examined and am familiar with this transmittal form, including any and all documents accompanying this submittal. In my professional opinion and judgment based upon application of (i) the standard of care in 309 CMR 4.02(1), (ii) the applicable provisions of 309 CMR 4.02(2) and (3), and 309 CMR4.03(2), and (iii) the provisions of 309 CMR 4.03(3), to the best of my knowledge, information and belief,

> *if Section B indicates that either an **RAO Statement, Phase I Completion Statement and/or Periodic Review Opinion** is being provided,* the response action(s) that is (are) the subject of this submittal (i) has (have) been developed and implemented in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes of such response action(s) as set forth in the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, and (iii) comply(ies) with the identified provisions of all orders, permits, and approvals identified in this submittal.

I am aware that significant penalties may result, including, but not limited to, possible fines and imprisonment, if I submit information which I know to be false, inaccurate or materially incomplete.

1. LSP #: 4492

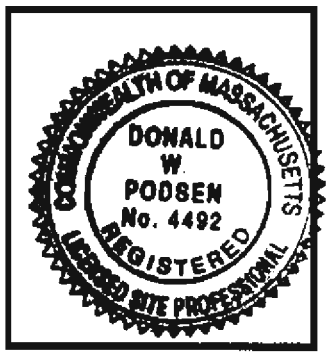
2. First Name: DONALD W 3. Last Name: PODSEN

4. Telephone: (978) 794-0336 5. Ext.: 6. FAX:

7. Signature: Donald W. Podsen

8. Date: 06/29/2007 (mm/dd/yyyy)

9. LSP Stamp:



H. PERSON MAKING SUBMITTAL:

1. Check all that apply: ☐ a. change in contact name ☐ b. change of address ☐ c. change in the person undertaking response actions

2. Name of Organization: MASS ELECTRIC CO DBA NATIONAL GRID

3. Contact First Name: MICHELE 4. Last Name: LEONE

5. Street: 25 RESEARCH DRIVE 6. Title: SR ENVMTL ENG

7. City/Town: WESTBOROUGH 8. State: MA 9. ZIP Code: 015820000

10. Telephone: (508) 389-4296 11. Ext.: 12. FAX:

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC104

RESPONSE ACTION OUTCOME (RAO) STATEMENT

Pursuant to 310 CMR 40.1000 (Subpart J)

Release Tracking Number
3 - 362

I. RELATIONSHIP TO RELEASE OR THREAT OF RELEASE OF PERSON MAKING SUBMITTAL:

☑ 1. RP or PRP ☐ a. Owner ☐ b. Operator ☐ c. Generator ☐ d. Transporter

☑ e. Other RP or PRP Specify: OTHER PRPS

☐ 2. Fiduciary, Secured Lender or Municipality with Exempt Status (as defined by M.G.L. c. 21E, s. 2)

☐ 3. Agency or Public Utility on a Right of Way (as defined by M.G.L. c. 21E, s. 5(j))

☐ 4. Any Other Person Making Submittal Specify Relationship:

J. REQUIRED ATTACHMENT AND SUBMITTALS:

☑ 1. Check here if the Response Action(s) on which this opinion is based, if any, are (were) subject to any order(s), permit(s) and/or approval(s) issued by DEP or EPA. If the box is checked, you MUST attach a statement identifying the applicable provisions thereof.

☐ 2. Check here to certify that the Chief Municipal Officer and the Local Board of Health have been notified of the submittal of an RAO Statement that relies on the public way/rail right-of-way exemption from the requirements of an AUL.

☑ 3. Check here to certify that the Chief Municipal Officer and the Local Board of Health have been notified of the submittal of a RAO Statement with instructions on how to obtain a full copy of the report.

☑ 4. Check here to certify that documentation is attached specifying the location of the Site, or the location and boundaries of the Disposal Site subject to this RAO Statement. If submitting an RAO Statement for a PORTION of a Disposal Site, you must document the location and boundaries for both the portion subject to this submittal and, to the extent defined, the entire Disposal Site.

☑ 5. Check here to certify that, pursuant to 310 CMR 40.1406, notice was provided to the owner(s) of each property within the disposal site boundaries, or notice was not required because the disposal site boundaries are limited to property owned by the party conducting response actions. (check all that apply)

- ☐ a. Notice was provided prior to, or concurrent with the submittal of a Phase II Completion Statement to the Department.
- ☐ b. Notice was provided prior to, or concurrent with the submittal of this RAO Statement to the Department.
- ☑ c. Notice not required. d. Total number of property owners notified, if applicable:

☐ 6. Check here if required to submit one or more AULs. You must submit an AUL Transmittal Form (BWSC113) and a copy of each implemented AUL related to this RAO Statement. Specify the type of AUL(s) below: (required for Class A-3, A-4, B-2, B-3 RAO Statements)

- ☐ a. Notice of Activity and Use Limitation b. Number of Notices submitted:
- ☐ c. Grant of Environmental Restriction d. Number of Grants submitted:

☐ 7. If an RAO Compliance Fee is required for any of the RTNs listed on this transmittal form, check here to certify that an RAO Compliance Fee was submitted to DEP, P. O. Box 4062, Boston, MA 02211.

☐ 8. Check here if any non-updatable information provided on this form is incorrect, e.g. Site Address/Location Aid. Send corrections to the DEP Regional Office.

☑ 9. Check here to certify that the LSP Opinion containing the material facts, data, and other information is attached.

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC104

RESPONSE ACTION OUTCOME (RAO) STATEMENT

Pursuant to 310 CMR 40.1000 (Subpart J)

Release Tracking Number
3 - 362

K. CERTIFICATION OF PERSON MAKING SUBMITTAL:

1. I, MICHELE V. LEONE, attest under the pains and penalties of perjury (i) that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this transmittal form, (ii) that, based on my inquiry of those individuals immediately responsible for obtaining the information, the material information contained in this submittal is, to the best of my knowledge and belief, true, accurate and complete, and (iii) that I am fully authorized to make this attestation on behalf of the entity legally responsible for this submittal. I/the person or entity on whose behalf this submittal is made am/is aware that there are significant penalties, including, but not limited to, possible fines and imprisonment, for willfully submitting false, inaccurate, or incomplete information.

2. By: _____ (Signature)

3. Title: SR ENVMTL ENG

4. For: MASS ELECTRIC CO DBA NATIONAL GRID
(Name of person or entity recorded in Section H)

5. Date: 06/26/2007 (mm/dd/yyyy)

☐ 6. Check here if the address of the person providing certification is different from address recorded in Section H.

7. Street: _____

8. City/Town: _____ 9. State: _____ 10. ZIP Code: _____

11. Telephone: _____ 12. Ext.: _____ 13. FAX: _____

YOU ARE SUBJECT TO AN ANNUAL COMPLIANCE ASSURANCE FEE OF UP TO $10,000 PER BILLABLE YEAR FOR THIS DISPOSAL SITE. YOU MUST LEGIBLY COMPLETE ALL RELEVANT SECTIONS OF THIS FORM OR DEP MAY RETURN THE DOCUMENT AS INCOMPLETE. IF YOU SUBMIT AN INCOMPLETE FORM, YOU MAY BE PENALIZED FOR MISSING A REQUIRED DEADLINE.

Date Stamp (DEP USE ONLY:)

ATTACHMENT TO SECTION J OF RESPONSE ACTION OUTCOME (RAO) STATEMENT TRANSMITTAL FORM
RELEASE TRACKING NUMBER 3-0362

Item 1. This RAO Partial for the Malden River portion of the Former Malden MGP Site is being submitted in accordance with an Amended Notice of Noncompliance with the Massachusetts Contingency Plan (MCP). The Notice was issued by the Massachusetts Department of Environmental Protection (DEP) on December 23, 2005. This Notice established a new compliance deadline for the submittal of a Phase IV Remedy Implementation Plan (RIP) to the DEP by July 1, 2007. This Partial RAO is being submitted in place of the Phase IV RIP which will not be required for the Malden River portion of the Site.

Item 5. The Malden River portion of the Site is owned by the Commonwealth of Massachusetts. Therefore, although MEC does not own the portion of the Site to which this RAO Partial applies, a separate notice to property owners is not required as this submittal serves as notification to the Commonwealth.

1 Corporate Drive
Andover, MA 01810

Tel: (978) 794-0336
Fax: (978) 794-0534

BROWN AND CALDWELL

June 29, 2007

Massachusetts Department of Environmental Protection
Northeast Regional Office
205B Lowell Street
Wilmington, MA 01887

36-25469

Subject: Submittal of Response Action Outcome Partial Statement
Former Malden Manufactured Gas Plant (MGP) Site – Malden River Portion
(RTN 3-0362)

Dear Sir or Madam:

Enclosed please find a copy of the Response Action Outcome Partial Statement for the Malden River Portion of the Former Malden Manufactured Gas Plant (MGP) Site. Please call me or Michele Leone at National Grid (508-389-4296) if you have any questions.

Sincerely,

BROWN AND CALDWELL

Donald W. Podsen
Licensed Site Professional

cc: Michele Leone – National Grid

1 Corporate Drive
Andover, MA 01810
Tel: (978) 794-0336
Fax: (978) 794-0534

BROWN AND CALDWELL

June 29, 2007

Mr. Christopher J. Webb
City of Malden Board of Health
200 Pleasant Street
Malden, Massachusetts 02148

Subject: Notice of Availability of Response Action Outcome Partial Statement
Former Malden Manufactured Gas Plant (MGP) Site – Malden River Portion
RTN 3-0362
Tier 1B Permit No. 7378

Dear Mr. Webb:

In accordance with the Massachusetts Contingency Plan (310 CMR 40.0000), Brown and Caldwell has completed and filed with the Massachusetts Department of Environmental Protection a Response Action Outcome Partial Statement for the above referenced site on behalf of Massachusetts Electric Company d/b/a National Grid (National Grid). A complete copy of the report is available for review at the Massachusetts Department of Environmental Protection's Northeast Regional Office in Wilmington, Massachusetts. Alternatively, a copy may be obtained by contacting Michele V. Leone of National Grid at 508-389-4296.

If you have any questions concerning this Notice of Availability, please contact Ms. Leone at the number provided above.

Sincerely,

Donald W. Podsen

Donald W. Podsen
Licensed Site Professional

cc: Michele Leone, National Grid

1 Corporate Drive
Andover, MA 01810
Tel: (978) 794-0336
Fax: (978) 794-0534

BROWN AND CALDWELL

June 29, 2007

Mr. Richard C. Howard
City of Malden Office of the Mayor
200 Pleasant Street
Malden, Massachusetts 02148

Subject: Notice of Availability of Response Action Outcome Partial Statement
Former Malden Manufactured Gas Plant (MGP) Site – Malden River Portion
RTN 3-0362
Tier 1B Permit No. 7378

Dear Mr. Howard:

In accordance with the Massachusetts Contingency Plan (310 CMR 40.0000), Brown and Caldwell has completed and filed with the Massachusetts Department of Environmental Protection a Response Action Outcome Partial Statement for the above referenced site on behalf of Massachusetts Electric Company d/b/a National Grid (National Grid). A complete copy of the report is available for review at the Massachusetts Department of Environmental Protection's Northeast Regional Office in Wilmington, Massachusetts. Alternatively, a copy may be obtained by contacting Michele V. Leone of National Grid at 508-389-4296.

If you have any questions concerning this Notice of Availability, please contact Ms. Leone at the number provided above.

Sincerely,

Donald W. Podsen

Donald W. Podsen
Licensed Site Professional

cc: Michele Leone, National Grid

RESPONSE ACTION OUTCOME PARTIAL STATEMENT

FORMER MALDEN MGP SITE (MALDEN RIVER PORTION) MALDEN, MASSACHUSETTS RTN 3-0362

June 2007

Prepared For:
National Grid
25 Research Drive
Westborough, MA 01582

BROWN AND CALDWELL

One Corporate Drive
Andover, Massachusetts 01810-2447

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

1.1 Background

This Response Action Outcome Partial (RAOP) Statement was prepared by Brown and Caldwell on behalf of the Massachusetts Electric Company d/b/a National Grid (National Grid). It was prepared in accordance with 310 CMR 40.1000 for a Class A-2 Permanent Solution for the Malden River portion (as opposed to the Upland portion) of the former Malden Manufactured Gas Plant (MGP) Site located in Malden, Massachusetts (RTN 3-0362). Figure 1 shows the general location of the former Malden MGP Site (the Site). As shown on Figure 2, the former MGP occupied land referred to as Parcels A, B, C, D, and E. A Waiver Completion Statement for Parcel C (RTN 3-2066) was filed in September 1990, and a Class A-3 RAOP was filed for a portion of Parcel D (RTN 3-13310) referred to as Callahan Park in December 1999. A Class C Response Action Outcome Partial (RAOP) was filed for the remainder of the Upland portion of the former MGP Site in February 2004. The Malden River portion of the Site consists of the Malden River from the Malden River (MR) Culvert outfall extending downstream for approximately 1,400 feet.

A Phase II Comprehensive Site Assessment (CSA) Report for the Site was prepared by Haley & Aldrich in December 2001. A Phase III Remedial Action Plan (RAP) for the Upland portion of the Site was prepared by Haley & Aldrich in June, 2003. In June 2006, Brown and Caldwell prepared a Phase III RAP for the Malden River portion of the Site. A description of the Site from the Phase III RAP for the Upland portion of the Site is summarized below.

The former Malden and Melrose Gas Light Company (MMGLC) and its successor, the Mystic Valley Gas Company (MVGC), operated a MGP on approximately 16.4 acres of land in the vicinity of the intersection of Commercial and Charles Streets in Malden, Massachusetts from approximately the mid to late 1800s to the late 1960s/early 1970s. The former holdings occupied land currently referred to as Parcels A, B, C, D and E, as shown on Figure 2. Each of these properties was redeveloped following the decommissioning of the former MGP facilities in the 1970s, and is now owned and controlled by various parties.

The Site is located within a designated Industrial Zone, and there are no institutions located within 500 feet. There are numerous residences within 0.5 miles of the Site and it is estimated that greater than 1,000 people live within 0.5 miles of the Site. The Site is not located within 3,000 feet of an Area of Critical Environmental Concern. Based on area groundwater use and recharge characteristics, the Site is not included in areas designated Zone I, Zone II, or Zone III.

Contamination at the Site is the result of over 100 years of MGP operations, and has impacted soil, groundwater, indoor air, sediment and surface water to varying degrees. Earliest available information indicates that the Malden and Melrose Gas Light Company (MMGLC) erected a gas manufacturing facility in 1855. The facility, which consisted of coal storage buildings, retort houses, a gas manufacturing building, a condenser house and limited purification facilities on Parcel A. As the plant was expanded, operations spread to parcels B, D, and E. Parcel B was used primarily for gas purification operations, Parcel D was used primarily for storage and distribution of gas product, and Parcel E was the location of the second condenser house, as series of above-ground storage tanks, and various tar handling facilities. By 1920 a tar refinery, the American Tar Company, was built on the northern portion of Parcel A.

The former Malden MGP was located in a marshy area. Historically, the Malden River meandered through the Site, flowing generally from the north to south side of the Site, along the eastern Site boundary. The West End Brook, a tributary to the Malden River, flowed across the center of the Site from west to east before emptying into the Malden River. The West End Brook was straightened sometime in the mid 1900s, and in approximately1970-1971, the Metropolitan District Commission (MDC) constructed a culvert to convey the West End Brook (WEB) across the Parcel E portion of the Site. In 1977, the Malden River (MR) culvert was constructed. Both culverts are supported on wooden piles driven through the organic deposit to provide structural support, and are underlain by a layer of crushed stone, approximately 3 feet thick.

As mentioned above, a Class C RAOP was filed for the Upland portion of the Site in February 2004.

1.1.1 Upland Portion of Site

The following provides an overview of conditions on the Upland portion of the Site, as background for understanding the Malden River portion of the Site.

1.1.1.1 Summary of Contamination

Contamination in the Upland portion of the Site is summarized in the 2003 Phase III RAP. In general, the predominant classes of chemical compounds identified as the primary residuals from the processes used at the former Malden MGP include PAHs, VOCs, and cyanide. The former Malden MGP Conceptual Site Model (CSM) presented in this report identifies seven types of contamination. These types of contamination are: (1) tar-saturated materials (TSM); (2) shallow (i.e., above the layer of organic deposits) DNAPL (coal tar); (3) deep DNAPL (i.e., below the layer of organic deposits) in the subsurface; (4) light, non-aqueous phase liquid (LNAPL) identified in monitoring wells; (5) BTEXSN [benzene, toluene, ethylbenzene, xylene, styrene, and naphthalene] compounds in soil and groundwater on Parcel B; (6) BTEX contamination in soil and groundwater located south of Callahan Park in the area of the former Governor House, and (7) petroleum/MGP – impacted soil in the vicinity of the historical tank farm on Parcel E.

1.1.1.2 Summary of Groundwater Flow Paths/Migration Pathways

As indicated in the Phase II and III reports, shallow groundwater in the center of the Site is strongly influenced by the WEB Culvert, as groundwater appears to drain into the culvert or the crushed stone backfill beneath the culvert. Elsewhere at the Site, the predominant direction of groundwater flow is toward the South, likely discharging into the Malden River. Deep groundwater appears to flow to the south-southwest, also likely discharging into the Malden River

The Phase III RAP for the Upland portion of the Site concluded that although groundwater contains elevated concentrations of contaminants, remediation of groundwater in Upland areas is not required to achieve a condition of No Significant Risk (with the possible exception of a portion of the 129 Commercial Street property). This conclusion was based on the fact that groundwater is not used as a resource (i.e., for drinking water or industrial use), and based on groundwater sampling data obtained during the Phase II investigation which showed that plumes of groundwater contamination do not appear to be leaving the Site. Additionally, remedial approaches to remediate

LNAPL, DNAPL and soil would have a beneficial effect on groundwater quality. Therefore, with the exception of a portion of the 129 Commercial Street property, Remedial Action Alternatives did not include an evaluation of remedial components for groundwater. Remedial measures to reduce VOC concentrations in groundwater were evaluated for a portion of the 129 Commercial Street property because elevated concentrations in groundwater likely contribute to elevated VOC concentrations in indoor air within the building on that property.

The significance of the preceding discussion to the Malden River portion of the Site is that it indicates groundwater is not a significant contaminant migration pathway to the River.

1.1.1.3 Summary of Remedial Actions in the Malden River Culvert and West End Brook Culvert

Several remedial actions have been conducted on the Upland portion of the Site to address potential impacts to the Malden River portion of the Site. The impacts of TSM had historically been observed within the WEB and MR Culverts, and coal tar DNAPL had been detected in the crushed stone bedding beneath the WEB Culvert. An Immediate Response Action (IRA) was initiated in May 1996 and completed in September 2003 in response to observations of an intermittent sheen on the surface of water flowing in the MR Culvert.

As described in the IRA Completion Report (Haley & Aldrich, September 2003), IRA conditions were assessed using a variety of investigation methods including sediment sampling and analysis, installation of test borings to evaluate subsurface conditions along the culvert, monitoring of sheens, installation and monitoring of Tar Monitoring Points installed in the culvert bedding, and periodic monitoring of lined catch basins and drain lines using video surveys. Based on these assessment activities, response actions conducted under the IRA focused on preventing the migration of coal tar into the culverts. These actions included removal of over 500 tons of contaminated sediment and debris from the culverts; repair of existing culvert expansion joints; grouting of culvert weep holes; lining of catch basins and drain lines that lead into the culverts (including a 42-inch drain line in Centre Street); design and installation of a seepage collar below and around the outside of the MR culvert at a location just downstream of the confluence with the WEB culvert; and extraction of DNAPL from proximate to the culvert bedding (700 gallons total removed).

The culverts were de-watered and inspected annually from 1999 through 2004 to observe for coal tar impacts to sediments and surface water. No olfactory or visual evidence of coal tar in sediment or the culverts was observed, and expansion joints were inspected and found to be in good condition. The IRA was completed in September 2003, as sheens had not been observed in the culverts since the final storm drain lining activities in October 2002. It was concluded that the source of coal tar seepage into the culverts (and associated sheens) had been eliminated through the IRA activities.

In 2006 and 2007, the culvert was inspected "in the wet" and no coal tar impacts or sheens were observed, with the most recent inspection having been conducted in June 2007. Additionally, the tar monitoring port installed in the culvert bedding at the end of the MR Culvert is monitored annually as part of the Class C RAO for the Upland portion of the Site.. No tar has been observed in the bedding at this location to date.

1.1.1.4 Summary of Additional Response Actions to be Conducted

Based on the Phase III RAP, the selected Remedial Action Alternative for the Upland portion of the former Malden MGP Site consisted of numerous response actions to reduce the volume of DNAPL and LNAPL in the environment and to reduce VOC concentrations in soil, groundwater and indoor air. National Grid is currently preparing a Post-Class C RAO RAM for the installation of 7 new DNAPL recovery wells on Parcel A. As appropriate, the system will be expanded to include other areas of the Site. In addition, operation and maintenance of a sub-slab depressurization system and indoor air sampling are on-going at the 129 Commercial Street property. The sub-slab depressurization system continues to be successful in precluding the soil vapor intrusion into the 129 Commercial Street building. The selected remedy represents a Temporary Solution for the Upland portion of the Site because of the long time frame required to remove DNAPL and LNAPL (and the increased difficulty of recovering product in areas covered by buildings), and the difficulty of excavating UCL exceedances in soil (a significant portion of which is located under active commercial/industrial buildings not owned by National Grid).

1.1.2 Malden River Portion of Site

The open channel portion of the Malden River currently begins at the outfall from the MR culvert (historically the open channel portion of the River extended farther upstream). Between the outfall and the Medford Street Bridge (located approximately 1,600 feet downstream of the outfall) the Malden River is approximately 30 feet wide and has a fairly low flow velocity. As described in the Method 3 Risk Characterization for the Site (AMEC, 2001) included in the Phase II CSA, the River is classified as a Class B Warm Water Surface Water Body (314 CMR 4.06), designating it appropriate for recreational use by humans and habitats for fish and other aquatic life.

As described in the Phase II CSA, at the time the former MGP began operations, the West End Brook (WEB) and the Malden River meandered through the site in open channels. Over the course of several years these channels were first straightened and later culverted. Currently, the WEB culvert bisects the site and empties into the MR culvert, which is located along the eastern site boundary. As a result of this proximal location, coal tar contamination had historically impacted sediments in the WEB culvert, the MR culvert and the Malden River. MGP residuals likely entered the Malden River through several routes, including discharge of waste into historical Malden River tributaries during early periods of gas production and purification, subsurface DNAPL migration along the organic deposit into the historical channel of the Malden River, and infiltration through joints and weep holes into the WEB and MR culverts of the site. As described in Section 1.1.1.3, the IRA activities conducted between May 1996 and September 2003 eliminated the migration of coal tar (and associated sheens) into the culverts, and no coal tar has been detected in the tar monitoring port in the bedding material at the end of the MR culvert.

The Phase II CSA indicates that numerous industrial facilities operated along the shore of the Malden River downstream of the former MGP Site since the early 1800s. Releases of oil and hazardous materials have been documented at some of these sites and are suspected at others. Between the MR culvert and the Medford Street Bridge were located a former industrial manufacturing facility (Rohm Tech Corporation – which included several releases of fuel oil totaling more than 25,000 gallons), an oil company (Morton Oil Company), and a tar distillery (Huggins Tar Distillery) as shown on the insert to Figure 2. Another tar distillery was located approximately 1,700 feet downstream of the Medford Street Bridge (Bartlett Tar Distillery).

As part of the Phase II CSA, readily available historical Malden River total PAH sediment data (TRC Environmental Consultants, Inc investigation, 1985; Massachusetts Department of Environmental Protection investigations, 1987 and 1989; and Rohm Tech sediment assessment data, 1996) were compiled for the upstream end of the Malden River. These data indicated elevated concentrations of total PAHs in Malden River sediments between the former Malden MGP Site and the Medford Street Bridge.

1.1.2.1 Summary of Phase II Investigation (Malden River Portion of the Site)

In April 2000, additional sediment sampling was conducted in the Malden River to fill data gaps and provide additional data required for the Phase II CSA. A total of 95 sediment samples were collected from 21 locations (HASED-1 through HASED-21) along the Malden River using direct push and vibracore methods. Samples were collected between the MR culvert outfall to a point approximately 1750 feet downstream (just south of the Medford Street Bridge). The purpose of the sampling was to observe the geologic strata and preliminarily assess the biological quality of the sediments, assess the nature and extent of contamination in the River, and evaluate the most probable sources of contamination using chemical fingerprinting analyses. Sediment samples were selectively analyzed for VOCs, SVOCs, 13 priority pollutant metals, total cyanide, physiologically available cyanide, total organic carbon, volatile petroleum hydrocarbon (VPH) and extractable petroleum hydrocarbon (EPH) fractions, ammonia, polychlorinated biphenyls (PCBs), chlorinated pesticides, chlorinated herbicides, RCRA hazardous waste characteristics and acid volatile sulfide/simultaneously extracted metals (AVS/SEM). The samples were also subjected to the Toxicity Characteristic Leaching Procedure (TCLP) and a variety of fingerprinting tests.

A review of these results, combined with historical data, indicated abrupt increases in PAH concentrations at several locations in a downstream direction from the MR culvert outfall (corresponding to the locations of other known or potential sources of PAH contamination, i.e., the former Rohm Tech facility, the former Morton Oil Company, and the former Huggins Tar Distillery). To distinguish PAHs attributable to fuel oil versus coal tar, fingerprinting analyses were performed (comparison of PAH profile histograms and comparison of aliphatic hydrocarbon histograms). These analyses indicated combined sources of PAH contamination approximately 1,050 feet downstream of the MR culvert outfall (vicinity of Rohm Tech fuel oil spill). A significant increase in PAH concentration was identified approximately 1,590 feet downstream of the MR culvert outfall, coincident with the location of the former Huggins Tar Distillery. Based on the information summarized above, the Phase II CSA concluded the extent of impact to the Malden River sediments attributable to the former Malden MGP Site to be approximately 1,400 feet downstream of the MR culvert outfall.

