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March 30, 2009

Mr. Martin Suuberg, Regional Director
Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup
Central Regional Office
627 Main Street
Worcester, MA 01608

Subject: Former Brookfield Mill
MassDEP Release Tracking Number 2-10354
59-67 Mill Street, Brookfield, MA 01506
File No. ACO-CE-08-3T006

Dear Mr. Suuberg,

Please find enclosed the following for the subject site:

- Phase III Remedial Action Plan
- Form BWSC108
- Copy of notice to public officials

If you have any questions, please do not hesitate to call me at (781) 224-6608.

Very truly yours,

Barbara A. Weir
Licensed Site Professional

cc: James Allen, Chairman
Brookfield Board of Selectman
6 Central Street
Brookfield, MA 01506

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March 30, 2009

Mr., Michael Seery, Chairman
Board of Health
Town of Brookfield
6 Central Street
Brookfield, MA 01506

Subject: Former Brookfield Mill
MassDEP Release Tracking Number 2-10354
59-67 Mill Street, Brookfield, MA 01506

Dear Mr. Seery,

The purpose of this letter is to inform you that a Phase III Remedial Action Plan report for the subject release has been completed, in accordance with the Massachusetts Contingency Plan (MCP). The report develops and evaluates actions to remediate the soil contamination at the site, and recommends that an isolation barrier (such as a soil cap or pavement) be put in place to prevent exposure to the soil, followed by an Activity and Use Limitation to make sure the barrier remains protective in the long term.

A copy of the report may be obtained from James Allen, Chairman, Board of Selectmen, Town of Brookfield, or reviewed at the Central Regional Office of the Massachusetts Department of Environmental Protection at 627 Main Street, Worcester, MA 01608. A copy can also be viewed on line using the MassDEP Site File Viewer via the Internet:

http://public.dep.state.ma.us/wsc_viewer/main.aspx

To use this site, search on the Release Tracking Number (2 is the region number and 10354 is the Tracking ID). Reports involving this RTN that are available electronically will be listed, including the Phase III Remedial Action Plan.

If you have any questions, please do not hesitate to call me at (781) 224-6608.

Very truly yours,

Barbara A. Weir, P.E.
Licensed Site Professional

Cc: James Allen, Chairman
Brookfield Board of Selectman
6 Central Street
Brookfield, MA 01506

Mr. Martin Suuberg, Regional Director
Massachusetts Department of Environmental Protection

TARGETED BROWNFIELDS ASSESSMENT REPORT

PHASE III REMEDIAL ACTION PLAN
FORMER BROOKFIELD MILL SITE
59-67 MILL STREET
BROOKFIELD, MASSACHUSETTS
RTN 2-10354

Prepared for:

United States Environmental Protection Agency
Region 1

Prepared by:
Advanced Environmental Solutions, Inc.
90 Madison Street, Suite 605
Worcester, Massachusetts 01608-2030

In Coordination with:
AECOM Environment

Contract No. EP-W-07-095

Order No. 0003

March 2009

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EXECUTIVE SUMMARY

On behalf of the U.S. Environmental Protection Agency (EPA) Region 1, Advanced Environmental Solutions (AES) of Worcester, Massachusetts, and its team subcontractor, AECOM Environment (formerly known as Metcalf & Eddy) of Wakefield, Massachusetts, prepared this Phase III Remedial Action Plan (RAP) for use by the Town of Brookfield, Massachusetts for MassDEP release tracking number (RTN) 2-10354, associated with the former Brookfield Mill property at 59-67 Mill Street in Brookfield (herein referred to as the Site). The purpose of this Phase III Remedial Action Plan is to identify, evaluate, and recommend appropriate comprehensive remedial actions that will result in a condition of No Significant Risk and achieve either a permanent or temporary solution, leading to a Response Action Outcome (RAO).

The former Brookfield Mill, a four-story wooden structure, was destroyed in a fire in August 2000. The Site is presently devoid of buildings or structures. All that remains of the former four-story mill building is the foundation and some rubble and debris on the old mill footprint. It appears that after the fire, the remnants of the building either collapsed or were demolished, such that they now partially fill the basement.

Remedial action objectives were developed based on the Phase II report, Method 3 Risk Characterization, and ecological screening, with updates as documented in this report. The remedial action objectives include: 1) Prevention of future direct exposures to Site soils by child residents and child recreational users; and 2) Removal of unstable slopes and prevention of direct exposures to glass, rusted wastes, and other debris that may pose a physical hazard. The Phase II report also indicated the possibility that lead concentrations in surface water, via groundwater discharge, may pose a risk of harm to aquatic habitat in the wetland area to the south of the former mill property. However, additional groundwater sampling has since been performed in the wetland area and no lead was detected above screening criteria, indicating that discharge of lead-contaminated groundwater to surface water within the wetland does not appear to be a concern. Therefore, remedial actions to prevent migration of groundwater from the Site to the wetland area are not necessary, and the remedial actions evaluated are designed solely to limit direct exposure to Site soils.