Table 1 (reproduced from Table 2-40 of the Method 3 Risk Characterization) provides a summary of constituents detected in Malden River sediment, as well as each constituent's minimum, maximum, and arithmetic average concentrations. Constituents detected included a variety of VOCs, SVOCs, metals and EPH/VPH fractions. Those constituents detected in all sediment samples included a variety of PAHs (anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene), two EPH fractions (C11-C22 aromatics and C19-C36 aliphatics), and lead. The average concentrations of these constituents were generally elevated ranging from 8.77 to 25.6 mg/kg for individual PAHs, 893 to 1156 mg/kg for EPH fractions, and 306 mg/kg for lead. In contrast, VOCs were generally detected in less than one quarter of the samples analyzed, and average concentrations of individual VOCs were less than 1 mg/kg.

Surface water sampling was conducted in conjunction with the sediment sampling at five locations (SW-1 through SW-5). The surface water samples were analyzed for VOCs, SVOCs, 13 priority pollutant metals, total cyanide, and pH. Table 2 (reproduced from Table 2-39 of the Method 3 Risk Characterization) provides a summary of constituents detected in Malden River surface water, as well as each constituent's minimum, maximum, and arithmetic average concentrations. The constituents detected included a variety of VOCs, copper and lead. Those constituents detected in at least four of the surface water samples included benzene, cis-1,2-dichloroethene, methyl tert butyl ether, methylene chloride, naphthalene, toluene, and lead. The majority of constituents detected had average concentrations less than 1.0 µg/l, with a maximum average concentration of 20.7 µg/l for copper (although copper was only detected in two samples).

1.1.2.2 Summary of Method 3 Risk Characterization (Malden River Portion of the Site)

AMEC performed a Method 3 Human Health and Environmental Risk Characterization (RC) for the former Malden MGP site in December 2001. With respect to the Malden River, potential human exposure pathways included ingestion and dermal contact with sediment and surface water, and ingestion of fish. A condition of No Significant Risk could not be demonstrated in the RC for current child and adult fishers who were assumed to ingest recreationally caught fish from the Malden River. This conclusion was based on food web models to derive indirect (food-chain) uptakes for fish.

Based on the results of Stage I Environmental Screening, a more detailed Stage II Environmental Risk Characterization was performed. The ecological receptors evaluated in the Stage II included benthic macroinvertebrates and fish, omnivorous birds (represented by the mallard), and piscivorous birds (represented by the great blue heron). These receptors were assumed to be exposed to contaminants via incidental ingestion of sediment and/or surface water and food web exposure via the ingestion of prey exposed to contaminants in sediment and/or surface water.

The conclusions of the Stage I and II evaluations were that:

- Concentrations of Chemicals of Potential Ecological Concern (COPEC) in surface water do not contribute to ecological risks and do not appear to be an issue in the study area.
- Concentrations of Inorganic COPEC in sediment do not contribute to ecological risks and do not appear to be an issue in the study area.
- The evaluation of organic COPEC (PAHs and EPH) gave variable results, such that it was not possible at the time to definitively conclude that there were No Significant Risk to ecological receptors.

1.1.2.3 Summary of Phase III Remedial Action Plan (Malden River Portion of Site)

The June 2006 RAP for the Malden River portion of the Disposal Site concluded that a Permanent Solution could be achieved through implementation of the No Further Action Alternative in the River, since a condition of No Significant Risk currently exists. The No Further Action Alternative is expected to achieve a Class A-2 RAO Partial.

As a conservative measure prior to submitting a Class A-2 RAO Partial, additional investigation activities were proposed to confirm that the selected remedy was the most appropriate for the Site, with a high degree of confidence. This investigation (described in Section 1.1.2.4 below and conducted in November 2006) included re-sampling locations where previous sampling indicated higher concentrations of PAHs than other locations, and collecting samples between existing sample locations and intervals.

1.1.2.4 Summary of 2006 Supplemental Data Collection (Malden River Portion of Site)

Brown and Caldwell conducted two supplemental sediment investigations in 2006. The first investigation (conducted in January 2006) included the collection of six sediment cores to a depth of 10 feet or refusal. The samples were analyzed for geotechnical parameters for use in evaluating various remedial action alternatives during preparation of the Phase III RAP. The second investigation was conducted in November 2006 and included the collection and analysis of 40 sediment samples (in 6-inch intervals from the upper two feet of sediment at 10 locations) to better define contaminant concentrations in sediment for use in confirming the conclusions of the Phase III RAP. A description of the sampling, field and laboratory testing, data evaluation and conclusions for the January 2006 sediment sampling event was included in the Phase III RAP. A description of the sampling, analytical results, data evaluation and conclusions for the November 2006 sediment sampling events are included in Appendix A of this RAO.

The PAH data collected in November 2006 were consistent with previous sediment sampling results in the Malden River portion of the Site. One objective of the sampling was to further evaluate concentrations of carcinogenic PAHs (cPAHs) for use in the development of a sediment cleanup goal. The November 2006 data showed an average cPAH concentration of 12.6 mg/kg in the top six inches of sediment, compared to an average concentration of 12 mg/kg for Phase II CSA sediment samples collected from the same depth interval.

Another objective of the November 2006 field effort was to confirm that a Substantial Hazard does not exist at the Site. Field observations during sampling did not identify the visible presence of oil, tar or other non-aqueous phase hazardous material within one foot of the sediment surface. These observations confirmed the conclusion in Brown and Caldwell's Phase III RAP that a Substantial Hazard does not exist at the Site.

1.1.2.5 Development of Remedial Action Goal

The overall framework for selecting a remedial action goal was based on the Method 3 Risk Characterization (RC) that was completed by AMEC Earth and Environmental (AMEC) as part of the Phase II CSA. A site-specific sediment cleanup goal was calculated using the methodologies from the Method 3 RC. Based on a literature review, two of the variable values originally used in the Method 3 RC were refined in the Phase III RAP (Brown and Caldwell, 2006). A Substantial Hazard Evaluation for the Malden River portion of the Site was also completed as part of the Phase III RAP. Both sediment toxicity and fish ingestion were evaluated to determine which was more appropriate for use in developing sediment remediation goals.

The chemicals predicted to be responsible for the greatest portion of risk are cPAHs. The fish bioaccumulation pathway is based on a quantitative relationship between sediment and cPAHs which can be used to predict impacts. This pathway was therefore used to develop the sediment cleanup goal of 31 mg/kg cPAHs for the Malden River portion of the Site. Using these data, both the Method 3 RC and Substantial Hazard Evaluation were revisited, and the conclusions in the Phase III RAP remained unchanged. Appendix B documents the risk evaluation process that was relied upon to select and support a remedy for the Malden River portion of the Site.

1.2 Report Organization

This RAO Partial Statement has been structured to follow the content requirements provided in 310 CMR 40.1056, as applicable. The requirements of 40.1056(1) are addressed in Section 2.1 and the requirements of 40.1056(2) are addressed in Section 2.2.

2 RESPONSE ACTION OUTCOME STATEMENT

2.1 Description of RAO

2.1.1 Disposal Site Name, Address, and Release Tracking Number [310 CMR 40.1056(1)(a)]

The Disposal Site name that is the subject of this RAO Partial is the Malden River portion of the former Malden Manufactured Gas Plant (MGP) Site (RTN 3-0362) located in Malden, Massachusetts. The Malden River portion of the Site is the uppermost portion of the open-channel Malden River which is bounded in general, by Charles Street to the north, Medford Street to the south, Canal Street to the east and Commercial Street to the west. The specific portion of the Malden River that is considered part of the Disposal Site begins at the outfall of the MR culvert and extends approximately 1,400 feet downstream.

2.1.2 Class of Response Action Outcome [310 CMR 40.1056(1)(b)]

A Class A-2 (Permanent Solution) has been achieved for the Malden River portion of the Site. A Class A-2 RAO Partial is appropriate for this portion of the Site because:

1) Response actions have been conducted on the Upland portion of the Site as described in Section 1.1.1.3.

2) A Permanent Solution has been achieved (Supplemental Risk Characterization indicated the Malden River portion of the Site poses "No Significant Risk" to human health, public welfare, safety, and the environment);

3) The level of oil and hazardous material in the environment has not been reduced to background;

4) One or more Activity and Use Limitations (AULs) are not required to maintain a level of "No Significant Risk"; and

5) Sources of oil or hazardous material have not been identified in the Malden River portion of the Site. In addition, each source of oil and/or hazardous material on the Upland portion of the Site likely to result in an increase in concentrations of oil or hazardous material in the Malden River has been controlled.

2.1.3 Risk Characterization Method [310 CMR 40.1056(1)(c)]

As described in Section 1.1.2.2, AMEC performed a Method 3 Human Health and Environmental Risk Characterization for the former Malden MGP Site. The environmental risk characterization focused on the Malden River portion of the Site. Brown and Caldwell performed supplemental Method 3 Risk Characterization activities to further evaluate those issues associated with the Malden River that had been identified as posing a potential Significant Risk to human health and the environment. The following is a summary of the supplemental Method 3 RC for the Malden River portion of the Site:

- A Substantial Hazard Evaluation for the Malden River portion of the Site concluded that there were no substantial hazards.

- Revised Method 3 RC calculations using updated information concluded that the Malden River portion of the Site posed No Significant Risk to human health and the environment.

- The chemicals predicted to be responsible for the greatest portion of risk are cPAHs. The fish bioaccumulation pathway is based on a quantitative relationship between sediment and cPAHs which can be used to predict impacts.

- Evaluation of the fish bioaccumulation pathway resulted in a sediment cleanup goal of 31 mg/kg cPAHs for the Malden River portion of the Site.

2.1.4 Relationship of RAO Statement to any Other RAO Statements for the Disposal Site and Need for any Additional Response Actions for any Other Portions of the Disposal Site [310 CMR 40.1056(1)(d)]

A Class C-1 RAOP was filed for the Upland portion of the Former Malden MGP Disposal Site on February 27, 2004. No additional response actions are needed to support the RAOP for the River portion of the Site as the migration pathway from the Upland Portion of the site to the River has been mitigated and is also being monitored.

2.1.5 Dependence of RAO on Implementation of Activity and Use Limitation [310 CMR 40.1056(1)(f)]

This Class A-2 RAO Partial for the Malden River portion of the former Malden MGP site is not dependent upon the implementation of an Activity and Use Limitation.

2.1.6 Licensed Site Professional Opinion [310 CMR 40.1056(1)(g)]

In the opinion of Donald Podsen, Licensed Site Professional (LSP) for the Malden River portion of the Site, this submittal meets the requirements for a Class A-2 RAO Partial as specified in 310 CMR 40.1000. This Opinion is provided in Section H of the Transmittal Form. The LSP Opinion is supported by the information presented in the Phase II Comprehensive Site Assessment Report (Haley & Aldrich, December 2001), the Phase III Remedial Action Plan (Haley & Aldrich, 2003), the Phase III Remedial Action Plan for the Malden River portion of the Site (Brown and Caldwell, June 2006), and the additional sediment sampling/analysis and supplemental Risk Characterization provided in Appendices A and B of this RAO Partial Statement.

2.1.7 Certification of Person Making Submittal [310 CMR 40.1056(1)(h)]

The certification required by 310 CMR 40.0009 is provided in Section L of the Transmittal Form.

2.1.8 Comparison to Upper Concentration Limits [310 CMR 40.1056(1)(i)]

Analytical data associated with the Malden River portion of the Site exists for sediment and surface water. The Upper Concentration Limits provided in 310 CMR 40.0996(7) pertain to soil and groundwater, and therefore are not applicable to the analytical data collected for the Malden River portion of the Site.

In accordance with the MCP (310 CMR 40.0996(6)), the presence of non-aqueous phase liquids (NAPL) having a thickness greater than 1/2 inches in any environmental medium shall be considered a level which exceeds Upper Concentration Limits. A review of the 16 core logs for sediment samples collected by Brown and Caldwell in 2006 indicates that NAPL was not observed in any of the sediment samples. At two locations, a sheen rose to the surface of the water as the cores were pulled up from the bottom of the River, however, no NAPL was observed in the sediment associated with these cores. Probe reports for the sediment samples collected at 21 locations by Haley & Aldrich in 2000 (HASED-1 through HASED-21) do not indicate the presence of NAPL at any of these locations. Boring logs are not available for the eight samples collected by AMEC.

Based on the above information, exceedances of Upper Concentration Limits have not been detected or observed in the Malden River portion of the Site.

2.1.9 Indication that Analytical Data meets CAM Requirements [310 CMR 40.1056(1)(j)]

As indicated in Section F of the Transmittal Form, some of the analytical data used to support this Class A-2 RAO Partial was not generated pursuant to the Compendium of Analytical Methods (CAM). The following is a brief summary of the information provided in Section 2.2.5.1.1 and 2.2.5.1.2 with respect to CAM Requirements for data used to support this RAO Partial.

- November 2006 sediment analytical data (40 samples) were generated in accordance with CAM requirements.

- April 2000 sediment analytical data (95 samples) and surface water analytical data (5 samples) were generated prior to August 1, 2003 and are therefore considered "Pre-CAM data." The analyses performed on these samples were conducted using either USEPA (SW-846 Series) or MADEP methods (e.g. EPH/VPH). Brown and Caldwell has reviewed the available laboratory case narratives and data reports and believes that these Pre-CAM analytical data are comparable to "CAM Compliant" data (i.e. data with Presumptive Certainty).

- August 2001 sediment analytical data (8 samples) were generated prior to August 1, 2003 and are therefore considered "Pre-CAM data." The analyses performed on these samples were conducted using either USEPA (SW-846 Series) or MADEP methods (e.g. EPH/VPH). Laboratory case narratives and data reports were not available for this data set, however, the data values are generally comparable to adjacent CAM Compliant data described above.

2.2 Supporting Documentation for the RAO

2.2.1 Location and Description of Portion of Site to which the RAO Applies [310 CMR 40.1056(2)(a)]

This RAO Partial for a Class A-2 Permanent Solution applies to the Malden River portion of the former Malden MGP Site located in Malden, Massachusetts (RTN 3-0362). The specific portion of the Malden River that is considered part of the Disposal Site begins at the outfall of the MR culvert located at the upstream end of the River, and extends approximately 1,400 feet downstream. This downstream boundary was established in the Phase II CSA after a thorough evaluation of potential impacts from the former Malden MGP Site, the distribution of polynuclear aromatic hydrocarbons

(PAHs) in the River, other potential sources of PAHs (evaluated through fingerprinting analysis), and locations of other industries with ties to PAHs. The site location is shown on Figure 1 and a detailed site map is presented as Figure 2.

Between the MR culvert outfall and the Medford Street Bridge (located approximately 1,600 feet downstream of the outfall) the Malden River is approximately 30 feet wide and has a fairly low flow velocity. The maximum water depth in the center of the River ranges from approximately four to seven feet within the boundaries of the Site. As described in the 2001 Method 3 Risk Characterization for the Site, the River is classified as a Class B Warm Water Surface Water Body (314 CMR 4.06), designating it appropriate for recreational use by humans and habitat for fish and other aquatic life.

2.2.2 Demonstration that Uncontrolled Sources Have Been Eliminated or Controlled[310 CMR 40.1056(2)(b)]

Based on the several rounds of sediment sampling that have been conducted in the Malden River by Haley & Aldrich, AMEC, and Brown and Caldwell, there is no visual indication of oil, tar or NAPL that could be considered a potential source in the River. The source of former Malden MGP residuals that have been detected in the River sediment are attributed to the migration of oil/coal tar along former tributaries that have since been culverted (WEB and MR culverts), and seepage into the culverts. The IRA that was conducted between 1996 and 2003 has effectively sealed the joints of the pipe, and prevented migration in the bedding material. As described in Section 1.1.1.3, these actions have eliminated the migration of MGP residuals into the Malden River. As a result, the former Malden MGP source of contamination to the River has been controlled and there is no reason to expect an increase in concentrations of oil or hazardous material (related to the former Malden MGP Site) in an environmental medium associated with the Malden River portion of the Disposal Site.

2.2.3 Information Supporting Conclusion that a Level of "No Significant Risk" has been Achieved [310 CMR 40.1056(2)(c)]

The remedial action goal development presented in Appendix B supports the conclusion that a condition of "No Significant Risk" has been achieved for the Malden River portion of the Site.

2.2.4 Feasibility of Achieving or Approaching Background [310 CMR 40.1056(2)(e)]

The feasibility of achieving or approaching background was evaluated in Section 6.3 of the RAP for the Malden River portion of the Site (Brown and Caldwell, June 2006) and is provided as follows. Since the Site is located at the headwaters of the Malden River, there is no appropriate background to reference, which complicates the ability to readily evaluate the feasibility of achieving background. However, Alternative 5 (Deep Sediment Removal) involves removal of sediment exhibiting the most elevated concentration of cPAHs at the Site and can therefore be considered the alternative that would best approach "background" concentrations, if implemented. Comparing the selected alternative (i.e. No Further Action Alternative), which has no implementation or O&M costs, to Alternative 5 (Deep Sediment Removal), which was estimated to cost $1.9 million, it is evident that the cost to approach background is significant. The MADEP guidance, "Conducting Feasibility Evaluation Under the MCP" (WSC-04-160), states that it shall be considered feasible to conduct remedial actions to achieve or approach background conditions if the additional costs to remediate beyond a condition of No Significant Risk conditions are equal to or less than 20% of the cost to

remediate to No Significant Risk. Therefore, based on this interpretation of the MCP provided by MADEP guidance, the substantial incremental costs to approach background are not justified.

2.2.5 Data Usability Assessment and Data Representativeness Evaluation [310 CMR 40.1056(2)(k)]

The data usability assessment and data representativeness evaluation are presented below.

2.2.5.1 Data Usability Assessment

A data quality review of the Malden River sediment and surface water analytical data used to support this RAO Partial was conducted by Brown and Caldwell using the following criteria: data completeness, holding time, temperature, blanks, laboratory control samples, and surrogate recoveries. This review provides an overall assessment of data quality and relies on the general data quality guidelines published by the USEPA and MADEP. Due to the large number of samples that have been collected over the years, and the fact that the primary constituents of concern (risk drivers) in sediment at the site have been determined to be PAHs, Brown and Caldwell limited the detailed analytical data review to PAH sample results.

Analytical results for sediment samples collected in November 2006 by Brown and Caldwell were generated in accordance with the requirements of the Compendium of Analytical Methods (CAM; MADEP Policy WSC #02-320 Compendium of Quality Assurance and Quality Control Requirements and Performance Standards for Selected Analytical Methods) and meet Presumptive Certainty requirements.

Analytical results for sediment and surface water samples collected in April 2000 by Haley & Aldrich in support of the Phase II Comprehensive Site Assessment are considered Pre-CAM data, as they were generated prior to August 1, 2003, when the CAM requirements became effective. The analyses performed on these samples were conducted using either USEPA (SW-846 Series) or MADEP methods (e.g. EPH/VPH). Brown and Caldwell has reviewed the available laboratory case narratives and data reports (in particular the PAH data) and believes that the Pre-CAM analytical data are comparable to "CAM Compliant" data (i.e. data with Presumptive Certainty). In addition, the PAH data results were comparable to the more recent CAM Compliant data collected by Brown and Caldwell in November 2006.

Analytical results for sediment samples collected in August 2001 by AMEC in support of the Method 3 Risk Assessment are also considered Pre-CAM data, as they were generated prior to August 1, 2003. Laboratory case narratives and data reports were not available for this data, however, data values are generally comparable to adjacent sediment data collected by Brown and Caldwell and Haley & Aldrich.

The sensitivity of the majority of the data met project-specific objectives. Surface water data detection limits were less than Ambient Water Quality Criteria (AWQCs were calculated only for detected constituents, including some VOCs and metals). Sediment PAH data detection limits were evaluated with regards to Brown and Caldwell's calculated risk-based cleanup goal for total cPAHs, which is 31 mg/kg. To calculate a reliable cPAH value for each sample, the detection limits for each individual PAH compound needed to be in the low ppm range. There were a total of 82 shallow sediment samples (0-6 inches) collected by Haley & Aldrich, AMEC, and Brown and Caldwell, and all but six samples had detection limits in the low ppm range (<5 ppm). The higher detection limits

were caused by dilutions due to higher concentrations of target compounds in these six samples. Some of the deeper samples also had relatively higher detection limits, but these samples do not affect risk conclusions for the Site.

The following review identifies analytical deficiencies identified in the Laboratory Case Narratives associated with the data. While these deficiencies may affect laboratory accuracy and precision, method accuracy, and accuracy in sample matrix, the potential inaccuracies are slight and therefore have little to no impact on overall data usability. Brown and Caldwell concludes that the data is usable for its intended purposes and is suitable for use under the MCP. As part of this data review, Brown and Caldwell made a number of conservative assumptions (as described below) in order to be more protective of human health, public welfare, and the environment.

2.2.5.1.1 Sediment Data Quality Review

Analytical results for 40 sediment samples collected in 2006 to support this RAO Partial meet the requirements for Presumptive Certainty established by MADEP. The only quality control issues identified were low matrix spike/matrix spike duplicate (MS/MSD) recoveries. Spike recoveries for the majority of PAH compounds in the MS/MSD associated with analysis batch 220-2403 were diluted to below detection limits because of higher levels of target compounds, and as a result some associated Relative Percent Differences (RPDs) exceeded limits. In Brown and Caldwell's opinion, because the sample results are generally comparable to concentrations in adjacent sediment samples, this issue appears to have minimal impact on the data. In addition, spike recoveries for three PAH compounds in the MS/MSD associated with sample SED-206 (0-6") were below acceptance limits. The low spike recoveries introduce a potential low bias to the data, and therefore these data may be underestimated. However, PAH concentrations in SED-206 (0-6") are generally comparable to concentrations in adjacent sediment samples and therefore this issue appears to have minimal impact on the overall data set.

Analytical results for 95 sediment samples collected in 2000 and analyzed by Groundwater Analytical Laboratory are considered Pre-CAM data, but appear to be generally comparable to "CAM Compliant" data (i.e. data with Presumptive Certainty). The only quality control issue identified was an exceedance of holding times (by one day) for several samples analyzed for USEPA Method 8270C. Deviations from Presumptive Certainty requirements include: no Laboratory Control Sample (LCS) Duplicates were run and no time of analysis was included in the sample results. The only other quality control issue Brown and Caldwell identified was high surrogate recoveries for 2,4-dinitrotoluene in the LCS. The high recoveries introduce high bias to the data, and therefore these data may be overestimated. Brown and Caldwell has taken a conservative approach and accepted these reported concentrations with the understanding that actual concentrations may be lower.

Analytical results for eight sediment samples collected in August 2001 are considered Non-CAM data. Laboratory case narratives and data reports were not available for this data, however, data values are generally comparable to adjacent sediment data collected in 2000 and 2006, and therefore the data are considered usable.

PAH fingerprint results for sediment samples collected in 2000 and analyzed by Arthur D. Little are considered Pre-CAM data. A case narrative, analytical data sheets, and chain of custody were not provided with the data in the Phase II CSA. However, the Phase II CSA report indicated that a

review of analytical data had been performed and the data was qualified as necessary. Because this data was used to evaluate the source of contamination in the River (as opposed to calculating potential risks) it is considered useable for its intended purposes.

In summary, although some sediment data are not CAM-compliant and/or have some minor quality control deficiencies, all of the data are considered usable for the intended purposes.

2.2.5.1.2 Surface Water Data Quality Review

Analytical results for five surface water samples collected in 2000 and analyzed by Groundwater Analytical Laboratory are Pre-CAM data, as they were generated prior to August 1, 2003. Brown and Caldwell has reviewed the laboratory case narrative and data report and believes that these Pre-CAM analytical data are comparable to "CAM Compliant" data (i.e. data with Presumptive Certainty).

The only quality control issue Brown and Caldwell identified was low surrogate recoveries (2-fluorophenol) for Method 8270 analysis in samples SW-3, SW-4, and SW-5 due to sample matrix interference. The 2-fluorophenol is an acidic surrogate, so only acidic compounds (those ending in "phenol" or "acid") are affected. The low recoveries in samples SW-4 and SW-5 introduce a potential low bias to the data, and therefore these data may be underestimated. However, these data are considered useable because PAHs are insoluble and are not likely to be present in surface water, so the non-detect values are likely representative and not grossly underestimated. Data for acidic compounds associated with sample SW-3 should be rejected because the surrogate recovery was <10%. Concentrations of PAHs in sample SW-3 are similar to the other four surface water samples (collected both upstream and downstream of SW-3), therefore despite the rejection of the data from a few acidic compounds, these data are still considered representative of surface water conditions at the Site.

2.2.5.1.3 Field Data Usability Assessment

Sediment and surface water analytical data used to support the RAO Partial was collected using proper sampling techniques (e.g. collection of sediment cores, decontamination of sampling equipment, etc.). Laboratory-supplied sampling containers with appropriate preservatives were utilized throughout the investigation. Duplicate sediment samples were collected as appropriate. All samples submitted for chemical analyses were placed on ice and transported with a chain of custody, and were received by the laboratory within allowable temperature ranges. Analytical holding times were met for all samples, with the exception of an exceedance of holding times (by one day) for some sediment samples collected in 2000 and analyzed using USEPA Method 8270C.

2.2.5.2 Representativeness Evaluation

2.2.5.2.1 Conceptual Site Model

A site-wide Conceptual Site Model (CSM) for both the Upland and River portions of the Site was presented in the Phase II CSA. The following CSM has been prepared for the Malden River portion of the former Malden MGP Site (with some discussion of the Upland portion of the site with respect to source areas and migration pathways).

Manufactured Gas Plant operations were conducted on approximately 16.4 acres of land in the vicinity of the intersection of Commercial and Charles Streets in Malden, Massachusetts from

approximately the mid to late 1800s to the late 1960s/early 1970s. The former holdings included land referred to as Parcels A, B, C, D and E.

The following seven types of contamination have been identified on Upland portions of the Site associated with the former Malden MGP:

- Tar-saturated materials consisting of soil or fill saturated with coal tar. Coal tar at the Site appears to have migrated vertically downward as DNAPL through the upper soil or fill. Tar saturated materials have been observed on approximately 5.5 acres of the Site on Parcels A and E.

- Shallow DNAPL (coal tar) observed in monitoring wells above the organic deposits within the portion of the Site impacted by TSM. The DNAPL has migrated via gravity along the upper surface of an organic deposit to low spots in the organic deposit, which includes historical river channels and the West End Brook (WEB) and Malden River (MR) culverts.

- Deep DNAPL (coal tar residuals) which have migrated vertically downward where the organic deposit is not present (southern portion of the Site), resulting in impacts to deeper soil and groundwater.

- LNAPL is composed of oils representing the lighter fraction of MGP residuals. LNAPL is present on the southern portions of Parcels A and E, and a portion of Commercial Street. Phase II investigation results indicate that the LNAPL area is stable and not migrating to new areas of the Site.

- BTEXSN compounds and cyanide are the primary contaminants in soil and groundwater on Parcel B. Volatilization of contaminants from impacted soil and groundwater poses a potential risk to indoor air for the building at Parcel B.

- Petroleum impacted soil is located on the northern half of Parcel E in the vicinity of historical above-ground petroleum and coal tar tanks. Impacts to soil in this area are primarily from petroleum compounds, although mixtures of tar-related compounds and petroleum compounds are present in some areas.

The former Malden MGP was located in a marshy area and historically the Malden River meandered through the Site along the eastern Site boundary. The West End Brook, a tributary to the Malden River, flowed across the center of the Site from west to east before emptying into the Malden River. The West End Brook was straightened in the mid 1900s, and in 1970-1971 was culverted across the Parcel E portion of the Site. In 1977, the Malden River (MR) culvert was constructed, which discharges at the current headwaters of the Malden River. Both culverts are underlain by a layer of crushed stone, approximately 3 feet thick. The WEB Culvert transects the TSM area, flowing from the western boundary of TSM impacts toward the east, where it discharges into the MR Culvert, which is located along the eastern Site boundary.

As described in the Phase II CSA, MGP residuals likely entered the Malden River though several routes over time, including discharge of MGP waste into historical Malden River tributaries during early periods of gas production and purification, subsurface DNAPL migration along the organic

deposit into the historical channel of the Malden River, and infiltration through joints and weep holes into the WEB and MR Culverts.

Constituents detected in sediment in the Malden River portion of the Site include a variety of VOCs, SVOCs, metals and EPH/VPH fractions. Potential human exposure pathways in the Malden River include ingestion and dermal contact with sediment and surface water, and ingestion of fish. Potential ecological exposure pathways include incidental ingestion of sediment and/or surface water, and food web exposure via the ingestion of prey exposed to contaminants in sediment and/or surface water. Based on the 2001 Method 3 Risk Characterization, PAHs are the primary constituents of concern in the sediment. Constituents detected in surface water in the River include a variety of VOCs, copper and lead. Based on the Method 3 Risk Characterization, the concentrations detected in surface water do not pose a Significant Risk.

Impacts to sediment in the Malden River downstream of the MR outfall has been attributed to the former Malden MGP and a number of historical sources of contamination located along the banks of the River. These sources include an industrial manufacturing facility with large releases of fuel oil, an oil company, and two tar distilleries. Phase II sediment sampling indicated abrupt increases in PAH concentrations at several locations downstream from the MR culvert corresponding to the locations of other known or potential sources of PAH contamination. A significant increase in PAH contamination was also identified approximately 1500 feet downstream of the MR culvert outfall, coincident with a former tar distillery. Based on this information, the Phase II CSA concluded the extent of impact to the Malden River attributable to the former Malden MGP Site is approximately 1,400 feet downstream of the MR culvert outfall.

An IRA was conducted between 1996 and 2002 to address an intermittent sheen observed on surface water flowing in the MR culvert. The IRA included the sealing of expansion joints and weep holes in the culverts, the relining of catch basins and storm drain pipes that lead into the culverts, and the injection of grout beneath the MR culvert just downstream of the confluence with the WEB culvert to prevent DNAPL migration in the crushed stone bedding. In addition, an extraction well was installed adjacent to the WEB culvert to remove DNAPL and reduce the potential for DNAPL migration into the culverts. An IRA Completion Report was prepared after it had been shown that these activities eliminated the migration of MGP residuals to the River, and test holes drilled into the crushed stone bedding near the MR culvert outfall did not detect DNAPL.

Based on the Phase II and III reports for the Site, groundwater contamination does not appear to be leaving the Site. In addition, remediation of groundwater is not required to achieve a level of No Significant Risk (except to address potential impacts to indoor air on Parcel B). These conclusions indicate that groundwater is not a significant contaminant migration pathway to the River. Given that groundwater is not considered an ongoing source of contamination to the River, and migration pathways associated with the culvert have been eliminated, there is no reason to anticipate that contaminants associated with the Upland portion of the former Malden MGP site will migrate to the River in the future. Through natural attenuation processes (e.g., PAH degradation and sediment deposition), concentrations of PAHs in Malden River sediment surface are expected to decrease over time.

2.2.5.2.2 Use of Field/ Screening Data

Sediment samples collected from sixteen locations in the Malden River in 2006 by Brown and Caldwell were observed for evidence of contamination and also classified. Part of this work was to evaluate whether a substantial hazard exists at the site, i.e. if there is visible presence of oil, tar, or other non-aqueous phase hazardous material in greater than 1,000 square feet within one foot of the sediment surface [310 CMR 40.0956(b)]. Observations made during the 2006 sediment sampling events did not identify visible evidence of such materials in any of the samples collected within one foot of the sediment surface. In addition, no such visible evidence was noted in the probe reports for sediment samples collected from 21 locations by Haley & Aldrich in 2000. Boring logs for the eight sediment samples collected by AMEC are not available.

2.2.5.2.3 Selection of Sampling Locations and Depths, Number and Spatial Distribution of Sampling Locations, and Collection and Handling of Samples

As part of the Phase II CSA, historical Malden River sediment PAH data (IRC Environmental Consultants Inc. investigation, 1985; Massachusetts Department of Environmental Protection, 1987 and 1989; and Rohm Tech sediment assessment data, 1996) was reviewed. In order to fill in data gaps and substantiate the historical data, 95 composite sediment samples were collected from intervals within the 0 to 4.5 feet depth range at 21 locations. Five surface water samples were also collected upstream of the Medford Street bridge to characterize surface water quality.

To delineate Site boundaries in the River, PAH "fingerprint" analyses were conducted on selected samples from the aforementioned 21 locations (to identify the presence or absence of MGP-related constituents in sediment). Based on the fingerprint analyses, the specific portion of the Malden River determined to be part of the Disposal Site (i.e. attributed to the former Malden MGP) starts at the outfall of the MR culvert and extends approximately 1,400 feet downstream.

In August 2001, an additional eight composite samples were collected in the upper 6 inches of sediment within the Malden River portion of the Disposal Site for use in the Method 3 Environmental Risk Characterization.

In 2006, an additional 40 composite sediment samples were collected from intervals within the 0 to 2 feet depth at 10 locations in the Malden River portion of the Disposal Site to further characterize river sediments so there would be a high degree of confidence that the selected remedy would be the most appropriate for the Site. Sediment and surface water sample locations from all phases of sampling are shown in Figure 3.

A total of 143 sediment samples were collected at 39 locations and five surface water samples at five locations along the Malden River as part of the Phase II CSA and Phase III RAP. The 1,400 foot length of the river that is considered the Malden River portion of the Disposal Site has been characterized by 110 sediment samples from 32 locations and 5 surface water samples. A review of Figure 3 indicates that the largest spacing between sediment samples in a downstream direction is less than 75 feet. The majority of samples (82) were collected in the shallow depth interval (0-6 inches) which is most relevant to the evaluation of risk to human health and the environment. Therefore, Brown and Caldwell concludes that the distribution and depth of sampling locations is sufficient to support this RAO Partial and provide the data set necessary to support a conclusion of No Significant Risk for the Malden River portion of the Disposal Site.

Specific samples were not required to document the elimination or control of discrete OHM sources. As discussed in Section 2.2.2, numerous rounds of sediment sampling confirmed that there is no visual indication of oil, tar or NAPL that could be considered a potential source in the River The source of former Malden MGP- residuals that have been detected in the River sediment are attributed to the migration of oil/coal tar along former tributaries that have since been culverted (WEB and MR culverts), and seepage into the culverts. The IRA that was conducted between 1996 and 2002 has effectively sealed the joints of the pipe, and prevented migration in the bedding material. These actions have resulted in the mitigation of sheens to surface water in the culvert, thereby eliminating the migration of MGP residuals from the former Malden MGP Site into the Malden River.

2.2.5.2.4 Temporal Distribution of Samples

Disposal Site conditions do not warrant the collection and analysis of temporal samples. Concentrations of constituents of concern in sediment are not expected to change significantly with time, as evidenced by the comparable PAH concentrations observed in the sediment samples collected in 2000 and 2006.

Concentrations of constituents of concern in surface water were at least one order of magnitude below Ambient Water Quality Criteria. Since surface water is not considered an exposure pathway, it was not evaluated further.

2.2.5.2.5 Critical Samples

There are no critical samples for the Malden River portion of the Site. The risk associated with the critical interval for ecological receptors is the upper six inches of sediment. A total of 82 sediment samples have been collected from sediment in that depth interval, and Brown and Caldwell believes these samples are adequate to evaluate risk to human health, public welfare and the environment.

2.2.5.2.6 Completeness

No significant data gaps have been identified for the Malden River portion of the Disposal Site.

2.2.5.2.7 Inconsistency and Uncertainty

Spike recoveries for three PAH compounds in the MS/MSD associated with sediment sample SED-206 (0-6") were below acceptance limits. The low spike recoveries introduce a potential low bias to the data, and therefore these data may be underestimated. However, PAH concentrations in SED-206 (0-6") are generally comparable to concentrations in adjacent sediment samples and therefore the level of uncertainty is minimal.

Analytical data reports and case narratives were not available for the sediment data collected by AMEC, so a full data quality review was not possible. However, the majority of the sediment results have been confirmed by more recent CAM Compliant data collected by Brown and Caldwell in 2006. Quality control data and case narratives were also not available for the PAH "fingerprint" sediment data . The Phase II CSA report, however, indicated that a review of analytical data had been performed and the data was qualified as necessary.

2.2.5.3 Data Usability and Representativeness Evaluation Summary

The analytical data used to support this Class A-2 RAO Partial for the Malden River portion of the Site were generated from site investigations conducted over a six year period. A total of 143 sediment samples were collected at 39 locations along the river and 5 surface water samples. The 1,400 foot portion of the river that is considered the Disposal Site has been characterized by 110 sediment samples from 32 locations and 5 surface water samples from 5 locations. The analytical data collected in 2006 to support this RAO Partial is CAM Compliant data (which meet the requirements for Presumptive Certainty). The analytical data collected in 2000 and 2001 are Pre-CAM analytical data, but Brown and Caldwell believes these data are comparable to "CAM Compliant" data (i.e. data with Presumptive Certainty). Brown and Caldwell has conducted a data quality review for the Malden River portion of the Disposal Site and believes that the analytical data used to support this RAO Partial are scientifically valid and defensible; of a sufficient level of precision, accuracy and completeness; and are spatially and temporally adequate to represent Site conditions. In particular, the available data are sufficient to characterize the potential risk posed by the site and to demonstrate that a Condition of No Significant Risk has been achieved.

2.3 RAO Summary

This RAO Partial Statement for a Class A-2 Permanent Solution has been prepared for the Malden River Portion of the Former Malden MGP Site in Malden, Massachusetts (RTN 3-0362). The specific portion of the Malden River that is part of the Disposal Site begins at the outfall of the MR culvert located at the upstream end of the River and extends approximately 1400 feet downstream.

Based on several rounds of sediment sampling that have been conducted in the Malden River portion of the Site, there is no visual indication of oil, tar or NAPL that could be considered a potential source in the River. The source of the former Malden MGP-residuals that have been detected in River sediment are attributed to the migration of oil/coal tar along former tributaries that have since been culverted (WEB and MR culverts), and seepage into the culverts that have since been sealed. Constituents detected in sediment in the Malden River portion of the Site include a variety of VOCs, SVOCs, metals and EPH/VPH fractions, however, PAHs are the primary constituents of concern in the sediment.

An IRA that was conducted between 1996 and 2002 has effectively sealed the joints of the culvert pipes, and prevented migration of oil/coal tar in the bedding material of the culverts. These actions have eliminated the migration of MGP residuals into the Malden River.

The Phase II and III reports for the Site have concluded that groundwater contamination does not appear to be leaving the Upland portion of the Site. In addition, remediation of groundwater is not required to achieve a level of No Significant Risk (except to address potential indoor air issues on Parcel B). These conclusions indicate that groundwater is not a significant contaminant migration pathway to the River.

Supplemental Method 3 Risk Characterization activities have indicated that a condition of "No Significant Risk" exists in the Malden River portion of the Site for human health, safety, public welfare, and the environment. However, a condition of No Significant Risk was not initially concluded for exposure to cPAHs via fish ingestion. The fish bioaccumulation pathway was re-evaluated using updated information and it was concluded that the River portion of the Site did not

present unacceptable risks. Additional data were collected after this conclusion was reached to confirm that it was still the case. The Method 3 RC calculations were revised using updated information and they showed that the Malden River portion of the Site posed No Significant Risk to human health and the environment.

Given that groundwater is not considered an ongoing source of contamination to the River, and migration pathways associated with the culvert have been eliminated, contaminants associated with the Upland portion of the former Malden MGP Site are not expected to migrate to the River in the future. PAH concentrations in the Malden River sediment are expected to decrease over time through natural attenuation processes such as degradation and sediment deposition.

This Class A-2 RAO Partial is appropriate for the Malden River portion of the former Malden MGP Site because:

1) Response actions have been conducted on the Upland portion of the Site as described in Section 1.1.1.3.

2) A Permanent Solution has been achieved (the Risk Characterization indicated the Malden River portion of the Site poses "No Significant Risk" to human health, safety, public welfare, and the environment);

3) The level of oil and hazardous material in the environment has not been reduced to background;

4) One or more Activity and Use Limitations are not required on the Malden River portion of the Site to maintain a level of No Significant Risk; and

5) No sources of oil or hazardous material have been identified in the Malden River portion of the Site. In addition, each source of oil and/or hazardous material on the Upland portion of the Site likely to result in an increase in concentrations of oil or hazardous material in the Malden River has been controlled.

3 REFERENCES

Brown and Caldwell, June, 2006. "Phase III – Remedial Action Plan, Former Malden Manufactured Gas Plant Site (Malden River Portion), Malden, Massachusetts."

Haley & Aldrich Inc., September 2003, "Immediate Response Action (IRA) Completion Report, West End Brook – Malden River Culverts, Malden, Massachusetts."

Haley & Aldrich Inc., June, 2003. "Phase III – Remedial Action Plan, Former Malden Manufactured Gas Plant Site, Malden, Massachusetts."

Haley & Aldrich Inc., December, 2001. "Phase II – Comprehensive Site Assessment, Former Malden Manufactured Gas Plant Site, Malden, Massachusetts."

Table 1

(Table 2-40 from Method 3 Risk Characterization)
Summary Of Constituents Detected In Sediment
Malden River
Former Malden Manufactured Gas Plant
Malden, Massachusetts

Constituent	Number of Detections	Total Number of Samples	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Arithmetic Average Concentration (mg/kg)
1,2,4-Trimethylbenzene	9	21	0.41	3.6	0.78
1,3,5-Trimethylbenzene	4	21	0.59	1.9	0.48
1,3-Dichlorobenzene	1	21	0.51	0.51	0.39
1,4-Dichlorobenzene	4	21	0.5	2.2	0.55
2-Methylnaphthalene	15	29	0.733	60	7.05
4-Isopropyltoluene	1	21	0.32	0.32	0.41
Acenaphthene	25	29	0.27	75	7.76
Acenaphthylene	24	29	0.299	27	3.26
Anthracene	29	29	0.6	91	8.77
Antimony	1	21	2.5	2.5	0.99
Arsenic	16	29	2.4	30	7.43
Barium	6	8	15.1	51.7	24.33
Benzene	5	29	0.4	4.8	0.55
Benzo(a)anthracene	29	29	1.75	46	929
Benzo(a)pyrene	29	29	1.715	38	9.14
Benzo(b)fluoranthene	29	29	1.555	34	9.65
Benzo(g,h,i)perylene	23	29	0.54	14	2.79
Benzo(k)fluoranthene	28	29	0.977	11	3.51
bis(2-Ethylhexyl)phthalate	20	21	0.73	75	17.50
Butylbenzylphthalate	2	21	0.68	4.2	1.77
C11-C22 Aromatics	29	29	71.6	2100	893.14
C19-C36 Aliphatics	29	29	67	4000	1156.02
C5-C8 Aliphatics	1	29	0.8	0.8	1.56
C9-C10 Aromatics	20	21	3	55	13.92
C9-C12 Aliphatics	10	29	1.15	13	2.65
C9-C18 Aliphatics	25	29	11	650	134.02
Cadmium	23	29	0.313	4.8	1.64
Carbazole	3	21	1.1	1.9	1.72
Chlorobenzene	3	21	1	11	1.22
Chromium	24	29	5.4	73	25.81
Chrysene	29	29	1.835	44	8.99
Copper	26	29	19.1	240	83.74
Di-n-octylphthalate	7	21	0.89	4.4	1.87
Dibenzo(a,h)anthracene	7	29	0.325	3.2	1.33
Dibenzofuran	12	21	1	12	3.10

Constituent	Number of Detections	Total Number of Samples	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Arithmetic Average Concentration (mg/kg)
Ethylbenzene	5	29	0.184	4.6	0.51
Fluoranthene	29	29	3.64	98	19.23
Fluorene	23	29	0.282	70	6.66
Indeno(1,2,3-cd)pyrene	24	29	0.66	15	3.27
Isophorone	9	20	0.69	6	2.19
Lead	29	29	30	850	306.13
m,p-Xylene	3	29	0.31	1.2	0.37
Mercury	21	29	0.06	1.9	0.40
Naphthalene	28	29	0.227	76	10.02
Nickel	8	21	12	37	14.45
o-Xylene	1	29	0.77	0.77	0.34
Phenanthrene	29	29	2.948	220	25.60
Pyrene	29	29	3.645	110	19.48
Toluene	2	29	0.311	0.39	0.34
Zinc	28	29	69	1500	331.69

Note:
mg/kg = milligram per kilogram

Table 2
(Table 2-39 from Method 3 Risk Characterization)

Summary Of Constituents Detected In Surface Water
Former Malden Manufactured Gas Plant
Malden, Massachusetts

Constituent	Number of Detections	Total Number of Samples	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Arithmetic Average Concentration (mg/L)
1 4-Dichlorobenzene	1	5	0.0006	0.0006	0.0002
1 ,2,4-Trimethylbenzene	2	5	0.0006	0.0006	0.0003
Benzene	5	5	0.002	0.004	0.0028
Chloroform	3	5	0.0006	0.0009	0.0004
cis-1 2-Dichloroethene	4	5	0.0006	0.0007	0.0006
Copper (1)	2	5	0.0278	0.0380	0.0207
Ethylbenzene	3	5	0.0005	0.0015	0.0006
Lead (1)	4	5	0.007	0.046	0.0156
m,p-Xylene	2	5	0.0004	0.0007	0.0002
Methyl tert-butyl ether	5	5	0.0025	0.0050	0.0037
Methylene chloride	5	5	0.008	0.025	0.0174
Naphthalene	5	5	0.001	0.006	0.003
Toluene	5	5	0.0025	0.008	00055

Notes:
mg/L = milligram per liter
(1) For copper and lead, the detected concentrations represent total fraction; dissolved fraction was not detected above laboratory reporting limits.

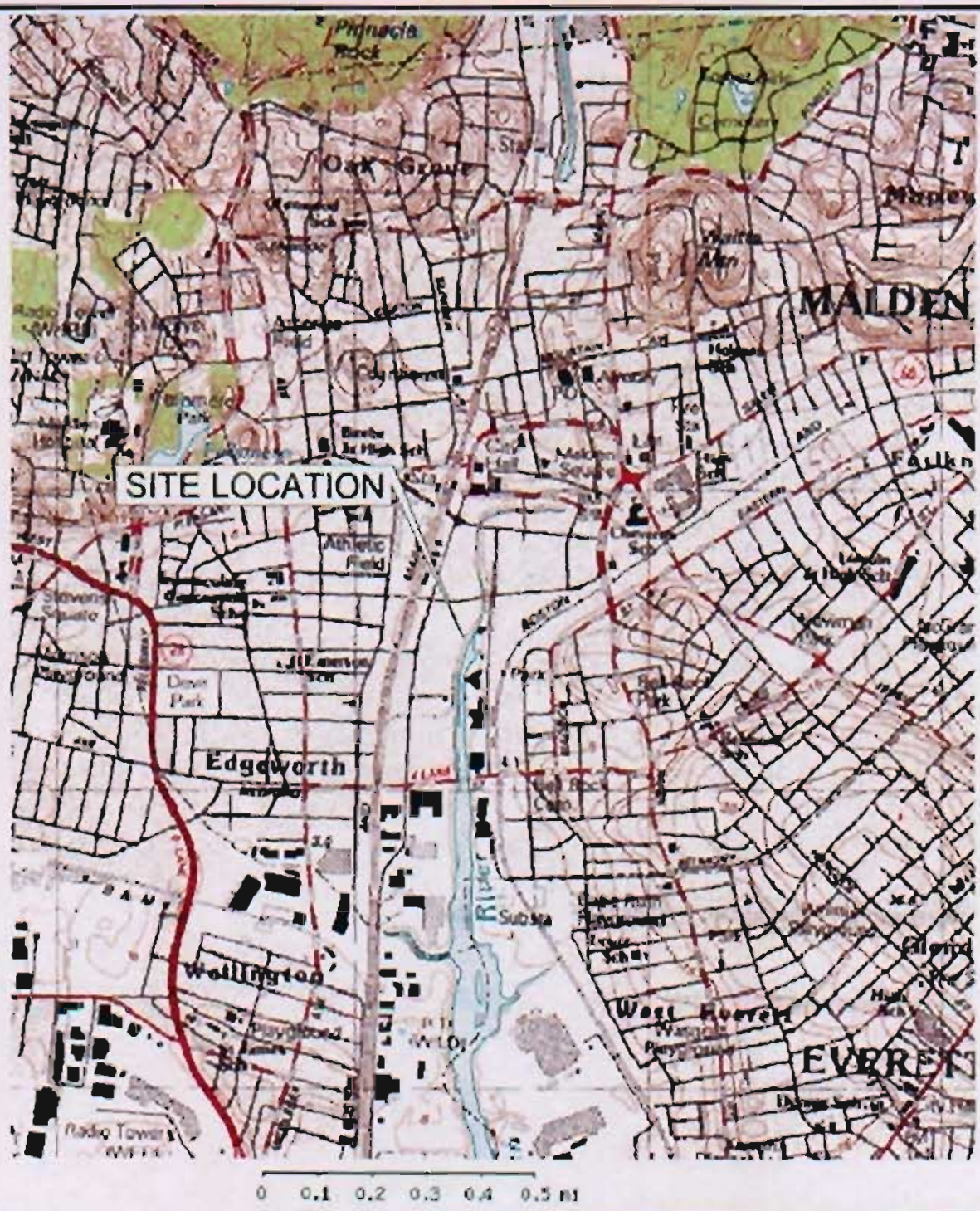


FIGURE 1

SITE LOCATION MAP
MALDEN RIVER SITE

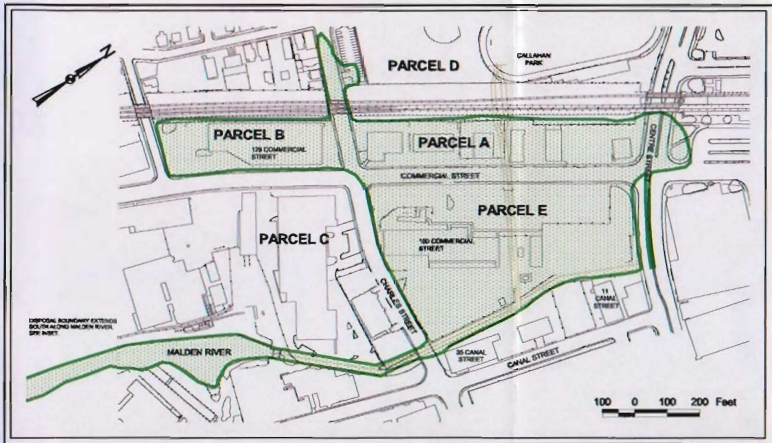
SOURCE: www.Topozone.com
MAP CENTER IS UTM 19 329536E 4698893N
(WGS84/NAD83)
BOSTON NORTH QUADRANGLE

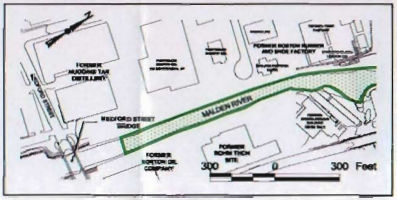
MALDEN, MA.

DATE	PROJECT NUMBER
JUNE, 2006	129490.050

BROWN AND CALDWELL
ALLENDALE, NEW JERSEY

P:\DRAFTING\NATIONAL_GRID\MALDEN\129490\FIGURE 1 (LOCATION MAP).DWG 06/29/2007 10:46:13AM ByRow XREFS Layout: 8.5x11





LEGEND:

FORMER MALDEN MGP DISPOSAL SITE BOUNDARY

PILE - SUPPORTED CONCRETE CULVERTS INSTALLED BY MDC

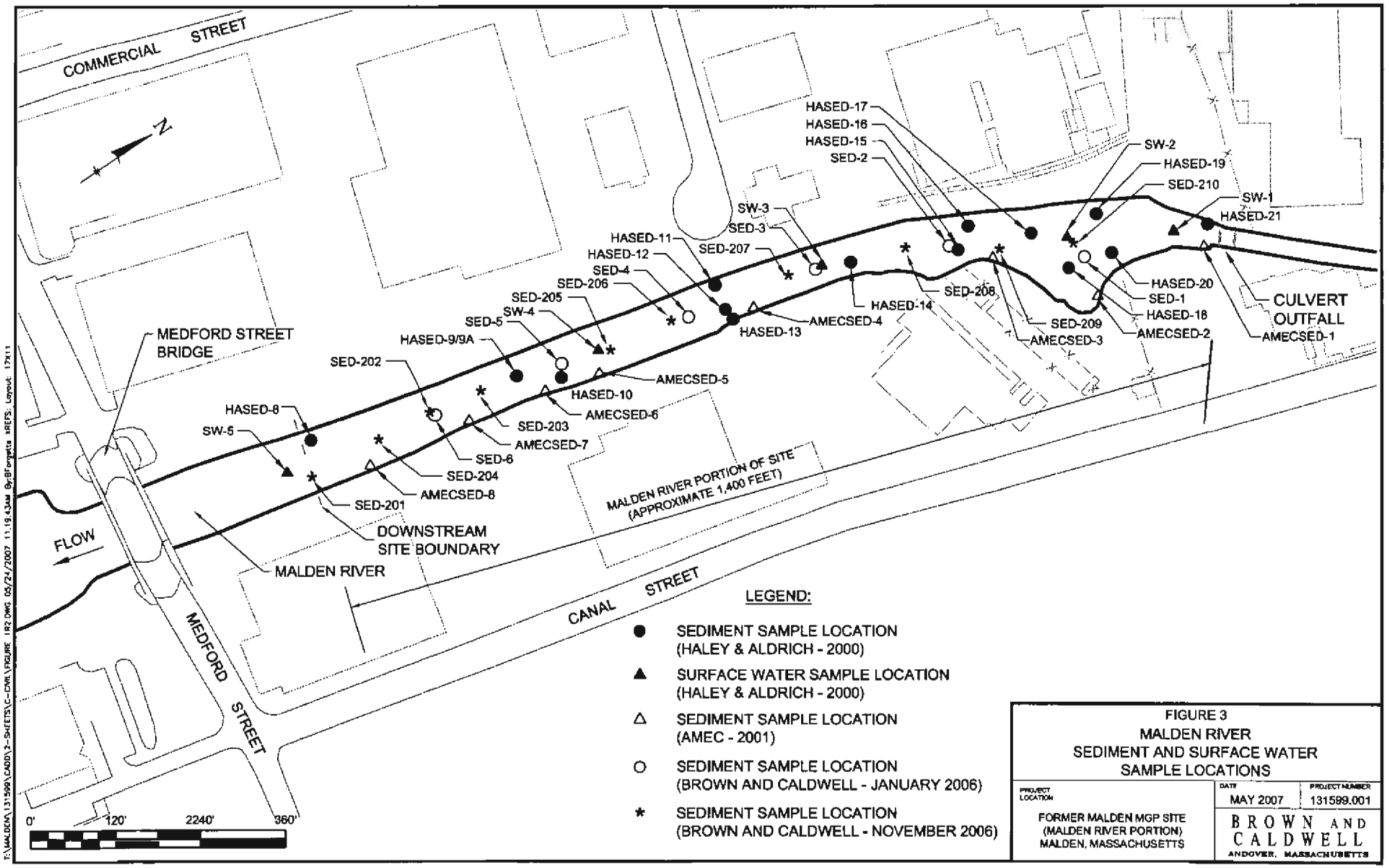
NOTES:

1. BASE PLAN ADAPTED FROM "TOPOGRAPHIC WORKSHEET OF THE MANUFACTURED GAS PLANT, MALDEN, MA" FOR MASSACHUSETTS ELECTRIC COMPANY BY EASTERN TOPOGRAPHICS, JUNE 1995, AND CITY OF MALDEN ASSESSOR'S PLAN, SHEETS 7 AND 9, JUNE 1995, AND SHEET NO. 53 BY FAY, SPOFFORD & THORNDIKE, INC., UPDATED JUNE 1978 AND REVISED 30 JULY 1979.

FIGURE 2
DISPOSAL SITE BOUNDARY
FORMER MALDEN MGP SITE
MALDEN, MASSACHUSETTS

PROJECT NUMBER: 131599.003	MAY 2007

NOTE:
INSERT TAKEN FROM PHASE II CSA, HALEY & ALDRICH, 2001



T:\MALDEN\131599\CADD\2-SHEETS\C-DWG\FIGURE 1R2.DWG 05/24/2007 11:19:43AM By:BFongella XREFS: Layout: 17x11

FIGURE 3
MALDEN RIVER
SEDIMENT AND SURFACE WATER
SAMPLE LOCATIONS

PROJECT LOCATION	DATE	PROJECT NUMBER
FORMER MALDEN MGP SITE (MALDEN RIVER PORTION) MALDEN, MASSACHUSETTS	MAY 2007	131599.001

BROWN AND CALDWELL
ANDOVER, MASSACHUSETTS

APPENDIX A

NOVEMBER 2006 ADDITIONAL DATA COLLECTION REPORT

APPENDIX A
Response Action Outcome – Partial Statement
Former Malden MGP Site
(Malden River Portion) - Malden, Massachusetts

NOVEMBER 2006 ADDITIONAL DATA COLLECTION REPORT

Introduction. This report presents supplemental data that were collected for the Malden River portion of the Former Malden Manufactured Gas Plant (MGP) Site (the Site) located in Malden, Massachusetts. These data were collected in November, 2006.

Site Description. The Malden River portion of the Site is the uppermost portion of the Malden River which is bounded, in general, by Charles Street to the north, Medford Street to the south, Canal Street to the east and Commercial Street to the west. The specific portion of the Malden River that is considered to be part of the Disposal Site starts from the discharge culvert at the upstream end and extends 1,400 feet downstream (Figure 1). This downstream boundary was established in the Phase II Comprehensive Site Assessment (CSA) after a thorough evaluation of potential impacts from the former Malden MGP, polynuclear aromatic hydrocarbon (PAH) distribution in the River, other potential sources of PAHs (evaluated through fingerprinting analysis) and locations of other industries with ties to PAHs.

Site History. The Malden River was investigated as part of the former Malden MGP Site which operated at Commercial and Center Streets in Malden for approximately 120 years. Data assessment has indicated PAH impacts to sediments in the Malden River that are related to the long industrial history of the area. These impacts are documented in the Phase II CSA Report (Haley and Aldrich, 2001) that was completed for the Site, consistent with the Massachusetts Contingency Plan (MCP) coded as 310 CMR 40.0000. A Phase III Remedial Action Plan (RAP) for the Malden River portion of the Site was prepared in accordance with 310 CMR 40.0850 of the MCP and submitted to the Massachusetts Department of Environmental Protection (MADEP) in June 2006 (Brown and Caldwell, 2006).

The Malden River RAP concluded that a Permanent Solution can be achieved through implementation of No Further Action in the River which is expected to achieve a Class A-2 Response Action Outcome (RAO). Although the No Further Action remedial action alternative is expected to achieve a Class A-2 RAO, the RAP recommended that additional steps be taken prior to filing the RAO. These steps included collection of additional field data, which is the subject of this report.

Field Activities. The objective of the field sampling effort was to collect additional data for use in confirming the conclusions in the Phase III RAP. Specifically, the investigation included re-sampling locations where previous sampling indicated higher concentrations of PAHs than other locations, and collecting samples between existing sampling locations and intervals. The field work involved collection of sediment cores from the River for observations and analysis. A total of 10 locations (Figure 1) were sampled to a depth of 2 feet. Samples were collected in 6-inch intervals resulting in 4

samples per location for a total of 40 samples for analysis. Additional samples were included for quality control purposes (i.e. two field duplicates and two matrix spikes with duplicates). The samples were analyzed for PAHs and total organic carbon (TOC). While in the field, cores were observed for visual evidence of non-aqueous phase liquid (NAPL), water depths were noted and sample locations were recorded using a Global Positioning System (GPS). Field documentation included core logs, and sediment descriptions. Sample collection was performed by TG&B Marine Services Inc., acting as a subcontractor to Brown and Caldwell.

Sample Analysis. All samples were analyzed by STL of Shelton, Connecticut for PAHs using Method 8270 and for TOC using the Lloyd Kahn (1988) method.

Results. Sediment core logs for each of the ten locations sampled are presented in Attachment A. The laboratory data sheets are presented in Attachment B. Concentrations of individual PAHs in the various samples are presented in Table 1. These concentrations were summed for each sample and reported as total PAHs in Table 2. Also reported in Table 2 are the sum of "carcinogenic" PAHs (cPAHs), TOC and solids content. Both previous and current data for surficial cPAHs are presented in Figure 1. The individual PAHs included in the sum of cPAHs are:

Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Dibenzo(a,h,)anthracene
Indeno(1,2,3-cd)pyrene
Benzo(k)fluoranthene
Chrysene

Data Evaluation and Conclusions. The remedial action objective in the Phase III RAP was to address those portions of the Malden River sediment that resulted in an overall average of 31 milligram per kilogram (mg/kg) cPAHs across the sediment surface. The Phase II CSA Report data showed an average cPAH concentration of 12 mg/kg in the top 6 inches of sediment. The November 2006 data showed an average cPAH concentration of 12.8 mg/kg in the top 6 inches of sediment and both sets of data resulted in an overall average cPAH concentration of 12.3 mg/kg. Although two of the 40 samples exceeded the average of 31 mg/kg, they do not constitute "hot spots", and the averages in the vicinity of each of these two samples are well below the remedial action objective of 31 mg/kg.

Another objective of the field effort was to confirm that a substantial hazard did not exist at the Site. A substantial hazard exists if there is the visible presence of oil, tar or other non-aqueous phase hazardous material in greater than 1,000 square feet within one foot of the sediment surface {310 CMR 40.0956(b)}. Observations made during the recent field effort did not identify visible evidence of such materials which confirmed the prior conclusion that a substantial hazard does not exist at the Site. The prior observations were made during sediment sampling conducted by Brown and Caldwell (June 2006) and Haley & Aldrich (2001). These observations, together with the acceptable average cPAH concentration discussed above, support the conclusion in the Phase III RAP that No

Further Action is the appropriate remedial alternative for the Malden River portion of the Former Malden MGP Site.

References.

Brown and Caldwell. "Phase III Remedial Action Plan: Former Malden MGP Site (Malden River Portion) Malden, Massachusetts." June 2006.

Haley and Aldrich. "Phase II Comprehensive Site Assessment: Former Malden MGP Site (Malden River Portion) Malden, Massachusetts." December 2001.

Kahn, Lloyd. 'Determination of Total Organic Carbon in Sediment (Lloyd Kahn Method)." United States Environmental Protection Agency, Region II, Edison New Jersey, July 27, 1988.

TABLES

TABLE 1

Former Malden MGP Site
Malden River -- Malden, Massachusetts

Polynuclear Aromatic Hydrocarbon (PAH) Concentrations, mg/Kg

Chemical	SED-201				SED-202				SED-203			
Compounds	0 - 6"	6" - 12"	12" - 18"	18" - 24"	0 - 6"	6" - 12"	12" - 18"	18" - 24"	0 - 6"	6" - 12"	12" - 18"	18" - 24"
Acenaphthene	J 0.5	4.5	J 22.0	21.0	4.9	U 0.4	J 0.2	J 0.1	J 0.1	1.3	0.9	J 0.2
Acenaphthylene	J 0.3	2.7	4.7	J 5.5	2.0	U 0.4	U 0.4	U 0.4	1.5	0.6	J 0.4	U 0.4
Anthracene	1.1	7.2	15.0	13.0	3.3	U 0.4	J 0.1	U 0.4	1.8	1.1	0.6	J 0.1
Benzo[a]anthracene	3.3	14.0	10.0	10.0	6.4	U 0.4	U 0.4	U 0.4	4.2	1.3	0.6	J 0.1
Benzo[a]pyrene	3.1	12.0	8.3	7.5	5.6	U 0.4	U 0.4	U 0.4	4.1	1.1	0.6	J 0.1
Benzo[b]fluoranthene	3.0	10.0	6.0	J 4.8	4.4	U 0.4	U 0.4	U 0.4	3.1	0.8	0.5	U 0.4
Benzo[g,h,i]perylene	3.6	16.0	9.3	7.3	7.2	U 0.4	U 0.4	U 0.4	4.9	1.1	0.6	U 0.4
Benzo[k]fluoranthene	2.9	11.0	J 5.6	J 5.3	4.7	U 0.4	U 0.4	U 0.4	3.3	0.8	J 0.5	U 0.4
Chrysene	3.8	16.0	10.0	9.9	7.5	U 0.4	U 0.4	U 0.4	4.9	1.6	0.7	J 0.1
Dibenz(a,h)anthracene	J 0.6	J 2.6	J 1.6	J 1.2	J 1.3	U 0.4	U 0.4	U 0.4	J 0.9	J 0.2	J 0.1	U 0.4
Fluoranthene	7.4	30.0	19.0	17.0	13.0	U 0.4	U 0.4	U 0.4	7.9	2.7	1.4	J 0.2
Fluorene	J 0.4	3.5	12.0	16.0	2.5	U 0.4	J 0.1	J 0.1	1.0	J 0.3	J 0.3	U 0.4
Indeno[1,2,3-cd]pyrene	3.4	15.0	8.0	J 6.1	6.9	U 0.4	U 0.4	U 0.4	5.1	1.2	0.6	U 0.4
Naphthalene	J 0.2	13.0	83.0	82.0	13.0	U 0.4	J 0.3	J 0.2	J 0.8	0.7	1.6	J 0.3
Phenanthrene	4.6	34.0	45.0	41.0	13.0	J 0.1	J 0.3	J 0.2	6.6	2.9	1.4	J 0.2
Pyrene	8.7	32.0	30.0	26.0	14.0	U 0.4	J 0.1	U 0.4	8.8	3.3	2.0	J 0.3
2-Methylnaphthalene	J 0.9	J 2.0	31.0	26.0	2.9	U 0.4	J 0.1	U 0.4	J 0.4	J 0.1	J 0.2	U 0.4
Total PAHs	47.7	225.5	320.5	299.6	112.6	6.7	5.0	5.6	60.3	21.1	12.9	4.6

See notes on page 4 of 4

TABLE 1 (cont'd)

Former Malden MGP Site
Malden River -- Malden, Massachusetts

Polynuclear Aromatic Hydrocarbon (PAH) Concentrations, mg/Kg

Chemical	SED-204				SED-205				SED-206			
Compounds	0 - 6"	6" - 12"	12" - 18"	18" - 24"	0 - 6"	6" - 12"	12" - 18"	18" - 24"	0 - 6"	6" - 12"	12" - 18"	18" - 24"
Acenaphthene	0.7	6.8	U 0.4	U 0.4	J 0.5	J 0.2	J 0.1	U 0.4	0.6	0.9	U 0.4	U 0.4
Acenaphthylene	1.1	5.5	U 0.4	U 0.4	2.1	J 0.3	J 0.1	U 0.4	J 0.3	J 0.3	U 0.4	U 0.4
Anthracene	1.6	10.0	J 0.1	U 0.4	2.4	0.4	J 0.1	U 0.4	1.1	0.9	U 0.4	U 0.4
Benzo[a]anthracene	3.8	12.0	J 0.1	U 0.4	4.8	0.9	J 0.2	U 0.4	2.0	1.0	U 0.4	U 0.4
Benzo[a]pyrene	3.4	11.0	J 0.1	U 0.4	3.5	0.8	J 0.2	U 0.4	1.7	0.9	U 0.4	U 0.4
Benzo[b]fluoranthe	2.7	7.5	J 0.1	U 0.4	2.4	0.8	J 0.1	U 0.4	1.3	0.5	U 0.4	U 0.4
Benzo[g,h,i]perylen	3.3	10.0	J 0.8	U 0.4	3.0	0.8	J 0.1	U 0.4	1.7	0.7	U 0.4	U 0.4
Benzo[k]fluoranthe	2.7	8.2	U 0.4	U 0.4	2.5	0.7	J 0.2	U 0.4	1.4	0.7	U 0.4	U 0.4
Chrysene	4.3	14.0	J 0.1	U 0.4	4.6	1.1	J 0.2	U 0.4	2.1	1.0	U 0.4	U 0.4
Dibenz(a,h)anthrace	0.6	J 0.2	U 0.4	U 0.4	J 0.6	J 0.2	U 0.4	U 0.4	0.4	J 0.2	U 0.4	U 0.4
Fluoranthene	6.7	26.0	J 0.3	J 0.1	7.4	2.0	J 0.4	U 0.4	4.2	2.2	J 0.1	U 0.4
Fluorene	0.8	6.4	U 0.4	U 0.4	J 0.6	J 0.2	U 0.4	U 0.4	0.6	0.6	U 0.4	U 0.4
Indeno[1,2,3-cd]pyr	3.6	11.0	J 0.1	U 0.4	3.4	0.9	J 0.1	U 0.4	1.5	0.6	U 0.4	U 0.4
Naphthalene	0.8	4.2	J 0.2	J 0.2	U 1.0	J 0.1	U 0.4	U 0.4	J 0.2	J 0.2	U 0.4	U 0.4
Phenanthrene	5.8	34.0	J 0.3	U 0.4	6.2	1.2	J 0.1	U 0.4	3.8	3.3	J 0.2	J 0.1
Pyrene	7.3	27.0	J 0.3	J 0.2	9.2	2.4	0.5	U 0.4	4.5	2.5	J 0.1	J 0.1
2-Methylnaphthalen	0.7	4.3	U 0.4	U 0.4	U 1.0	U 0.4	U 0.4	U 0.4	J 0.1	J 0.1	U 0.4	U 0.4
Total PAHs	49.9	199.9	4.8	5.9	55.0	13.2	4.2	6.1	27.5	16.5	6.5	6.5

See notes on page 4 of 4

TABLE 1 (cont'd)

Former Malden MGP Site
Malden River -- Malden, Massachusetts

Polynuclear Aromatic Hydrocarbon (PAH) Concentrations, mg/Kg

Chemical	SED-207				SED-208				SED-209			
Compounds	0 - 6"	6" - 12"	12" - 18"	18" - 24"	0 - 6"	6" - 12"	12" - 18"	18" - 24"	0 - 6"	6" - 12"	12" - 18"	18" - 24"
Acenaphthene	3.2	7.4 J	0.1	18.0	J 0.5	0.6	0.6	J 1.6	21.0	1.1	0.9	29.0
Acenaphthylene	J 2.3	4.1	J 0.1	12.0	J 0.3	0.5	0.5	2.0	J 2.4	0.7	1.0	5.4
Anthracene	6.0	12.0	J 0.1	34.0	1.3	1.2	0.8	3.6	33.0	1.0	1.2	20.0
Benzo[a]anthracene	11.0	17.0	J 0.2	30.0	3.4	2.8	2.0	8.8	49.0	1.3	1.9	15.0
Benzo[a]pyrene	10.0	14.0	J 0.2	23.0	2.8	2.4	1.7	7.6	43.0	1.1	1.8	13.0
Benzo[b]fluoranthe	9.2	11.0	J 0.1	16.0	2.8	2.0	1.5	6.3	30.0	0.7	1.3	9.8
Benzo[g,h,i]perylen	9.3	12.0	J 0.1	18.0	2.9	1.6	1.0	3.9	29.0	0.5	0.7	7.9
Benzo[k]fluoranthe	8.4	9.4	J 0.1	19.0	2.2	1.9	1.4	6.3	34.0	0.7	1.6	10.0
Chrysene	13.0	19.0	J 0.2	32.0	4.0	3.1	2.2	9.3	47.0	1.3	2.0	16.0
Dibenz(a,h)anthrace	J 2.5	J 3.1	U 0.4	J 5.2	1.0	0.6	J 0.3	J 1.4	J 8.0	0.2	0.3	2.0
Fluoranthene	25.0	35.0	J 0.3	68.0	7.5	5.9	4.1	20.0	120.0	2.2	3.6	39.0
Fluorene	3.8	7.6	J 0.1	17.0	J 0.6	0.6	0.6	J 1.4	23.0	0.8	0.8	24.0
Indeno[1,2,3-cd]pyr	7.9	11.0	J 0.1	17.0	2.7	1.6	1.0	3.9	27.0	0.5	0.7	6.9
Naphthalene	J 1.3	J 3.1	U 0.4	J 11.0	J 0.3	J 0.4	J 0.3	J 0.8	25.0	1.4	0.2	27.0
Phenanthrene	21.0	39.0	J 0.4	95.0	5.9	4.1	2.3	12.0	140.0	2.6	2.6	76.0
Pyrene	24.0	37.0	0.5	70.0	7.0	5.3	3.4	15.0	97.0	2.6	2.4	42.0
2-Methylnaphthalen	J 0.8	J 2.7	U 0.4	J 4.8	J 0.2	J 0.2	J 0.1	J 0.3	J 9.3	0.7	0.2	49.0
Total PAHs	158.7	244.4	3.8	490.0	45.3	34.7	23.7	104.2	737.7	19.4	23.0	392.0

See notes on page 4 of 4

TABLE 1 (cont'd)

Former Malden MGP Site
Malden River -- Malden, Massachusetts

Polynuclear Aromatic Hydrocarbon (PAH) Concentrations, mg/Kg

Chemical Compounds	SED-210			
	0 - 6"	6" - 12"	12" - 18"	18" - 24"
Acenaphthene	3.6	1.5	12.0	3.7
Acenaphthylene	1.1	0.5	1.6	0.4
Anthracene	4.1	1.2	8.8	1.1
Benzo[a]anthracene	9.6	1.8	6.9	0.9
Benzo[a]pyrene	8.8	1.6	5.2	0.7
Benzo[b]fluoranthene	8.0	1.2	5.1	0.5
Benzo[g,h,i]perylene	7.4	0.8	3.0	0.5
Benzo[k]fluoranthene	6.5	1.1	3.8	0.5
Chrysene	11.0	1.9	7.2	1.0
Dibenz(a,h)anthracene	1.6	0.3	4.8	0.1
Fluoranthene	24.0	3.8	18.0	2.2
Fluorene	3.8	1.3	11.0	2.4
Indeno[1,2,3-cd]pyrene	5.9	0.8	2.7	0.4
Naphthalene	1.0	0.3	9.6	0.2
Phenanthrene	23.0	3.3	35.0	2.3
Pyrene	23.0	3.5	19.0	2.0
2-Methylnaphthalene	0.5	0.1	14.0	0.4
Total PAHs	142.8	25.1	167.7	19.2

NOTES: 1. PAH = Polynuclear aromatic hydrocarbons

2. mg/Kg = milligram per Kilogram
3. Each core was segmented into intervals of 0 - 6", 6" - 12", 12" - 18" and 18"- 24"
4. Samples were collected in November 2006
5. J = estimated concentration
6. U = chemical not detected at detection limit noted
7. Detection limits included in sum of total PAHs

TABLE 2

Former Malden MGP Site
Malden River -- Malden, Massachusetts

November 2006 Data Summary

Sample	Interval (inches)	Total PAHs (mg/Kg)	cPAHs (mg/Kg)	TOC (%)	Solids (%)
SED-201	0-6	48	4.7	1.2	77
	6-12	226	18.6	3.3	50
	12-18	321	12.4	5.2	56
	18-24	300	10.9	3.1	48
SED-202	0-6	113	8.1*	1.4	71
	6-12	3	6.5	0.1	81
	12-18	5	6.5	0.05	83
	18-24	6	6.5	0.0	82
SED-203	0-6	60	6.3	1.0	68
	6-12	21	1.7	0.8	75
	12-18	13	0.9	0.2	64
	18-24	5	0.3	0.05	79
SED-204	0-6	50	5.1	1.0	68
	6-12	200	16.2	8.30	45
	12-18	4	0.3	0.12	82
	18-24	6	0.5	0.036	80
SED-205	0-6	55	5.2	0.98	70
	6-12	13	1.2	0.60	82
	12-18	4	0.5	0.25	75
	18-24	6	0.4	0.38	91
SED-206	0-6	27	2.6	0.67	82
	6-12	17	1.3	0.35	85
	12-18	7	6.5	0.17	76
	18-24	7	0.5	0.14	80
SED-207	0-6	159	15.4	10.5	46
	6-12	244	21.1	8.1	51
	12-18	4	0.4	0.05	78
	18-24	490	34.7	5.96	57
SED-208	0-6	45	5.8*	0.88	75
	6-12	35	3.6	1.3	76
	12-18	24	2.5	0.74	78
	18-24	104	11.0	3.70	68
SED-209	0-6	738	62.0	0.71	89
	6-12	19	1.5	0.80	87
	12-18	23	2.5	0.19	87
	18-24	392	18.3	5.47	57
SED-210	0-6	143	12.8	0.31	83
	6-12	25	2.3	0.34	81
	12-18	168	9.1	4.76	67
	18-24	19	1.0	0.30	78

See notes on Page 2 of 2

TABLE 2

Former Malden MGP Site
Malden River -- Malden, Massachusetts

November 2006 Data Summary

NOTES:

Total PAHs are the sum of the concentrations listed in Table 1.
The detection limit was used where the compound was not detected

mg/kg = milligram per kilogram

cPAHs = sum of "carcinogenic" PAHs

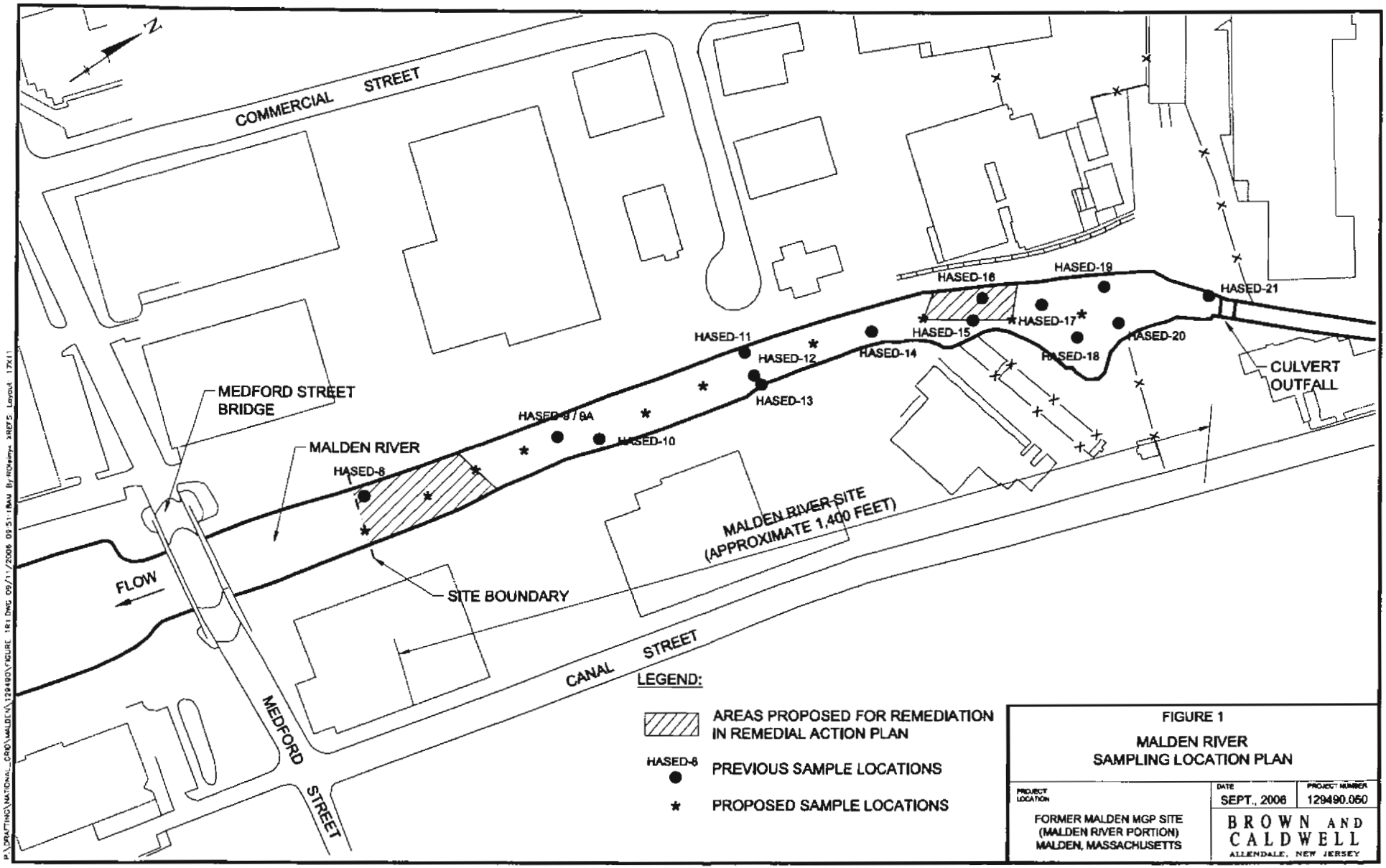
TOC = total organic carbon

% = percent

* denotes average of duplicate samples

Samples were collected in November 2006.

FIGURES


N
COMMERCIAL STREET
HASED-16
HASED-19
HASED-21
HASED-17
HASED-15
HASED-20
HASED-18
HASED-11
HASED-12
HASED-14
HASED-13
HASED-9 / 9A
HASED-10
HASED-8
MEDFORD STREET BRIDGE
MALDEN RIVER
CULVERT OUTFALL
MALDEN RIVER SITE (APPROXIMATE 1,400 FEET)
FLOW
SITE BOUNDARY
CANAL STREET
MEDFORD STREET
LEGEND:
AREAS PROPOSED FOR REMEDIATION IN REMEDIAL ACTION PLAN
HASED-8 PREVIOUS SAMPLE LOCATIONS
PROPOSED SAMPLE LOCATIONS
FIGURE 1
MALDEN RIVER
SAMPLING LOCATION PLAN
PROJECT LOCATION
FORMER MALDEN MGP SITE
(MALDEN RIVER PORTION)
MALDEN, MASSACHUSETTS
DATE
SEPT., 2006
PROJECT NUMBER
129490.060
BROWN AND CALDWELL
ALLENDALE, NEW JERSEY

ATTACHMENT A

SEDIMENT CORE LOGS

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-201**

Project:	Malden River	Project No:	131599
Client:	National Grid	Start Date:	11/8/2006
		Finish Date:	11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test: (cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade:	NA
TWC:	NA
TPC:	NA
Lat:	42° 25.1148 N
Long:	71° 04.3985 W

Geophysical Log: yes no X

Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	SAMPLE DATA Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	5.2' of Water							
					NT	NT	0-0.5' - Dark brown, fine to coarse sand with organics and a petroleum odor	1. 0-6" sample collected
					NT	NT	0.5-1' - Dark brown, fine sand and silt with a petroleum odor	2. 6-12" sample collected *MS/MSD sample collected*
1			1	2	NT	NT	1-1.5' - Tan, fine to medium sand with some coarse sand and a large rock in core. Slight petroleum odor.	3. 12-18" sample collected
					NT	NT	1.5-2' - Gray, fine sand and silt with trace clay. No odor	4. 18-24" sample collected
2								Samples @ 0810
	End of Boring							
3								

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-202** *Page 1 of 1*

Project:	Malden River	Project No:	Start Date: 11/8/2006
Client:	National Grid	131599	Finish Date: 11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test:	NA
(cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade: NA
TWC: NA
TPC: NA
Lat: 42° 25.1316 N
Long: 71° 04.4033 W

Geophysical Log: yes no X
Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	4.8' of Water	SAMPLE DATA						
					NT	NT	0-0.3' - Dark brown, fine to medium sand and organics	1. 0-6" sample collected **Dup 01 collected**
					NT	NT	0.3-0.5' - Dark brown, fine to coarse sand with a petroleum odor	2. 6-12" sample collected
1			1	2				3. 12-18" sample collected
					NT	NT	0.5-2' - Tan, medium to coarse sand with some fine sand and no odor or staining	4. 18-24" sample collected
2								Samples @ 0825
	End of Boring							
3								

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-203**

Project:	Malden River	Project No:	Start Date: 11/8/2006
Client:	National Grid	131599	Finish Date: 11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test: (cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade:	NA
TWC:	NA
TPC:	NA
Lat:	42° 25.1448 N
Long:	71° 04.4064 W

Geophysical Log: yes no X

Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	4.7' of Water							
					NT	NT	0-0.5' - Dark brown, fine sand and organics with a slight petroleum odor	1. 0-6" sample collected
1			1	2				2. 6-12" sample collected
					NT	NT	0.5-2' - Tan, medium to coarse sand with some fine sand. Bands of dark brown/black sand with a petroleum odor and a slight sheen at 1' depth	3. 12-18" sample collected
								4. 18-24" sample collected
2								Samples @ 0740
	End of Boring							
3								

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-204** *Page 1 of 1*

Project:	Malden River	Project No:	131599
Client:	National Grid	Start Date:	11/8/2006
		Finish Date:	11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test:	NA
(cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade:	NA
TWC:	NA
TPC:	NA
Lat:	42° 25.1575 N
Long:	71° 04.4073 W

Geophysical Log: yes no X

Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	4.2' of Water							
					NT	NT	0-0.5' - Dark brown, fine sand with some sitl and organics. No odor	1. 0-6" sample collected
					NT	NT	0.5-1' - Dark brown, fine sand and silt with a petroleum odor	2. 6-12" sample collected
1			1	2				3. 12-18" sample collected
					NT	NT	1'-2' - Tan, fine to coarse sand with some staining from 12-16". Petroleum odor present.	4. 18-24" sample collected
2								Samples @ 0750
	End of Boring							
3								

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-205**

Project:	Malden River	Project No:	131599
Client:	National Grid	Start Date:	11/8/2006
		Finish Date:	11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test:	NA
(cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade:	NA
TWC:	NA
TPC:	NA
Lat:	42° 25.1879 N
Long:	71° 04.4087 W

Geophysical Log: yes no X

Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	4.1' of Water							
1			1	1.8	NT	NT	0-1.5' - Dark brown, fine to medium sand with patches of gray/dark gray staining. A petroleum odor present	1. 0-6" sample collected
								2. 6-12" sample collected
								3. 12-18" sample collected
					NT	NT	1.5-1.8' - Coarse to very coarse gravel with trace fine to medium sand, no odor	4. 18-24" sample collected
2					NT	NT	Refusal at 1.8'	Samples @ 0835
	End of Boring							
3								

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-206** *Page 1 of 1*

Project:	Malden River	Project No:	131599
Client:	National Grid	Start Date:	11/8/2006
		Finish Date:	11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test:	NA
(cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade: NA
TWC: NA
TPC: NA
Lat: 42° 25.2046 N
Long: 71° 04.4116 W

Geophysical Log: yes no X
Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	4.2' of Water							
1			1	1.8	NT	NT	0-1' - Dark brown, fine to coarse sand with some organics at top, trace gravel, and a slight petroleum odor	1. 0-6" sample collected *MS/MSD sample collected*
								2. 6-12" sample collected
					NT	NT	1-1.8' - Light gray clay; Clay with some trace gravel and coarse sand, no odor	3. 12-18" sample collected
								4. 18-24" sample collected
2							Refusal at 1.8'	Samples @ 0900
	End of Boring							
3								

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-207** *Page 1 of 1*

Project:	Malden River	Project No:	131599
Client:	National Grid	Start Date:	11/8/2006
		Finish Date:	11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test:	NA
(cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade:	NA
TWC:	NA
TPC:	NA
Lat:	42° 25.2326 N
Long:	71° 04.4143 W

Geophysical Log: yes no X

Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	5.2' of Water							
					NT	NT	0-0.5' - Dark brown, fine to medium sand with organics and a slight petroleum odor	1. 0-6" sample collected
					NT	NT	0.5-1' - Dark brown, fine sand and silt with organics and a slight petroleum odor	2. 6-12" sample collected
1			1	2	NT	NT	1-1.5' - Tan, medium to coarse sand with patches of dark staining and a slight petroleum odor	3. 12-18" sample collected
					NT	NT	1.5-2' - Gray clay with patches of staining and a petroleum odor. Very soft clay	4. 18-24" sample collected
2								Samples @ 0915
	End of Boring							
3								

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-208** *Page 1 of 1*

Project:	Malden River	Project No:	131599
Client:	National Grid	Start Date:	11/8/2006
		Finish Date:	11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test: (cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade: NA
TWC: NA
TPC: NA
Lat: 42° 25.2604 N
Long: 71° 04.4122 W

Geophysical Log: yes no X
Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	3.8' of Water							
1			1	2	NT	NT	0-1.5' - Dark brown/gray, fine to coarse sand with a slight petroleum odor	1. 0-6" sample collected **Dup 02 collected** 2. 6-12" sample collected 3. 12-18" sample collected
2					NT	NT	1.5-1.8' - Coarser sand with some organics and a stronger petroleum odor. No sheen observed.	4. 18-24" sample collected Samples @ 0925
3	End of Boring							

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-209** *Page 1 of 1*

Project:	Malden River	Project No:	131599
Client:	National Grid	Start Date:	11/8/2006
		Finish Date:	11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test:	NA
(cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade:	NA
TWC:	NA
TPC:	NA
Lat:	42° 25.2818 N
Long:	71° 04.4042 W

Geophysical Log: yes no X

Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	2.9' of Water							
1			1	2	NT	NT	0-1.5' - Brown, medium to coarse sand wth trace fine sand and a light petroleum odor	1. 0-6" sample collected 2. 6-12" sample collected 3. 12-18" sample collected
2					NT	NT	1.5-1.8' - Fine sand with trace silt and organics. A petroleum odor present.	4. 18-24" sample collected Samples @ 0935
3	End of Boring							

BROWN and CALDWELL

Subsurface Boring Log

Well Name / Location: **Sed-210** *Page 1 of 1*

Project:	Malden River	Project No:	131599
Client:	National Grid	Start Date:	11/8/2006
		Finish Date:	11/8/2006

DRILLING DATA

Geologist:	Stephanie Root
Contractor:	TG&B
Equipment:	25' pontoon boat
Method:	Push core/Vibra Core

SAMPLING METHODS

	Sampler	Tube	Core
Type:			
Diameter:			
Other:			

WELL CONSTRUCTION

	Riser	Screen
Material:	NA	NA
Diameter (ID):	NA	NA
Coupling:	NA	NA

WELL DEVELOPMENT

Method:	NA
Duration:	NA
Gals. Purged:	NA
Slug Test:	NA
(cm / sec)	NA

SURVEY DATA

DATUM: NAD 83

Grade: NA
TWC: NA
TPC: NA
Lat: 42° 25.2977 N
Long: 71° 04.4009 W

Geophysical Log: yes no X
Comments:

depth (ft)	WELL CONSTRUCTION	soil / rock	Samp. No. / Run No.	Rec. (ft)	Penetrometer kg/cm²	Vane Shear kg/cm2	VISUAL CLASSIFICATION	REMARKS
0	1.5' of Water							
1			1	2	NT	NT	0-1' - Dark brown/dark gray, medium to coarse sand with trace fine sand and a slight petroleum odor	1. 0-6" sample collected
								2. 6-12" sample collected
					NT	NT	1-2' - Dark brown, fine to medium sand with a slight petroleum odor	3. 12-18" sample collected
								4. 18-24" sample collected
2								Samples @ 0945
	End of Boring							
3								

ATTACHMENT B

SEDIMENT ANALYTICAL DATA SHEETS


Former Malden MGP Site -
Malden River Portion
Response Action Outcome Partial Statement
WSC00443 B14
June 2007
Attachment to Appendix A
Sediment Analytical Data Sheets
BROWN AND CALDWELL

APPENDIX B

DEVELOPMENT OF REMEDIAL ACTION GOAL

APPENDIX B
Response Action Outcome – Partial Statement
Former Malden MGP Site
(Malden River Portion) – Malden, Massachusetts

DEVELOPMENT OF REMEDIAL ACTION GOAL

1 Overview

This Appendix documents the risk evaluation process that was relied upon to select a remedy for the Malden River portion of the Former Malden Manufactured Gas Plant (MGP) Site located in Malden, Massachusetts. It was prepared as a supporting document to the Response Action Outcome Partial (RAO-P) for the river portion of the site. The overall framework was based on the Method 3 Risk Characterization (RC) that was completed by AMEC Earth and Environmental (AMEC) as part of the Phase II CSA (Haley & Aldrich, 2001). A site-specific sediment cleanup goal was calculated using the methodologies from the Method 3 RC. Based on a literature review, two of the variable values originally used in the Method 3 RC were refined in the Phase III Remedial Action Plan (RAP) (Brown and Caldwell, 2006). A Substantial Hazard Evaluation for the Malden River portion of the Site was also completed as part of the Phase III RAP. Both sediment toxicity and fish ingestion were also evaluated to determine which was more appropriate for use in developing a sediment remedial action goal.

The sediment toxicity tests performed as part of the Method 3 RC were inconclusive because effects were small and inconsistent, and there was no relationship to measured contaminants. A review of the literature confirmed that the variables controlling polynuclear aromatic hydrocarbon (PAH) toxicity to benthic life are complex and that therefore it cannot be assumed that PAHs present at specific concentrations would be toxic. Sediment toxicity results could therefore not be relied upon to develop a defensible remedial action goal for the site.

The chemicals predicted to be responsible for the greatest portion of risk are carcinogenic PAHs (cPAHs). The fish bioaccumulation pathway is based on a quantitative relationship between sediment and cPAHs which can be used to predict impacts. This pathway was therefore used by Brown and Caldwell to develop the sediment cleanup goal of 31 mg/kg cPAHs for the Malden River portion of the Site. Using these data, both the Method 3 RC and Substantial Hazard Evaluation were revisited, and the conclusions in the Phase III RAP remained unchanged.

Based on a comparison of the remediation goal to Site concentrations, the RAP concluded that a Permanent Solution can be achieved through implementation of No Further Remedial Action in the River, with a Class A-2 Response Action Outcome. Additional field data collected in November 2006 supported this previous conclusion. Additional information on the development of the remedial action goal and selection of the remedy is presented below.

2 Background

The Method 3 RC prepared by AMEC included the following pathways that pertain to the Malden River portion of the Site:

Human Health

- Incidental ingestion of sediment and surface water
- Dermal contact with sediment and surface water
- Ingestion of Fish

Ecological Health

- Direct Contact with Surface Water and Sediment by Benthic Macroinvertebrates and Fish
- Consumption of Aquatic Prey by Birds

To avoid underestimating risk, detected analytes including volatile organic compounds (VOCs), volatile petroleum hydrocarbons (VPH), semivolatile organic compounds (SVOCs), extractable petroleum hydrocarbons (EPH), and inorganic elements, were assessed as Chemicals of Concern (COCs). This list of COCs included those typical of MGPs, notably PAHs and some VOCs. Since physiologically available cyanide (PAC) was not detected in surface water or sediment, cyanide was excluded as a COC.

The Method 3 RC found a condition of No Significant Risk associated with human health direct contact pathways (incidental ingestion and dermal contact with surface water and sediment). However, a condition of No Significant Risk was not concluded for exposure to cPAHs via fish ingestion. The fish ingestion risks, to both humans and birds (heron), were based on assumptions of cPAH bioaccumulation from sediment into fish. The fish bioaccumulation-related endpoints were identified by AMEC as the risk pathways of principal concern ("risk drivers"). In addition, AMEC identified a potential hazard to invertebrates living in direct contact with sediments as a secondary risk pathway of concern. This hazard was based on the results of sediment toxicity tests.

The pathways addressed by AMEC and the general risk assessment methodologies represent a complete overall assessment of human and environmental risk consistent with the Massachusetts Contingency Plan – CMR 40.0000 (MCP). Brown and Caldwell checked the calculations involved in the risk driver pathway identified for cleanup goal development. We found that the conclusion of No a Significant Risk, based on direct contact pathways, appears to be justified.

Brown and Caldwell also reviewed the risk pathways (those for which a conclusion of No Significant Risk was not concluded by AMEC in the Method 3 RC) to select an appropriate endpoint on which to base a potential sediment cleanup goal. To provide a basis for quantitative cleanup goal development, a risk pathway must:

- Present an observed or predicted hazard that is related to the Site; and

- Show a quantitative relationship between Site contaminants of concern (COCs) and risk.

The two exposure mechanisms identified in the Method 3 RC as potentially associated with risk (fish bioaccumulation and sediment toxicity) were assessed in detail to assess the appropriateness of each to serve as a basis for developing a potential cleanup goal. As demonstrated below, the fish ingestion pathway was determined to be more appropriate and was used to develop a goal for potential remediation.

3 Direct Contact by Invertebrates with Sediments

AMEC performed 10-day sediment toxicity tests for growth and survival endpoints in both midge larvae (*Chironomus tentans*) and amphipods (*Hyalella azteca*). These tests were run on nine sediment samples from the Malden River (eight stations and one duplicate) and three samples from the Mystic River. No statistically significant decrease in growth or survival in midge was reported. AMEC identified a small but statistically significant decrease in survival in the amphipods in tests from seven Malden River stations and in growth from one Malden River station (SED-3).

Because the effects on amphipods were small and variable, the results are inconclusive. The lowest survival rate in amphipods was 67% in sample SED-6; however, the duplicate from that station had 85% survival, which is not statistically different from the control. The control survival criterion in the United States Environmental Protection Agency (USEPA) method for these tests is 80% (USEPA, 2000a). The one instance of statistically significant reduced amphipod growth was 0.037 mg total average weight gain in the SED-3 sample, 85% of the control growth of 0.044 mg. Sample SED-2 had a slightly lower growth than SED-3 (0.034 mg) but was not statistically different from the control.

The variability and inconsistency in these data sets is typical of this type of testing. For this reason, researchers and agencies have developed statistical criteria based on large-scale data review. Phillips *et al.* (2001) calculated minimum significant difference values for marine amphipod tests and identified 77% as the survival threshold for significance. They contrast this value with the even more conservative threshold of 64% used by the California Bay Protection and Toxic Cleanup Program (CBPTCP). This threshold is lower than the lowest survival seen in the Malden River data set. Because the CBPTCP threshold is for a marine species, it may not be directly applicable to the Malden River study; however, it does illustrate that the level of difference from control observed in the AMEC study does not necessarily represent a concern in these types of tests.

Assuming that the small survival effects are representative of actual sediment toxicity, we reviewed the analytical data to determine whether any particular chemical characteristics might account for the survival variation. Figures 1 and 2 show the benthic invertebrate survival rates as a function of individual PAH compounds. There is no apparent correlation between concentration and survival rates for any of the compounds. Therefore, the slight reduction in amphipod survival exhibited at these stations is not attributable to the concentrations of PAHs in the sediment. In fact, the stations with the

higher PAH levels, AMEC SED-3 and AMEC SED-7, showed among the highest midge survival rates (88% and 90% respectively). A similar lack of correlation was observed for extractable petroleum hydrocarbons (EPH), as shown on Figure 3. Station AMEC SED-6 exhibited EPH levels in the range of other locations, and well below the maximum observed at AMEC SED-8.

In addition to PAHs, inorganics (metals and ammonia) were compared to benthic invertebrate survival rates (Figures 4a and 4b). These figures show that none of the analytes, with the possible exception of cadmium, shows a relationship to amphipod and midge survival. Cadmium is not a constituent of concern at the Site as it was present at very low concentrations in sediments (the exposure point concentration developed in the Method 3 RC for cadmium was 1.64 mg/kg). At SED-5, the station with less than 70% midge survival, the cadmium concentration is higher compared to the other stations (Figure 3). It is, however, unlikely that the reduced survival rate at that station is due to the presence of cadmium given that the freshwater sediment screening criterion for cadmium is 5 mg/kg (MADEP, 2006a) and the SED-5 cadmium concentration is 3 mg/kg. Therefore, the slight impacts on amphipod survival at this location cannot be linked to the inorganics tested in the sediment. These conclusions are supported by the result of the acid volatile sulfide/simultaneously extractable metal (AVS/SEM) data collected in the Phase II CSA, which indicated that metals in Site sediments are not bioavailable (Table XIII of the Phase II CSA report).

The absence of a relationship between PAH concentrations and toxicity is not unexpected. The USEPA (2000a) has noted that "bulk sediment concentrations have not been strongly correlated to bioavailability." A large number of studies and analyses have been attempted to elucidate the toxicity mechanisms of PAHs. Phototoxicty appears to be an important induction mechanism (Ankley *et al.*, 1995; Kosian *et al.*, 1998; Swartz, 1999; Vo *et al.*, 2004). Some studies correlate increasing toxicity with metabolites (Gewurtz *et al.*, 2000; Rust et *al.*, 2004), increasing molecular weight (Field *et al.*, 2002; Fleeger and Lotufo, 1999), or increased octanol/water partitioning/decreased water solubility (Lee *et al.*, 2004). However, Fay *et al.* (2000) reported that the highly insoluble PAHs benzo(a)pyrene (BaP) and benzo(a)anthracene (BaA) were not acutely toxic to amphipods up to maximum concentrations of 43 mg/kg and 1280 mg/kg, respectively. In contrast, the highest concentrations observed in Malden River sediments were 4.19 mg/kg BaP and 7.76 mg/kg BaA[1].

Since bioavailability is a key factor in toxicity (Driscoll *et al.*, 1997; Fay *et al.*, 2000; Sundelin *et al.*, 2004), insoluble compounds often manifest functionally low toxicity *in situ* because of low bioavailability. In fact, the current USEPA Equilibrium Partitioning Sediment Benchmark (ESB) guidance (USEPA, 2003) assumes that PAHs adsorbed to sediment are not bioavailable and estimates the partitioning of each PAH compound from sediment to pore water based on solubility. Using the hierarchy in the USEPA model, the most toxic of the PAHs analyzed in Malden River sediments are naphthalene,

[1] Only the 2001 AMEC data are considered here because they correlate specifically with the sediment toxicity stations. These data are similar to those from investigations by Haley & Aldrich (2001) and Brown and Caldwell (2006).

acenaphthylene, acenaphthene, fluorene, and phenanthrene. Driscoll *et al.* (1997) examined the toxicity of one of these compounds, fluoranthene, to *H. azteca* in spiked sediments and reported a statistically significant decrease in survival at 30 days at a measured sediment concentration of 876 nmol/g (equivalent to 175 mg/kg) and a small but not significant decrease at 392 nmol/g (78 mg/kg). These concentrations are significantly greater than the maximum fluoranthene observed in Malden River sediments (16 mg/kg), which would support the interpretation that the level of this PAH present in sediment in the Malden River portion of the Site area are not in the toxic range.

In situ toxicity may in fact be even lower than reported in the above studies, since spiked sediment studies can overestimate bioavailability. Biota sediment accumulation factors (BSAFs) from field data are generally much lower than for spiked data (Sundelin *et al.*, 2004). Gewurtz *et al.* (2000) measured benthic invertebrate and sediment PAH concentrations in a freshwater lake with the sum of 12 PAHs totaling 43 mg/kg and found very little accumulation in amphipod tissue (2.3 mg/kg). The more insoluble PAHs (BaP, BaA, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, dibenz(a,h,)anthracene, and benzo(g,h,i)perylene) were undetected in tissue. The authors predicted low toxicity since metabolism of PAHs, the mechanism of toxicity, can only occur if the compounds are first accumulated by the organisms.

The form of the carbon associated with PAHs in sediments appears to be critical and can explain why PAHs well above background levels may not be toxic. The presence of so-called "back carbon," pyrogenic PAHs formed as a result of incomplete combustion of fuels that enter the environment highly sorbs to particulate matrixes (Thorsen *et al.*, 2004), significantly reduces bioavailability (Sundelin *et al.*, 2004; Thorsen *et al.*, 2004) and can result in a large overestimate of bioavailability based on bulk concentrations (Swartz, 1999). Naes *et al.* (1998) reported that black carbon can increase adsorption (decrease bioavailability) by an order of magnitude. Because of this extra sorption, PAHs of pyrogenic origin are less bioavailable than those of petrogenic origin (petroleum derived). For MGP-derived PAHs, weathered pitch may play a similar and even greater role than black carbon in limiting bioavailability. Since PAHs derived from MGP may consist of 70 to 95% pitch, this carbon fraction is a major determinant of desorption, and hence bioavailability and toxicity (Khalil *et al.*, 2006).

Even assuming that the small effect on amphipod survival represents a real (if variable) effect, MGP residuals (which are largely pyrogenic, or combustion derived) may not be the cause. Because of the different environmental behavior of pyrogenic and petrogenic (petroleum-derived) PAHs, the source of PAHs is also a key predictor of bioavailability and toxicity. A variety of investigators have developed ratios based on different PAH species to characterize source (Carls *et al.*, 2006; Costa *et al.*, 2004; Sanders *et al.*, 2002; Zeng and Vista, 1997; Zhang *et al.*, 2005).

As part of the Phase II CSA, Haley and Aldrich submitted 21 sediment samples to Arthur D. Little (ADL) for contamination character signatures, including saturated hydrocarbons (alkanes), sterane-triterpane biomarkers, and oxygen-, nitrogen- and sulfur-containing PAHs, and decalins/substituted decalins (Tables XIV through XIX of the

Phase II CSA report). A brief discussion of these results and graphs of selected samples are presented in Appendix O of the Phase II CSA report. ADL concluded that the majority of samples reflect a coal tar composition, as opposed to petroleum. However, sample HASEC-10-S4, which contained among the highest total PAH concentrations observed in Site sediments (over 1,200 ppm target compound list PAHs), showed a mixed petroleum and coal tar profile.

Based on the ratios presented by Brändli *et al.* (2006), the PAHs in sediment at the Malden Site associated with the toxicity tests appear to derive from mixed vehicular, petrogenic, and pyrogenic sources. The ratios are shown in Table 1. This finding is consistent with other studies that have found PAHs in the vicinity of MGP sites to be derived from multiple sources (Saber *et al.*, 2006), even primarily urban background sources (Costa *et al.*, 2004). Urban stormwater is the major contributor of high-molecular weight PAHs to urban areas (Menzie *et al.*, 2002; McCarthy, 2003).

The Malden River portion of the Site is highly urbanized and is known to have received PAH input from multiple sources. For example, more than 25,000 gallons of fuel oil were released at the former Rohm Tech facility which was located on the south bank of the Malden River portion of the Site. In addition, flow at the headwaters of the Malden River is from the Malden River culvert, which receives stormwater runoff from a highly urbanized area. Petroleum sources such as diesel fuel are more toxic than individual PAHs (Fleeger and Lotufo, 1999). Sample SED-6 was collected adjacent to the Rohm Tech facility, near to petroleum-impacted station HA-SED-10-S4. This location is very close to the sediment toxicity station SED-6 itself, which had equivocal sediment toxicity results. Although SED-6 itself had relatively low PAH concentrations, it is possible that the area reflects impacts due to PAH species not analyzed by AMEC, notably alkylated PAHs.

The toxicity of petrogenic PAHs has been linked to alkylated PAHs (Fleeger and Lotufo, 1999; Kosian *et al.*, 1998; Thorsen *et al.*, 2004; Yaorong *et al.*, 2001). Analysis for alkylated PAHs was performed by ADL as part of the Phase II CSA. Although the results themselves do not appear in the Phase II CSA Report, selected profiles presented graphically indicate that parent compounds dominate. The exception is Station HASEC-10-S4, which shows alkylated compounds reflecting petroleum sources. Overall, however, the Site sediments show a pattern of greater concentrations of parent compounds, which are associated with lower toxicity than sediments containing a predominance of alkylated PAH species.

There is widespread PAH contamination in the Mystic River Basin, which includes the Malden River, with multiple, non-MGP sources present. The USEPA and the Massachusetts Department of Environmental Protection (MDEP) launched a program designed to improve water quality in the Mystic/Alewife Basin by eliminating illegal sewer discharges and improving the quality of storm water discharges (USEPA, 1998). An extensive bottom sediment study completed between 2001 and 2003 shows that deposition of PAHs has substantially declined over the past 50 years. Although PAH concentrations increase with depth, the top few centimeters of the sediment remain

elevated above background (Breault *et al.*, 2005). The findings that fluoranthene was the most commonly detected PAH and naphthalene the least commonly detected is consistent with the AMEC sediment data, which exhibited a high ratio of fluoranthene to naphthalene (Table 1).

Based on the above evaluations of Site sediment data, the results of toxicity test results presented in the Method 3 RC, and a review of PAH toxicity in the literature, Brown and Caldwell made the following conclusions:

- The results of the AMEC sediment toxicity tests are inconclusive.
  - Reported decreases in survival were relatively small and are within the range considered to be equivalent to control based on statistical analysis of large data sets.
  - Statistically significant findings on amphipod survival were not replicated in the duplicate pair, one sample of which showed the lowest survival.
- There was no relationship between contaminant concentrations and amphipod survival.
- The presence of multiple PAH sources in the Mystic River basin and the Malden River portion of the Site do not allow an association between toxicity (if any) of collected sediments and particular PAH sources. In particular, MGP-derived PAHs are likely to exhibit lower toxicity than PAHs from documented non-Site sources, such as oil spills.

For these reasons, the sediment toxicity endpoint is unconfirmed and is considered inappropriate as a basis for developing a potential sediment cleanup goal. The lack of a relationship between sediment concentrations and observed sediment toxicity test results also precludes use of these data in establishing the cleanup goal for sediments.

4 Bioaccumulation Through Fish Ingestion

Both the human health and environmental risk assessments indicated the potential for specific sediment contaminant-related impacts based on food chain exposure. The risks that exceeded the MADEP benchmarks of 10^{-5} cancer risk or 1.0 hazard index (humans or wildlife) in the Method 3 RC from the Phase II CSA are summarized below.

Receptor	Pathway	Carcinogenic Risk or Hazard	Ratio of Risk/Hazard to Benchmark	Constituents with Individual Risks/Hazards Above Benchmarks
Recreational fisher (adult and child)	Fish ingestion	2E-03 (risk)	2,000	Benzo(a)anthracene (BaA); benzo(a)pyrene (BaP); Benzo(b)-fluoranthene (BbF); Dibenzo(a,h,)anthracene (DahA); Indeno(1,2,3-

Receptor	Pathway	Carcinogenic Risk or Hazard	Ratio of Risk/Hazard to Benchmark	Constituents with Individual Risks/Hazards Above Benchmarks
				cd)pyrene (I123cdP)
Great blue heron	Fish Ingestion	6E+02[2] (haz)	600	BaA; BaP; BbF; benzo(g,h,i)perylene (BghiP); DahA; Benzo(k)fluoranthene (BkF); Chrysene; I123cdP
Mallard duck	Diet/sediment ingestion	2E+00	2	BbF

The calculated Phase II CSA Method 3 RC risks over benchmarks to both humans and wildlife were driven by cPAHs. The pathway which had the highest calculated risk in the Phase II evaluation relative to acceptable limits was fish ingestion in humans due to carcinogenic risk (2,000-fold over the acceptable MADEP limit of 10^{-5}, or one in one hundred thousand). The highest ecological risk, a hazard quotient of 600, was also due to fish ingestion. Therefore, a cleanup goal was developed by Brown and Caldwell for cPAHs in sediments. Because the fish ingestion pathway in humans represented the highest risk, this pathway served as the basis for the cleanup goal calculation. Since cPAHs represented all of the potential unacceptable risk associated with Malden River sediments, based on the results of the Method 3 RC, the sediment goal based on human fish ingestion will be protective of all human and ecological receptors exposed to media in the River. Since the Method 3 RC indicated that human health risks other than fish ingestion were negligible compared with the fish ingestion pathway, it was not necessary for other pathways to be considered in the sediment cleanup goal development.

4.1 Calculations

The Phase II risk assessment used conservative default assumptions. The cleanup goal development in the Phase III RAP relied on the risk algorithms used in the original Phase II CSA Method 3 RC. However, additional research on two critical factors related to the risk drivers (PAHs) was performed and the risk variables were updated. The human health risk algorithms from the Method 3 RC were as follows:

$$ELCR = ADD \times CSF$$

$$C_F = \frac{C_S \times BSAF \times L_F}{fOC}$$

$$ADD = \frac{C_F \times IR \times FI \times EF \times ED \times C}{BW \times AP}$$

Where:

[2] Based on the 0-6-inch sediment interval for consistency with the human health risk characterization.

ELCR	=	Excess lifetime cancer risk (unitless)
ADD	=	Average daily dose in milligram per kilogram – day (mg/kg-day)
CSF	=	Carcinogenic slope factor $(mg/kg\text{-}day)^{-1}$
C_F	=	OHM concentration in fish (mg/kg; wet weight)
C_S	=	OHM concentration in sediment (mg/kg; dry weight)
BSAF	=	Biota Sediment Accumulation Factor (kgOC/kg lipid)
fOC	=	Fraction organic carbon (unitless)
L_F	=	Fish lipid concentration (kg lipid/kg fish)
IR	=	Ingestion rate of fish (g/day)
FI	=	Fraction of fish ingestion from Site (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AP	=	Averaging period (days)
C	=	Conversion factor (kg/g)

The cleanup goal was derived by combining and inverting these equations to solve for C_S. To use the algorithms to set one cleanup goal that considers the additive effects of children and adults, the adult and child body weights, and fish ingestion rates were combined per United States Environmental Protection Agency (USEPA) guidance to derive a lifetime age-adjusted fish ingestion rate:

$$IR_{adj} = \left(IR_C \times {ED_C}/{BW_C} \right) + \left(IR_A \times {ED_A}/{BW_A} \right)$$

Where:

IR_{adj}	=	Age-adjusted ingestion rate of fish (kg fish-year/kg body weight-day)
IR_C	=	Child ingestion rate of fish (kg fish/day)
IR_A	=	Adult ingestion rate of fish (kg fish/day)
ED_C	=	Child exposure duration (years)
ED_A	=	Adult exposure duration (years)

The final cleanup goal algorithm is:

$$C_S = {(AP \times fOC \times ELCR)}/{(BSAF \times L_F \times IR_{adj} \times FI \times EF \times CSF)}$$

Table 2 presents the values for each of the variables.

4.2 Risk Variables

All variable values used in the cleanup goal development were MADEP or USEPA defaults except for the Biota-Sediment Accumulation Factor (BSAF) and fish ingestion rates. Discussion of values selected for each of these variables is presented below.

4.2.1 Biota-Sediment Accumulation Factor (BSAF)

A critical assumption used in the risk evaluation to estimate fish tissue concentrations was the value for BSAF. The BSAF used in the Phase II RC was a lipid- and organic carbon-normalized value of 0.29 (USEPA, 1997). Exposures were calculated assuming 3% lipid in fish tissue and 2% organic carbon (OC) in sediment, which calculates to an actual dry weight-based fish-to-sediment ratio of 0.44. The BSAF of 0.29 is the 50th

percentile statistic from a USEPA database, which, according to the USEPA (1997) document, was originally released in an internal 1995 USEPA memorandum. Although the actual BSAF values underlying the statistic are not available, USEPA states that the data were from benthic animals.

Studies have documented PAH accumulation in benthic animals (Hyotylainen *et al.*, 2002; Millward *et al.*, 2001; Brunson *et al.*, 1998; Kukkonnen *et al.*, 2004; Travey and Hansen, 1996). The United States Army Corps of Engineers (USACE) (2006) maintains a comprehensive BSAF database, with the studies cited by the database focusing almost exclusively on benthic invertebrates. The reported BSAF in the database for total PAHs in pooled organisms is 0.042 (dry weight based) with a pooled overall BSAF for BaP (the primary risk driver in the Malden River) of 0.03.

These values are approximately an order of magnitude below the BSAF of 0.29 used in the Phase II Risk Characterization. Furthermore, BSAFs to benthos over-predict uptake into fish. Benthos lives in direct contact with sediment, and many species feed by ingesting sediment, retaining sediment in their guts and thereby increasing empirical BSAFs. More important, fish are widely known to metabolize PAHs, thereby limiting accumulation (Eisler, 1987; McCarthy *et al.*, 2003; ATSDR, 1999, 1995). Specifically, rapid PAH metabolism occurs in teleost fish (Kolok *et al.*, 1996), which include virtually all food and game fish (Sportsmanschoice, 2006).

Since benthic-derived BSAFs cannot be used to reliably predict fish tissue concentrations, Brown and Caldwell performed a literature search to obtain representative BSAFs in fish. There is relatively little information in the literature on uptake of PAHs into fish, probably because fish uptake of PAHs is generally not of concern. A USEPA fish contaminant study of the Columbia River Basin (2002) detected little PAH presence in fish tissue. The cPAHs were only detected in the large-scale sucker (averaging 5 to 10 µg/kg [parts per billion or ppb] for each compound), with no detections in several other species analyzed. Sediment concentrations were not reported. A study of sediments and fish conducted by the Washington Department of Ecology (1999) did not even analyze for PAHs in fish, since the study was "limited to bioaccumulative chemicals." PAHs were measured in fish tissue from Chequamegon Bay by the Agency for Toxic Substances and Disease Registry (ATSDR) (1999). Despite their presence adjacent to an MGP Site and sediments contaminated with "substantial free-product PAHs," (Great Lakes Mid-Atlantic Center for Hazardous Substance Research, 2006), fish tissue samples were 200 to 10,000 times below health screening levels. No cPAHs or high-molecular weight PAHs were detected (with reporting limits in the low ppb range).

Adjacent to the Messer Street MGP Plant Site in Laconia, New Hampshire (New Hampshire Department of Health and Human Services, 2002), PAHs in fish tissue were reported to be hundreds of times below ATSDR Minimal Risk Levels (maximum of 2.5 ppb and 2.4 ppb for BaP and DahA, the only two cPAHs detected). Similarly, the New York State Department of Environmental Conservation (NYSDEC) (2000) reported that fish from Oneida Creek did not show elevated PAH presence compared with

background, although sediments were highly contaminated with PAHs (which were found in all sediment samples, up to 47,000 parts per million or ppm). The NYSDEC (2006) eliminated consideration of PAHs in the remedial action plan, and has concluded that "PAHs do not build up in edible tissues." The MADEP (2006) has stated that "because of their ability to metabolize and rapidly excrete PAHs, fish do not accumulate significant residues in muscle tissue."

The most relevant study identified in the literature for assessing fish BSAFs was completed by investigators from USEPA's Mid-Continent Ecology Division of the National Health and Environmental Effects Research laboratory (Burkhard and Lukasewycz, 2000), following an "extensive but unsuccessful literature search." The authors calculated BSAFs for several PAH compounds using field-measured sediment and lake trout tissue concentrations in the Lake Superior ecosystem. The calculated BSAF for BaA is 0.0054 kg OC/kg lipid (for chrysene/triphenylene, the BSAF is 0.00033 kg OC/kg lipid).

BaA and chrysene (with triphenylene) were the two cPAHs evaluated by Burkhard and Lukasewycz (2000). Of these, BaA is most appropriate for use at the Malden River Site because it is a more important risk driver than chrysene at this Site (chrysene did not have risks over MCP limits in the Phase II Risk Characterization), is generally more toxic (considered ten times more carcinogenic than chrysene), was measured as a single compound and not a mixture, and shows a higher (more conservative) BSAF from this study (thereby providing a protective bias). A BSAF of 0.0054 kg OC/kg lipid was therefore selected for the Malden River portion of the Site. Use of BaA as a proxy for predicting PAH accumulation in the Malden River fish is appropriate, since BaA is a high-molecular weight PAH (molecular weight = 228 g/mole). Higher-molecular weight PAHs drive risk since all the cPAHs are high molecular weight, and may show 10 to 100 times less bioconcentration than the lower-molecular weight, more soluble PAH species (Eisler, 1987). The uptake mechanism from sediment to biota reportedly occurs via partitioning from sediment to pore water (Eisler, 1987; Reible and Fleeger, 2004), with the kinetics of the rapidly desorbed portion most predictive of bioavailability (Kukkonen *et al.*, 2004). Uptake for higher-molecular weight, insoluble PAHs is therefore reduced by limited partitioning into the water column.

Overall, the scientific literature and various agency conclusions strongly support the position that cPAHs do not bioaccumulate and are rapidly metabolized by fish. The selected BSAF predicts a low level of tissue accumulation to allow the development of a quantitative cleanup goal from the fish ingestion pathway. It is unclear whether any PAH accumulation above background would be directly attributable to PAHs of MGP origin. Furthermore, BSAFs are also a function of sediment concentration, dropping as sediment PAH levels increase (Millward *et al.*, 2001), so BSAFs in heavily contaminated areas would be expected to be far lower than those predicted in the Lake Superior system with sediment PAHs in the ppb range. Using the average BaP concentration in Malden River sediments of 9.14 ppm, the average detected OC concentration of 6.34%, and the MADEP fish lipid estimate of 3%, the predicted fish tissue concentration is 23 ppb. This predicted fish tissue concentration is well above the levels that have been reported for

cPAHS in aquatic sites adjacent to other MGP Sites and is therefore a conservative estimate for the Malden River. It is also more than a hundred fold below the predicted BaP fish tissue concentration of 5.3 ppm that was used in the Phase II RC. As a result of recent literature reviews and additional studies, the 23 ppb concentration is very well supported relative to the 5.3 ppm.

The level of lipid in fish is an additional uncertainty with respect to the BSAF. Burkhard and Lukasewycz (2000) reported a fish lipid concentration of 20.5% (skinned and fat-trimmed fillets), which is several times above the MADEP value of 3% cited in the Phase II RC. Lower lipid values would be associated with lower empirical BSAFs. The actual lipid content in fish that could be caught in the Malden River is unknown. However, reported average edible fillet lipid levels in freshwater game fish (USEPA, 2002) range from around 1% (walleye) to around 6% (white sturgeon), with estimates in between for whitefish, sucker, and trout. Therefore, the MADEP estimate of 3% seems reasonable.

4.2.2 Fish Ingestion Rates

Human consumption rates for fish caught off the Medford Street Bridge used in the Phase II risk assessment were 12 g/day for adults and 8 g/day for children (multiplied by a Fraction Intake, or FI, of 0.25 to account for other fishing locations). The USEPA has estimated lower average intakes for freshwater anglers (8 g/day). A New York State angler survey (USEPA, 2000b) reported a 50th percentile ingestion rate of 4.0 g/day, and an upper-bound (90th percentile) rate of 32 g/day. Other surveys have also found that people release much of what they catch. An angler survey in Washington State (Washington Department Of Fish And Wildlife, 2004) reported that many recreational fishers throw back a substantial proportion of legal-sized fish that they catch (e.g., 42% for bass and 33% for carp). Overall, the statistics indicate that less than half of fish were retained. However, a large percentage of anglers did not release any legal fish of other species.

Overall, fish retention for consumption is variable and highly dependent on the species available and personal circumstances. "Subsistence" fishers typically addressed in risk scenarios might be expected to keep and eat most of what they catch. Since the published fish ingestion rates were reduced four-fold in the Phase II RC to account for fishing in other locations, no further adjustments to the fish ingestion rate were made as part of this cleanup goal development. These Site-specific ingestion rates (3 g/day for adults and 2 g/day for children) seemed reasonable and were retained for use in the cleanup goal development.

The quality of the habitat in this part of the river is relatively poor. Areas along the banks are lined with rip rap and steel sheeting. The water appeared to be stagnant during a Site visit in July 2005 and a docked boat suggests that there is propeller disturbance. The river appears to be limiting as a recreational resource due to poor access and no indication that game fish are present. The fish ingestion estimates from the Phase II RC can be considered upper-bound reasonable estimates of the fish ingestion that might actually occur.

4.2.3 Sediment Cleanup Goal

Applying the algorithms and variable values presented above, a sediment cleanup goal of 31 mg/kg total cPAHs was derived (Table 2 presents the values used in the calculations). That is, address those portions of the Malden River sediment that cause the overall average cPAHs concentration across the sediment surface to exceed 31 mg/kg. The PAHs that are considered carcinogenic by USEPA are BaA, BaP, BbF, BkF, chrysene, DahA and I123cdP. The toxicity of each of these compounds relative to BaP has been estimated by the USEPA and is reflected in a toxic equivalency factor or TEF. The TEFs for each of these compounds are 0.1, 1, 0.1, 0.01, 0.001, 1 and 0.1, respectively. The sum of the cPAHs in a given sample is determined by multiplying the concentration of each of the carcinogenic PAHs by its respective TEF and then summing each result. This procedure was followed for the sediment samples that were taken within the Site by Haley & Aldrich and BC. One-half the detection limit was used in the sum for samples where the compound was not detected.

5 Updated Human Health Risk Characterization

In addition to the updates presented above, the human health risks for the Malden River portion of the site were also recalculated. Risk and hazard calculations were revised using the updated information and are presented in Tables 4 through 7. The recalculation included the following:

- The Exposure Point Concentrations (EPCs) for PAHs in sediments were updated to include the result from the October 2006 sediment sampling. Consistent with the Method 3 HHRC, only data for the 0-6-inch sediment interval was included. The updated EPC calculation is shown in Table 3.
- The BSAF was adjusted to 0.0054 kg OC/kg lipid, as described in Section 4.2.1.
- The total organic carbon (TOC) concentration was changed from 0.015 kg OC/kg sed (the default value used in the Method 3 RC) to 0.0634 g OC/kg sed, the site-specific measured value from the October 2006 sampling event.
- Risks and hazards based on PAH accumulation in fish were updated by making the above adjustments to the sediment-to-fish tissue uptake.
- Risks and hazards due to accumulation of non-PAHs in fish were adjusted based on the updated carbon concentrations (Tables 5 and 7). The risk and hazard component based on bioconcentration from surface water was not modified, since TOC did not enter into those uptake estimates. The scaling of the risks is shown in Tables 5 and 7.
- Risks and hazards due to the four other exposure pathways for the River (incidental ingestion of, and direct contact with, surface water and sediment) were obtained directly from the Method 3 RC.
- Consistent with the Method 3 RC, risks and hazards for the five river-related pathways (fish ingestion plus direct contact) were summed. It is possible but conservative to assume that trespassers who could contact surface water and sediment as adolescent trespassers might be the same individuals who consume

fish over a lifetime. These individuals were not assumed to be upland trespassers in the non-river portions of the Site. In fact, as in the Method 3 RC, the fraction ingested (FI) from river sources for direct contact was set at 1 (100%) (i.e. all daily incidental contact occurs in the River) to avoid underestimating River exposure.

The revised carcinogenic risk for the Malden River portion of the site is 7E-6 (Table 4). The revised noncarcinogenic hazard is 0.3 (Table 6). These risks are below the applicable MCP risk limits and indicate that the Malden River portion poses No Significant Risk to human health.

Hazards to piscivorous birds were not recalculated, since the conclusions based on the estimated hazards in the Method 3 were equivocal. However, the updates reduced the estimate of fish tissue PAH concentrations more than 200-fold. Therefore, the estimated avian hazards (formerly in the range of 10) would be reduced comparably, confirming No Significant Risk.

6 Areas Subject to Remediation Remedial Approach

Under the MCP, risks are based on average concentrations throughout each exposure point area. Since sediment risks at the Site are related to fish uptake, and fish are mobile, both the Phase II RC and the cleanup goal development presented in the Phase III RAP (Brown and Caldwell, 2006) are based on consideration of the entire Disposal Site segment of river as one exposure point area. The mean concentration of cPAHs in the upper foot of sediment is 12.3 mg/kg which is significantly lower than the 31 mg/kg target. Based on this finding, no remedial action is necessary at the Site. Since the current risks at the Site are acceptable, any remediation would only further reduce a risk level that is already acceptable per the MCP risk limits.

Only the upper 6-inch sediment interval is considered the bioavailable zone, although a foot may sometimes be selected to be conservative. Fish uptake, the basis of the unacceptable risk identified in the Method 3 RC, would only reflect the surficial, bioavailable layer. Other risks, such as sediment exposure by waders, were insignificant and were also calculated based on the top 6 inches of material. Significant sediment erosion in this portion of the Malden River is expected to be minimal and, if it were to occur, would be limited to the upper few inches. The surface layer of sediment in this portion of the River is comprised of sand-sized particles which would resuspend less readily than smaller clay-sized particles. Furthermore, flow into the Malden River is through a culvert with fixed dimensions. Therefore, there is an upper limit to the threshold flow that will erode sediment in the Malden River, even during extreme precipitation events.

Since cPAHs are the risk drivers at the Site, the remediation goal for this group of constituents will address all of the unacceptable risks (if any) posed by the sediment. The cleanup goal that was developed for cPAHs in sediments, based on the results of the Method 3RC is protective of human and ecological receptors in the River portion of the Site. This goal of an average of 31 mg/kg cPAHs was already met across the Site.

7 References

Agency for Toxic Substances and Disease Registry (ATSDR), 1999. Health Consultation. Fish Tissue Exposure Investigation. Contaminated Chequamegon Bay Sediments at Kreher Park Ashland, Ashland County, Wisconsin. US Department of Health and Human Services, US Public Health Service, Atlanta, Georgia.

Ankley, Gerald T., Russell J. Erickson, Gary L. Phipps, Vincent R. Mattson, Patricia A. Kosian, Barbara R. Sheedy, and Julie S. Cox, 1995. Effects of light intensity on the phototoxicity of fluoranthene to a benthic macroinvertebrate, Environ. Sci. Technol., Vol. 11, No. 29, pp 2828-2833.

Agency for Toxic Substances and Disease Registry (ATSDR), 1995. Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs). (Update). US Department of Health and Human Services, US Public Health Service, Atlanta, Georgia. PB/95/264370.

Brändli, R.C., T.D. Bucheli, T. Kupper, F.X. Stadelmann, and J. Tarradellas, 2006. Can sources of environmental contamination with PAHs be identified in recipient matrices by concomitant analysis of molecular markers?, Organohalogen Compounds, Vol. 68, pp 292-294.

Brown and Caldwell, June, 2006. "Phase III – Remedial Action Plan, Former Malden Manufactured Gas Plant Site (Malden River Portion), Malden, Massachusetts."

Breault, Robert F., John L. Durant, and Albert Robbat, Jr., 2005. Sediment Quality of Lakes, Rivers, and Estuaries in the Mystic River Basin, Eastern Massachusetts, 2001-03, U.S. Dept. of Interior and U.S. Geological Survey.

Brunson EL, Canfield TJ, Dwyer FJ, Ingersoll CG, and NE Kemble, 1998. Assessing the bioaccumulation of contaminants from sediments of the Upper Mississippi River using field-collected oligochaetes and laboratory-exposed *lumbriculus variegatus*. Arch. Environ. Contam Toxicol. 5:191-201.

Burkhard, LP And MT Lukasewycz, 2000. Some bioaccumulation factors and biota-sediment accumulation factors for polycyclic aromatic hydrocarbons in lake trout. Environ. Toxicol. Chem. 19: 1427-1429.

Buscheli, Thomas D., and Orjan Gustaffson, 2000. Quantification of the soot-water distribution coefficient of PAHs provides mechanistic basis for enhanced sorption observations, Environ. Sci. Technol., Vol. 34, No. 24, pp 5144-5151.

Carls, Mark G., 2006. Nonparametric identification of petrogenic and pyrogenic hydrocarbons in aquatic ecosystems, Environ. Sci. Technol. Vol. 40, No. 13 , pp 4233-4239.

Costa, Helder J., Keith A. White, and John J. Ruspantini, 2004. Distinguishing PAH background and MGP residues in sediments of a freshwater creek, Environ. Forensics, 5:171-182.

Driscoll, Susan Kane, Gail A. Harkey and Peter F. Landrum, 1997. Accumulation and toxicokinetics of fluoranthene in sediment bioassays with freshwater amphipods. Environ. Toxicol. Chem. 16(4):742–753.

Eisler, R, 1987. Polycyclic Aromatic Hydrocarbon Hazards To Fish, Wildlife, And Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD

Fay, Amanda A., Bruce J. Brownawell, Adria A. Elskus, and Anne E. McElroy, 2000. Critical body residues in the marine amphipod *Ampelisca abdita*: Sediment exposures with nonionic organic contaminants, Environ. Toxicol. Chem., Vol. 19, No. 4, pp 1028-1035.

Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Ingersoll, C.G. Severn, D. Smorong, and R. Lindskoog. 2002. Predicting amphipod toxicity from sediment chemistry using logistic regression models. Environ. Toxicol. Chem. 21:9, pp 1993-2005.

Fleeger, John W., and Guilherme R. Lotufo, January 1999. Development and Application of a Sublethal Toxicity Test to PAH Using marine Harpacticoid Copepods, Coastal Marine Institute, OCS Study, MMS 99-0001.

Gewurtz, Sarah B., Rodica Lazar, and G. Douglas Haffner, 2000. Comparison of polycyclic aromatic hydrocarbon and polychlorinated biphenyl dynamics in benthic invertebrates of Lake Erie, USA, Environ. Toxicol. Chem., Vol. 19, No. 12, pp 2943-2950.

Great Lakes Mid-Atlantic Center for Hazardous Substance Research, 2006. TOSC Ashland, Wisconsin Project Update. University of Michigan Civil and Environmental Engineering. http://cee.engin.umich.edu/research/HSRC/outupdate.html.

Haley & Aldrich Inc., December 28, 2001. "Phase II – Comprehensive Site Assessment, Former Malden Manufactured Gas Plant Site, Malden, Massachusetts."

Hyotylainen T, Karels A, and A Oikari, 2002. Assessment of bioavailability and effects of chemicals due to remediation actions with caging mussels (*Anodonta anatina*) at a creosote-contaminated lake sediment site. Water Res. 36:4497-504

Khalil, Muhammad, F., Ghosh, Upal And Joseph P. Kreitinger (2006). Role of weathered coal tar pitch in the partitioning of polycyclic aromatic hydrocarbons in manufactured gas plant site sediments. Environ. Sci. Technol., Vol. 40, No. 18, pp 5681-5687.

Kolok, AS., Huckins, JN, Petty, JD and JT Oris, 1996. The role of water ventilation and sediment ingestion in the uptake of benzo[a]pyrene in gizzard shad (*dorsoma cepedianum*). Environ. Toxicol. Chem. 15: 1752-1759.

Kosian, Patricia A., Elizaeth A. Makynen, Philip D. Monson, David R. Mount, Ann Spacie, Ovanes G. Mekenyan, and Gerald T. Ankley, 1998. Application of toxicity-based fractionation techniques and structure-activity relationship models for the identification of phototoxic polycyclic aromatic hydrocarbons in sediment pore water, Environ. Toxicol. Chem., Vol. 17, No. 6, pp 1021-1033.

Kukkonen, JVK, Landrum, PF, Mitra, S, Gossiaux, DC, Gunnarsson, J and D. Weston, 2004. The role of desorption for describing the bioavailability of select polycyclic aromatic hydrocarbon and polychlorinated biphenyl congeners for seven laboratory-spiked sediments. Environ. Toxicol. Chem. 23:1842-1851.

Lee, J.-S., K.T. Lee, and K.N. Han, 2004. Comparison of toxicity of polycyclic aromatic hydrocarbons, heavy metals and organotins to benthic amphipods *Grandidierella japonica*, ark shell clams *Scapharca broughtonii* and puffer fish *Takifugu obscurus*, Institute of Environmental Protection & Safety, Seochogu, Seoul, Korea, The Society of Environ. Toxicol. Chem. – SETAC.

Massachusetts Department of Environmental Protection (MADEP), 2006a. Method 3 – Guidance for Environmental Risk Characterization in Support of the Massachusetts Contingency Plan. Interim Final Policy #WSC/ORS-95-141.

Massachusetts Department of Environmental Protection (MADEP), 2006b. Interim Technical Update, Revised Sediment Screening Values, Update to Section 9 of *Guidance for Disposal site Risk Characterization – In Support of the Massachusetts Contingency Plan* (1996).

McCarthy, JF, Burrus, LW and R Tolbert, 2003. Bioaccumulation of benzo(a)pyrene from sediment by fathead minnows: effects of organic content, resuspension and metabolism. Arch. Environ. Contam. Toxicol. 45:364-370.

McCarthy, Brian, June 2003. Polycyclic Aromatic Hydrocarbons (PAHs) in Urban Runoff, The GEI MGP Reporter.

Menzie, Charles A., Susanne S. Hoeppner, Jerome J. Cura, Jonathan S. Freshman, and Elizabeth N. LaFrey, April 2002. Urban and suburban storm water runoff as a source of Polycyclic Aromatic Hydrocarbons (PAHs) to Massachusetts estuarine and coastal environments, Estuaries, Vol. 25, No. 2, pp 165-176.

Millward, RN, Fleeger, JW, Reible, DD, Ketels, KA, Cunningham, BP and L Zhang, 2001. Pyrene bioaccumulation, effects of pyrene exposure on particle-size selection, and fecal pyrene content in the oligochaete *Limnodrilus hoffmeisteri* (tubificidae, oligochaeta). Environ. Toxicol. Chem. 20: 1359-1366.

Naes, Kristoffer, Johan Axelman, Carina Naf, and Dag Broman, 1998. Role of soot carbon and other carbon matrices in the distribution of PAHs among particles, DOC, and the dissolved phase in the effluent and recipient waters of an aluminum reduction plant, Environ. Sci. Technol., Vol. 32, No. 12, pp 1786-1792.

New Hampshire Department of Health and Human Services, 2002. Health Consultation. Review of 2002 Annual Groundwater Monitoring Report, Messer Street Manufactured Gas Plant Site, Laconia, Belknap County, New Hampshire. Bureau of Environmental and Occupational Health, Concord.

NYSDEC, 2006. What are the Environmental Impacts Resulting from a Former MGP?. http://www.dec.state.ny.us/website/der/mgp/environ.html

New York State Department of Environmental Conservation (NYSDEC), 2000. Record of Decision. Niagara Mohawk Oneida (Sconondoa Street) Former Manufactured Gas Plant Site. Oneida, Madison County, NY.

Phillips, Bryn M., John w. Hunt, Brian S. Anderson, H. Max Puckett, Russell Fairey, Craig J. Wilson, and Ron Tjeerdema, 2001. Statistical significance of sediment toxicity test results: Threshold values derived by the detectable significance approach, Environ. Toxicol. Chem., Vol. 20, No. 2, pp 371-373.

Reible, DD and JW Fleeger, 2004. Bioavailability of desorption-resistant contaminants. Progress Report November 19. Hazardous Substance Research Center/South and Southwest.

Rust, Aaron J., Robert M. Burgess, Bruce J. Brownawell, and Anne E. McElroy, 2004. Relationship between metabolism and bioaccumulation of benzo(a)pyrene in benthic invertebrates, Environ. Toxicol. Chem., Vol. 23, No. 11, pp 2587-2593.

Saber, Diane, David Mauro and Tanita Sirivedhin, 2003. Environmental forensics investigation in sediments near a former manufactured gas plant site. Environ. Forensics 1: 65 – 75.

Sanders, M., S. Sivertsen, and G. Scott, 2002. Origin and distribution of polycyclic aromatic hydrocarbons in surficial sediments from the Savannah River, Arch. Environ. Contam. Toxicol., 43, pp 438-448.

Sportmanschoice., 2006. A note about fish. http://www.sportsmanschoice.com/A%20Note%20Worth%20Reading/fish.htm.

Sundelin, Brita, Ann-Kristin Eriksson Wiklund, Göran Lithner, and Örjan Gustaffson, 2004. Evaluation of the role of black carbon in attenuating bioaccumulation of polycyclic aromatic hydrocarbons from field-contaminated sediments, Environ. Toxicol. Chem., Vol. 23, No. 11, pp 2611-2617.

Swartz, Richard C., 1999. Consensus sediment quality guidelines for polycyclic aromatic hydrocarbon mixtures, Environ. Toxicol. Chem., Vol. 18, No. 4, pp 780-787.

Thorsen, Waverly A., W. Gregory cope, and Damian Shea, 2004. Bioavailability of PAHs: Effects of soot carbon and PAH Source, Environ. Sci. Technol., Vol. 38, No. 7, pp 2029-2037.

Tracey GA and DJ Hansen, 1996. Use of biota-sediment accumulation factors to assess similarity of nonionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch. Environ. Contam. Toxicol. 4:467-475

United States Army Corps of Engineers (USACE), 2006. BSAF Database. http://el.erdc.usace.army.mil/bsaf/

United States Environmental Protection Agency (USEPA), 1997. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. Office of Science and Technology. EPA 823-R-97-006.

United States Environmental Protection Agency (USEPA), November 1998. EPA, DEP to focus on Mystic River Cleanup, Release # 98-11-11 (http://www.epa.gov/NE/pr/1998/113098.html).

United States Environmental Protection Agency (USEPA), 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. Region 10, Seattle, WA. EPA 910/R-02-006.

United States Environmental Protection Agency (USEPA), 2000a. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates, Second Edition, EPA 600/R-99/064.

United States Environmental Protection Agency (USEPA), 2000b. Phase 2 Report. Further Site Characterization And Analysis. Volume 2f - Revised Human Health Risk Assessment. Hudson River PCBs Reassessment RI/FS. http://www.epa.gov/hudson/hhra-tab-chpt3.pdf.

United States Environmental Protection Agency (USEPA), 2003. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms. Office of Research and Development, Washington, DC. EPA/600/R-02/013.

Vo, M., D.E. Porter, G.T. Chandler, H. Kelsey, S.P. Walker, and B.E. Jones, 2004. Assessing photoinduced toxicity of polycyclic aromatic hydrocarbons in an urbanized estuary, Ecology and Society, Vol. 9, No. 5.

Washington State Department of Ecology, 1999. Lake Whatcom Watershed Cooperative Drinking Water Protection Project. Results of 1998 Water, Sediment and Fish Tissue Sampling. Publication No. 99-337.

Washington Department Of Fish And Wildlife, 2004. A 2002 Survey Of Resident Freshwater Anglers In Washington State and Comparisons to the 1994 And 1988 Surveys. Fish Program, Fish Management Division.

Yaorong, Qian, Terry L. Wade, and Jose L. Sericano, December 2001. Sources and bioavailability of polynuclear aromatic hydrocarbons in Galveston Bay, Texas, Estuaries, Vol. 24, No. 6A, pp 817-827.

Zeng, Eddy Y., and Cherrie L. Vista, 1997. Organic pollutants in the coastal environment off San Diego, California. 1. Source identification and assessment by compositional indices of polycyclic aromatic hydrocarbons, Environ. Toxicol. Chem., Vol. 16, No. 2, pp 179-188.

Zhang, X.L., S. Tao, W.X. Liu, Y. Yang, Q. Zuo, and S.Z. Liu, 2005. Source diagnostics of polycyclic aromatic hydrocarbons based on species ratios: A Multimedia Approach, Environ. Sci. Technol., Vol. 39, No. 23, pp 9109-9114.

TABLES

Table 1
PAH Ratio's and origin source

Ratio	AMECSED-1	AMECSED-2	AMECSED-3	AMECSED-4	AMECSED-5	AMECSED-6	AMECSED-6DUP
ANT/(ANT+PHE)	**0.2179**	**0.2134**	**0.1056**	**0.1888**	**0.1043**	**0.1984**	**0.2126**
BaA/(BaA+CHR)	**0.5294**	**0.5305**	**0.4749**	**0.5034**	**0.4575**	**0.4784**	**0.5017**
FLT/(FLT+PYR)	0.4583	0.4918	0.5434	0.5105	0.5259	0.5228	0.5064
(IPY/(IPY+BPE)	**0.4729**	**0.4768**	**0.4824**	**0.4685**	**0.8980**	**0.4908**	**0.5129**
ComPAH/16PAH	0.5459	0.5718	0.6235	0.6294	0.8228	0.7641	0.7657
BaP/BPE	**2.0139**	**1.9814**	**1.7803**	**1.7522**	**14.9155**	**1.5974**	**1.9621**

Ratio	AMECSED-7	AMECSED-8	AMECSED-R9	AMECSED-R10	AMECSED-R11
ANT/(ANT+PHE)	**0.1833**	**0.2184**	0.0763	**0.1865**	0.0818
BaA/(BaA+CHR)	**0.4987**	**0.5005**	**0.4422**	**0.4585**	**0.4696**
FLT/(FLT+PYR)	0.5292	0.4631	0.5130	0.5148	0.5300
(IPY/(IPY+BPE)	**0.5068**	**0.4988**	**0.4777**	**0.5222**	**0.4756**
ComPAH/16PAH	0.7468	0.7310	0.8077	0.8136	0.7799
BaP/BPE	**2.1341**	**2.0144**	**1.5194**	**1.9550**	**1.4360**

Notes:

Petrogenic origin

Pyrogenic origin

Non-Traffic origin

Traffic origin

Anthracene/(Anthracene+ Phenanthrene) [ANT/(ANT+PHE)]
pyrogenic<0.1<petrogenic
Benzo(a)anthracene/(Benzo(a)anthracene+Chrysene) [BaA/(BaA+CHR)]
pyrogenic<0.35<petrogenic
Fluoranthene/(Fluoranthene+ Pyrene) [FLT/(FLT+PYR)]
petrogenic<0.4<pyrogenic
Indeno(1,2,3-cd)Pyrene/(Indeno(1,2,3-cd)Pyrene+ Benzo(ghi)perylene) [(IPY/(IPY+BPE)]
pyrogenic<0.2<petrogenic
Combustion PAHs/∑16PAH [ComPAH/16PAH)]
Combustion PAHs = Benzo(a)pyrene, Indeno(1,2,3-cd)Pyrene, Benzo(k)fluoranthene, Benzo(b)fluoranthene, Chrysene, Benzo(a)anthracene, Fluoranthene, and Pyrene
petrogenic<0.3<pyrogenic
Benzo(a)pyrene/Benzo(ghi)perylene [BaP/BPE]
non-traffic<0.6<traffic

Table 2
Former Malden MGP Site (Malden River Portion) - Malden, Massachusetts

Summary of Risk Variables

Variable		Value	Source/Comment
Excess lifetime cancer risk (unitless)	ELCR	1.00E-05	MCP Requirement
Carcinogenic slope factor $(mg/kg\text{-}day)^{-1}$	CSF	7.3	Value is for BaP; other cPAHs have CSFs scaled to BaP (see text)
Biota Sediment Accumulation Factor (kg OC/kg lipid)	BSAF	0.0054	Taken from Burkhard and Lukasewycz, 2000, following a literature review; see text
Fraction organic carbon in sediment	fOC	0.0634	Average of measured values in site sediments
Fraction lipid in fish tissue	L_F	0.03	MADEP estimate; value used in Phase II risk characterization
Ingestion rate of fish (kg/day), child	IR_c	0.0081	Value used in Phase II risk characterization; taken from Ebert et al, 1993
Ingestion rate of fish (kg/day), adult	IR_a	0.012	Value used in Phase II risk characterization; taken from Rupp et al, 1980
Age-adjusted fish ingestion rate (kg fish−years/kg bw−day)	IR_{adj}	0.00514	Calculated from IR and BW; see text
Fraction of fish ingestion from site (unitless)	FI	0.25	Value used in Phase II risk characterization; based on professional judgment
Exposure frequency (days/year)	EF	365	Default assuming year-round fish ingestion
Exposure duration (years), child	ED_C	6	Ages 10-16
Exposure duration (years), adult	ED_A	24	Default residence time of 30 years minus child ED of 6 years
Body weight (kg), child	BW_c	47.2	MADEP value used in Phase II risk characterization for ages 10-16
Body weight (kg), adult	BW_a	70	USEPA default value used in Phase II risk characterization
Averaging period (days)	AP	27375	75-year lifetime

Table 3
Former Malden MGP Site (Malden River Portion)
Malden, Massachusetts
Calculation of Update Exposure point Concentrations (EPCs) for the Human Health Risk Characterization

mg/kg	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	0 - 6"	Phase III (1) n=10	Phase II (2) n=29	OVERALL AVERAGE (3)
Acenaphthene	0.5	4.9	0.1	0.72	0.5	0.59	3.2	0.5	21	3.6	**3.56E+00**	**7.76E+00**	**6.68E+00**
Acenaphthylene	0.3	2	1.5	1.1	2.1	0.3	2.3	0.3	2.4	1.1	**1.34E+00**	**3.26E+00**	**2.77E+00**
Anthracene	1.1	3.3	1.8	1.6	2.4	1.1	6	1.3	33	4.1	**5.57E+00**	**8.77E+00**	**7.95E+00**
Benzo[a]anthracene	3.3	6.4	4.2	3.8	4.8	2	11	3.4	49	9.6	**9.75E+00**	**9.29E+00**	**9.41E+00**
Benzo[a]pyrene	3.1	5.6	4.1	3.4	3.5	1.7	10	2.8	43	8.8	**8.60E+00**	**9.14E+00**	**9.00E+00**
Benzo[b]fluoranthene	3	4.4	3.1	2.7	2.4	1.3	9.2	2.8	30	8	**6.69E+00**	**9.65E+00**	**8.89E+00**
Benzo[g,h,i]perylene	3.6	7.2	4.9	3.3	3	1.7	9.3	2.9	29	7.4	**7.23E+00**	**2.79E+00**	**3.93E+00**
Benzo[k]fluoranthene	2.9	4.7	3.3	2.7	2.5	1.4	8.4	2.2	34	6.5	**6.86E+00**	**3.51E+00**	**4.37E+00**
Chrysene	3.8	7.5	4.9	4.3	4.6	2.1	13	4	47	11	**1.02E+01**	**8.99E+00**	**9.31E+00**
Dibenz(a,h)anthracene	0.6	1.3	0.9	0.62	0.6	0.44	2.5	0.97	8	1.6	**1.75E+00**	**1.33E+00**	**1.44E+00**
Fluoranthene	7.4	13	7.9	6.7	7.4	4.2	25	7.5	120	24	**2.23E+01**	**1.92E+01**	**2.00E+01**
Fluorene	0.4	2.5	0.98	0.76	0.6	0.57	3.8	0.6	23	3.8	**3.70E+00**	**6.66E+00**	**5.90E+00**
Indeno[1,2,3-cd]pyrene	3.4	6.9	5.1	3.6	3.4	1.5	7.9	2.7	27	5.9	**6.74E+00**	**3.27E+00**	**4.16E+00**
Naphthalene	0.2	13	0.8	0.81	0.5	0.2	1.3	0.3	25	0.97	**4.31E+00**	**1.00E+01**	**8.56E+00**
Phenanthrene	4.6	13	6.6	5.8	6.2	3.8	21	5.9	140	23	**2.30E+01**	**2.56E+01**	**2.49E+01**
Pyrene	8.7	14	8.8	7.3	9.2	4.5	24	7	97	23	**2.04E+01**	**1.95E+01**	**1.97E+01**
2-Methylnaphthalene	0.45	2.9	0.4	0.7	0.5	0.1	0.8	0.2	9.3	0.47	**1.58E+00**	**7.05E+00**	**5.65E+00**

(1) Average of 0-6-inch concentrations from Brown and Caldwell October 2006 sampling. "U" values entered as 1/2 the reporting limit.

(2) Exposure Point Concentrations from Method 3 HHRC; based on Phase II H&A and AMEC data. EPC is average of 0-6-inch samples using 1/2 the reporting limit for "U" values.

(3) Obtained as follows:. [(BC average*10)+(Phase II average * 29)]/39

Table 4
Former Malden MGP Site (Malden River Portion)
Malden, Massachusetts
Calculation of Human Health Carcinogenic Risk

IR_c kgfish/day	IR_a kgfish/day	ED_c yrs	ED_a yrs	BW_c	BW_a
0.0081	0.012	6	24	47.2	70
IRadj =	**0.00514**				

	Sed. Conc.[a]	BSAF	fOC	L_F	IRadj	FI	EF	AP	CSF[a]	Risk
	mg/kg sed	(kg OC/ kg lipid)	kg OC/ kg sed	kg lip/ kg fish	kgfish-yr/ kgBW-day		days/yr	days	kg-day/ mg	
Fish Ingestion										
Benzo(a)anthracene	9.41E+00	0.0054	0.0634	0.03	0.005144	0.25	365	27375	0.73	**3E-07**
Benzo(a)pyrene	9.00E+00	0.0054	0.0634	0.03	0.005144	0.25	365	27375	7.3	**3E-06**
Benzo(b)fluoranthene	8.89E+00	0.0054	0.0634	0.03	0.005144	0.25	365	27375	0.73	**3E-07**
Benzo(k)fluoranthene	4.37E+00	0.0054	0.0634	0.03	0.005144	0.25	365	27375	0.073	**1E-08**
Chrysene	9.31E+00	0.0054	0.0634	0.03	0.005144	0.25	365	27375	0.073	**3E-08**
Dibenz(a,h,)anthracene	1.44E+00	0.0054	0.0634	0.03	0.005144	0.25	365	27375	7.3	**5E-07**
Indeno(1,2,3-cd)pyrene	4.16E+00	0.0054	0.0634	0.03	0.005144	0.25	365	27375	0.73	**1E-07**
									Total	**4E-06**

Non-CPAH constituents — From Phase II Method 3; see Table 5. **2E-06**

River Direct Contact[b]

Surface Water Ingestion	**1E-09**
Surface Water Dermal Contact	**2E-09**
Sediment Ingestion	**1E-07**
Sediment Dermal Contact	**9E-07**

RIVER TOTAL **7E-06**

See Table 2 for risk variable values except as noted below.
See Table 3 for sediment concentrations.

(a) MADEP values. http://www.mass.gov/dep/toxics/pahs.htm.

(b) River direct contact risk values from the Phase II Risk Characterization.

IR_a	=	Fish intake rate (adult)
IR_c	=	Fish intake rate (child)
IRadj	=	Age-adjusted fish intake rate
ED_a	=	Exposure duration (adult)
ED_c	=	Exposure duration (child)
BW_a	=	Body weight (adult)
BW_c	=	Body weight (child)
BSAF	=	Biota-sediment accumulation factor
fOC	=	Fraction organic carbon
L_F	=	Fraction lipid
FI	=	Fraction of fish ingested from site
EF	=	Exposure frequency
AP	=	Averaging period
CSF	=	Carcinogenic slope factor

Table 5
Former Malden MGP Site (Malden River Portion)
Malden, Massachusetts
Human Health Carcinogenic Risks from Fish Ingestion for C Other Than cPAHs

Non-cPAH Fish Carcinogenic Risks from Phase 2 Method 3 Risk Characterization

	Fish Ingestion		
	Lifetime (Child + Adult)	Adjusted Tot.(a)	
Arsenic	7E-05	0E+00	(b)
bi(2-Ethylhexyl)phthalate	8E-06	2E-06	
Carbazole	1E-06	3E-07	
Chloroform	2E-10	2E-10	
Isophorone	7E-08	2E-08	
Methylene chloride	1E-08	1E-08	
		2E-06	

(a) Risks based on fish tissue uptake from sediment that were org carbon (OC) based (all COPCs above except chloroform and methylene chloride) were scaled by 0.015/0.0634 based on site-specific organic carbon content of 6.34% vs. value of 1.5% in Phase II.

(b) Risk assumed to be 0 based on BSAF of 0 listed in Table 11 c Method 3 Environmental Risk Characterization from Phase II r

Table 6
Former Malden MGP Site (Malden River Portion)
Malden, Massachusetts
Calculation of Human Health Noncarcinogenic Hazard (a)

	Sed. Conc. [b] mg/kg sed	BSAF (kg OC/ kg lipid)	fOC kg OC/ kg sed	L_F kg lip/ kg fish	IR kgfish/ day	FI	EF days/yr	ED yrs	BW kg	AP days	RfD [c] mg/ kg-day	HQ
Fish Ingestion												
Acenaphthene	6.68E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.06	**1E-05**
Acenaphthylene	2.77E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**1E-05**
Anthracene	7.95E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.3	**3E-06**
Benzo(a)anthracene	9.41E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**3E-05**
Benzo(a)pyrene	9.00E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**3E-05**
Benzo(b)fluoranthene	8.89E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**3E-05**
Benzo(ghi)perylene	3.93E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**1E-05**
Benzo(k)fluoranthene	4.37E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**2E-05**
Chrysene	9.31E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**3E-05**
Dibenz(a,h,)anthracene	1.44E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**5E-06**
Fluoranthene	2.00E+01	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.04	**5E-05**
Fluorene	5.90E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.04	**2E-05**
Indeno(1,2,3-cd)pyrene	4.16E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**2E-05**
2-Methylnaphthalene	5.65E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.004	**2E-04**
Napthalene	8.56E+00	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.02	**1E-04**
Phenanthrene	2.49E+01	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**7E-05**
Pyrene	1.97E+01	0.0054	0.0634	0.03	0.012	0.25	365	24	70	8760	0.03	**2E-05**
											Total	**3E-04**
Non-CPAH constituents											From Phase II Method 3; see Table 7.	**2E-01**
River Direct Contact [d]												
Surface Water Ingestion												**6E-04**
Surface Water Dermal Contact												**3E-05**
Sediment Ingestion												**9E-03**
Sediment Dermal Contact												**1E-02**
RIVER TOTAL												**3E-01**

(a) See Table 2-1 for risk variable values except as noted below.
(b) For adult, which had a higher HI than child. Hazards are never summed across age groups.
(c) Sediment concentrations obtained from Phase II CSA "Risk Assessment Spreadsheets."
(d) Chronic; MADEP values. http://www.mass.gov/dep/toxics/pahs.htm.
IR River direct contact risk values from the Phase II Risk Characterization.

IR	=	Fish intake rate
ED	=	Exposure duration
BW	=	Body weight
BSAF	=	Biota-sediment accumulation factor
fOC	=	Fraction organic carbon
L_F	=	Fraction lipid
FI	=	Fraction of fish ingested from site
EF	=	Exposure frequency
AP	=	Averaging period
CSF	=	Carcinogenic slope factor
RfD	=	Reference Dose (chronic)

Table 7
Former Malden MGP Site (Malden River Portion)
Malden, Massachusetts
Human Health Noncarcinogenic Hazard from Fish Ingestion for COCs Other than cPAHs

	Fish Ingestion Hazards			
	Due to Sediment Uptake	Adjusted Due to Sediment Uptake (a)	Due to Surf. Water Uptake	**Adjusted HQ (b)**
1,2,4-Trimethlybenzene	5E-05	1E-05	2E-06	**1E-05**
1,3,5-Trimethlybenzene	8E-04	2E-04		**2E-04**
1,3-Dichlorobenzene	4E-04	9E-05		**9E-05**
1,4-Dichlorobenzene	2E-05	5E-06	9E-07	**6E-06**
4-Isopropyltoluene	4E-04	8E-05		**8E-05**
Antimony			1E-01	**1E-01**
Arsenic			(c)	
Barium	3E-02	6E-03		**6E-03**
Benzene	6E-04	1E-04	4E-05	**2E-04**
bi(2-Ethylhexyl)phthalate	8E-02	2E-02		**2E-02**
Butylbenzylphthalate	8E-04	2E-04		**2E-04**
Cadmium			3E-02	**3E-02**
Chlorobenzene	5E-03	1E-03		**1E-03**
Chloroform			7E-06	**7E-06**
Chromium			2E-04	**2E-04**
cis-1,2-Dichloroethene			5E-05	**5E-05**
di-n-Octyl phthalate	8E-03	2E-03		**2E-03**
Dibenzofuran	7E-02	2E-02		**2E-02**
Ethylbenzene	3E-05	8E-06	3E-06	**1E-05**
Isophorone	9E-04	2E-04		**2E-04**
Lead			7E-03	**7E-03**
m&p-Xylenes	1E-05	3E-06	7E-07	**4E-06**
Mercury	4E-03	4E-03		**4E-03**
Methylene chloride			7E-05	**7E-05**
Nickel			3E-03	**3E-03**
o-Xylene	2E-05	4E-06		**4E-06**
Toluene	7E-05	2E-05	1E-07	**2E-05**
Zinc			3E-02	**3E-02**
				2E-01

(a) Risks based on fish tissue uptake that were organic carbon (OC) based (all COPCs except Hg) were scaled by 0.015/0.0634 based on site-specific organic carbon content of 6.34% vs. value of 1.5% used in Phase II.

(b) Hazards were recalculated with the sediment contribution updated where it was OC based:
- If the HQ was just based on the BCF from surface water, no adjustment was made
- If the HQ was just based on the BSAF from sediment, an update was made using the site-specific OC, as indicated in Note (a)
- If the HQ contained a contribution from both surface water and sediment, the HQ related to each medium was calculated as follows:

HQsed = HQtot x [Fsed/(Fsed + Fsw)]
where Fsed = Fish tiss. conc. predicted from sediment
HQsw = HQtot x [Fsw/(Fsed + Fsw)]
where Fsw = Fish tiss. conc. predicted from surface water

(c) Risk assumed to be 0 based on BSAF of 0 listed in Table 11 of Method 3 Environmental Risk Characterization from Phase II report.

FIGURES

Figure 1 - Carcinogenic PAH concentrations and mean percent invertebrate survival

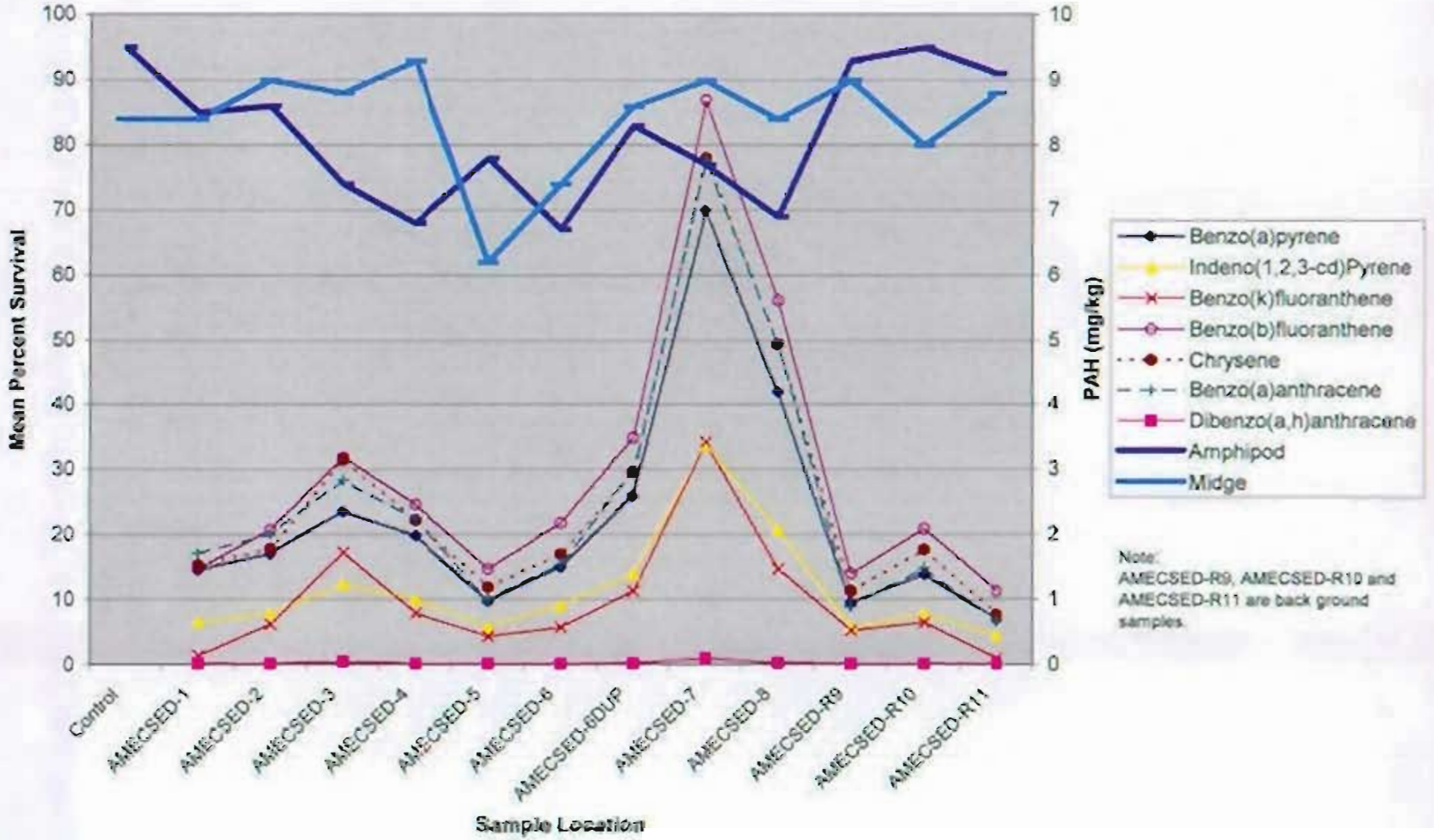


Figure 2 - PAH concentrations and mean percent invertebrate survival

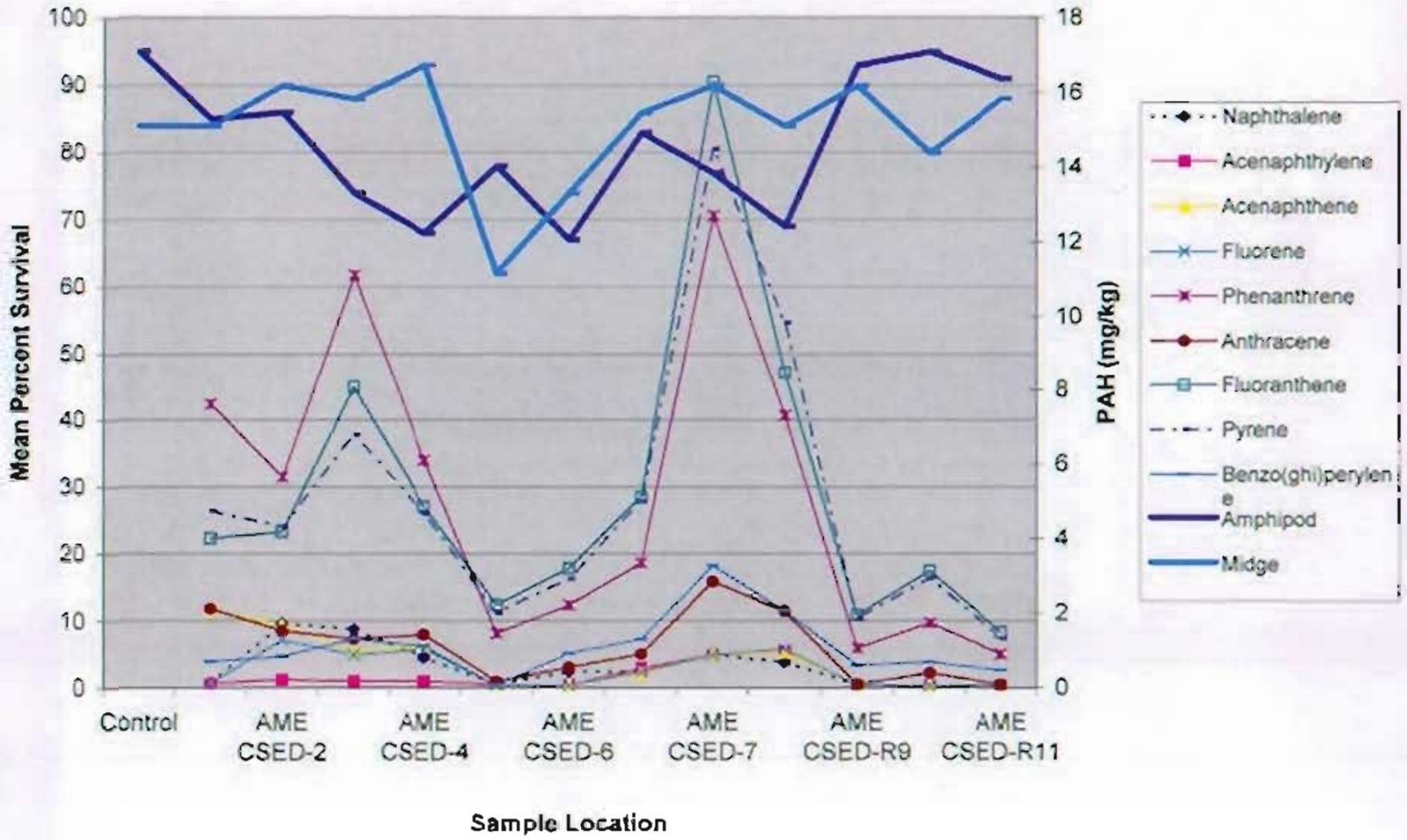


Figure 3 - EPH concentrations and mean percent invertebrate survival

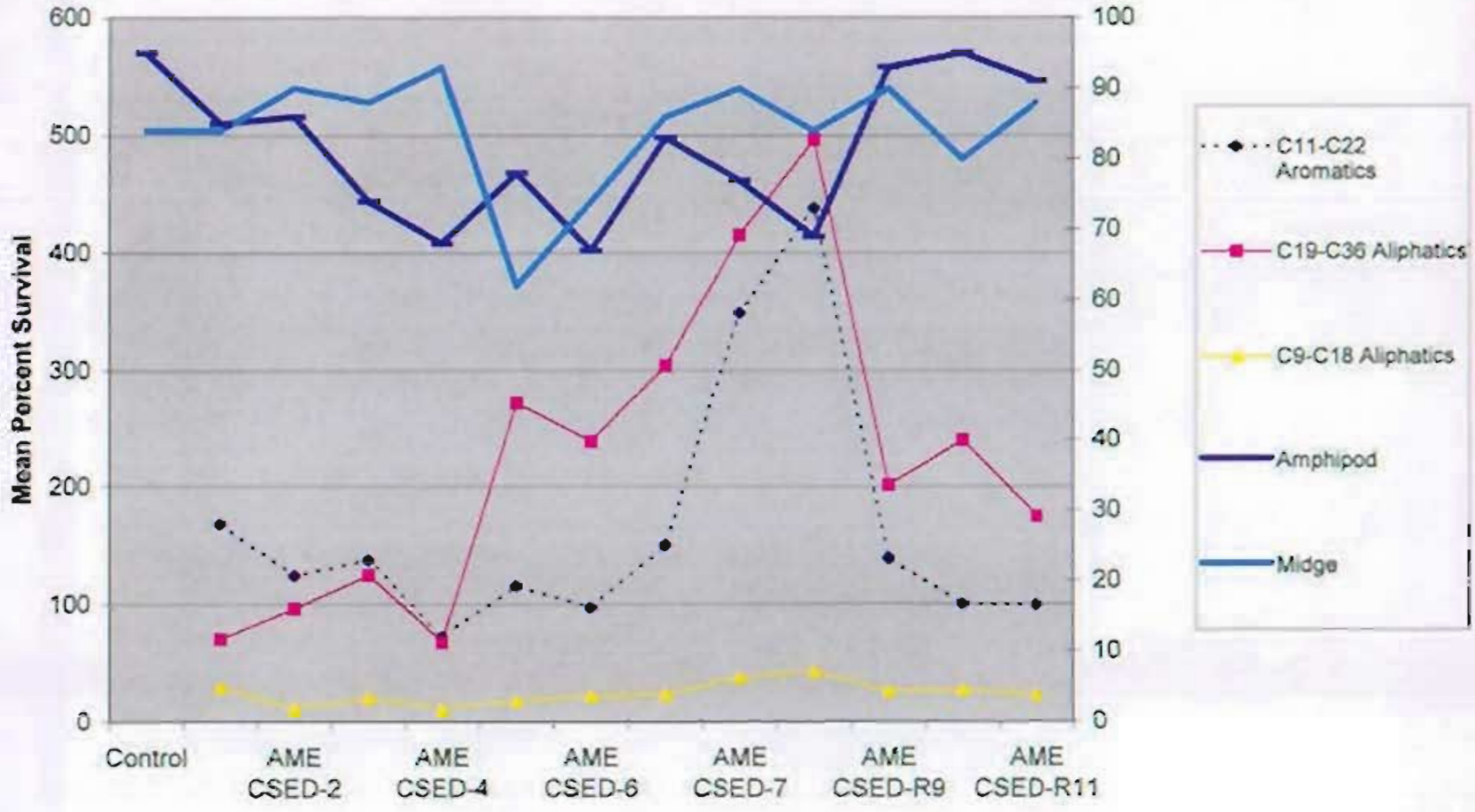
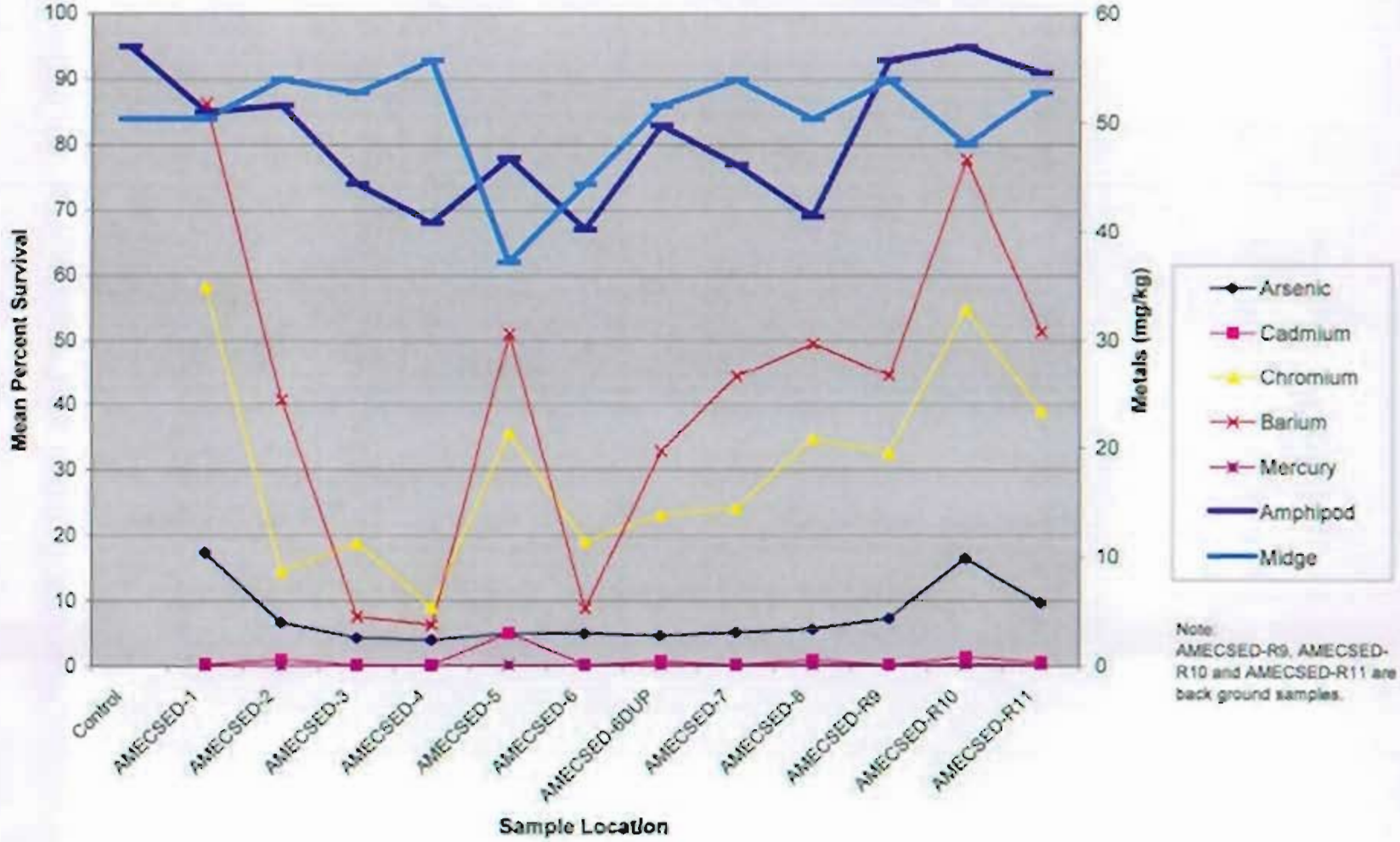


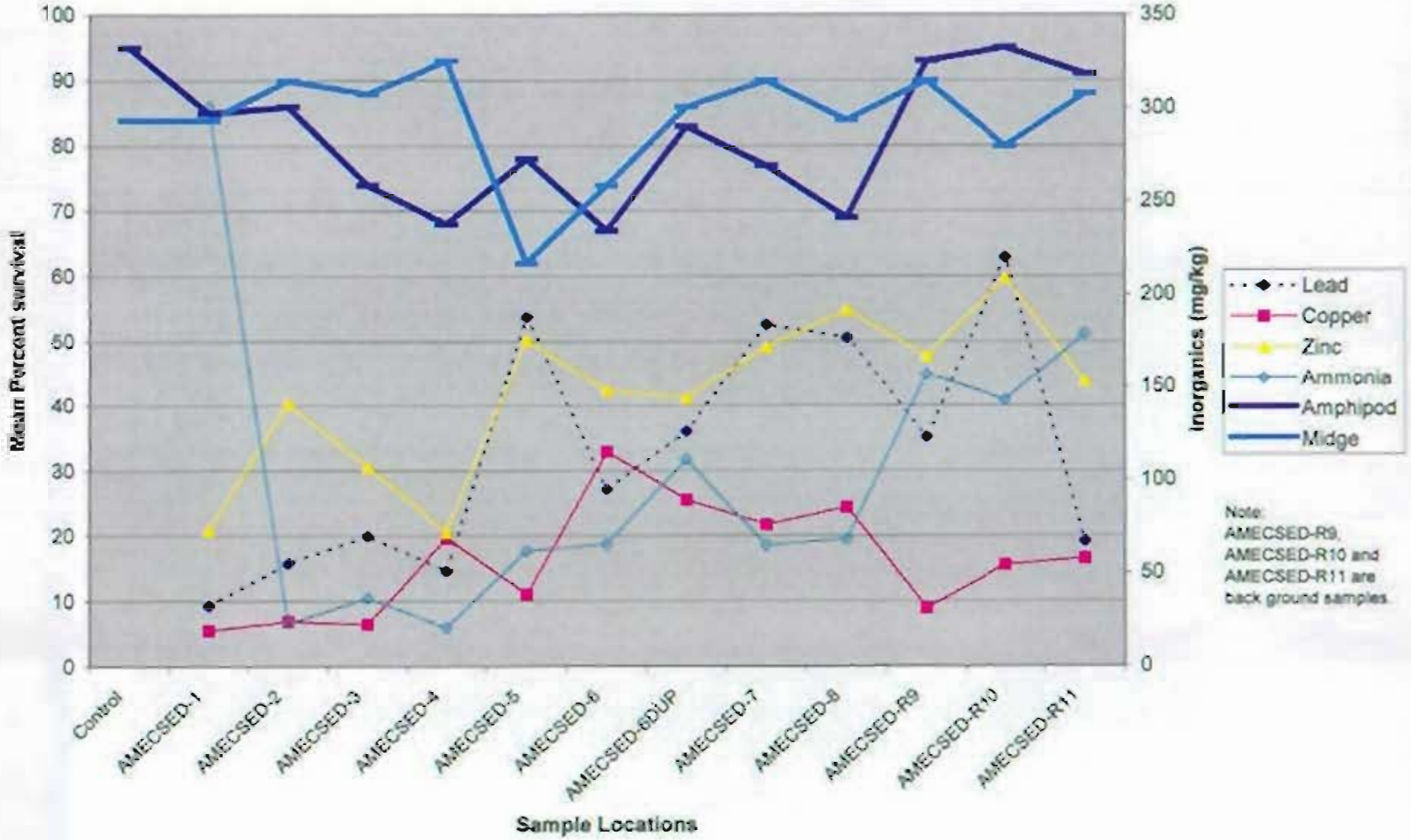
Figure 4a - Inorganic concentrations and mean percent invertebrate survival



Note:
AMECSED-R9, AMECSED-R10 and AMECSED-R11 are back ground samples.

P:\National Grid\Malden\River RAO\FINAL\Appendix B\Figure1_4 (AppdxB)\Figure 4a

Figure 4b - Inorganics concentrations and mean percent invertebrate survival



P:\National Grid\Malden\River RAO\FINAL\Appendix B\Figure1_4 (AppdxB)\Figure 4b