Background concentrations of metals are exceeded in surface and subsurface soils within the Site. As part of this Phase III report, the feasibility of achieving or approaching background levels was evaluated for Site soils. The only available method that would achieve background conditions for the Site would be removal and off-site reuse or disposal of the full extent of impacted soils. Because of Toxicity Characteristic Leaching Procedure (TCLP) lead exceedances, Site soils would be considered Resource, Conservation, and Recovery Act (RCRA) characteristic hazardous waste for off-site disposal. For that reason, removal, transport, and off-site disposal of this volume of soil would be extremely costly. A variation on this option,

involving stabilization of the excavated soil to allow for off-site landfill re-use, was evaluated in detail as described below, but was still costly in comparison to other feasible alternatives. Based on the high cost, it was determined that the benefits of approaching or achieving background conditions would not outweigh the costs that would be incurred. Therefore, it is not considered feasible to achieve or approach background levels for soil at the Site.

The following remedial actions were selected as potentially applicable and underwent initial screening for the Site:

- In-situ soil stabilization
- Excavation and off-site disposal
- Excavation, debris removal, and soil reuse on-site
- Excavation, on-site treatment to render soil non-hazardous, and off-site disposal
- Isolation barrier placement, or capping

In-situ stabilization alone was not retained for detailed evaluation because it may not fully achieve the remedial action objectives described above. Excavation and off-site disposal was screened out because, as described above, it was not expected to be cost effective. Excavation, debris removal, and soil reuse on-site was not retained for detailed evaluation because contaminated soil would remain and an AUL would be needed to prevent future recreational exposures, which is one possible future use that the Town of Brookfield has contemplated. The remaining two alternatives were retained for detailed evaluation.

Excavation of the full extent of contaminated soil and debris, separation and off-site disposal of the debris, on-site treatment of the contaminated soil to render the soil non-hazardous, and off-site disposal of the stabilized soil, was evaluated as a lower cost alternative to excavation and off-site disposal alone that would achieve background. This alternative would achieve a Permanent Solution by addressing human health risks associated with direct contact and risks to safety and would attain background conditions for the Site. The estimated cost to complete this alternative is $1.6 million.

Placement of an isolation barrier, or soil cap, across the Site was also evaluated in detail. The soil cap would provide a barrier to direct contact with impacted soils and debris. Under this alternative, an Activity and Use Limitation (AUL) would be needed to limit human activities that could breach the cap or expose underlying soils. Background conditions would not be attained under this alternative. The estimated cost to complete this alternative is $250,000. Other options for capping the Site to prevent exposure to soils and debris are available that the Town may consider depending on the future use of the Site and cost and constructability considerations. While costs for other capping options were not developed, their costs would

be more in line with the soil cap alternative and much lower than the excavation, on-site treatment, and off-site disposal alternative.

Therefore, the selected alternative is placement of a cap with an AUL to limit future Site activities. Based on the high relative cost of the excavation, on-site treatment, and off-site disposal alternative, it was determined that the benefits of approaching or achieving background conditions would not outweigh the costs that would be incurred. The capping alternative would achieve a Permanent Solution for the Site.

1.0 INTRODUCTION

On behalf of the U.S. Environmental Protection Agency (EPA) Region 1, Advanced Environmental Solutions (AES) of Worcester, Massachusetts, and its team subcontractor, AECOM Environment (formerly known as Metcalf & Eddy) of Wakefield, Massachusetts, prepared this Phase III Remedial Action Plan (RAP) for use by the Town of Brookfield, Massachusetts for MassDEP release tracking number (RTN) 2-10354, associated with the former Brookfield Mill property at 59-67 Mill Street in Brookfield (herein referred to as the Site). The purpose of this Phase III Remedial Action Plan is to identify, evaluate, and recommend appropriate comprehensive remedial actions that will result in a condition) of No Significant Risk and achieve either a permanent or temporary solution, leading to a Response Action Outcome (RAO). The EPA provided the services of AES as part of its Targeted Brownfields Assessment (TBA) program.

This RAP was prepared in accordance with the Massachusetts Contingency Plan (MCP), following guidance outlined in 310 CMR 40.0850, and is based on information presented in previous studies and reports, including a Phase II Comprehensive Site Assessment, which included a Method 3 Risk Characterization and a Method 3 Stage I Environmental Screening (M&E, 2007).

1.1 Site Location and Description

The former Brookfield Mill property is located on Mill Street, just north of the former Boston and Albany railroad tracks (now operated by CSX) on the southern edge of the business district of Brookfield, Massachusetts. The location is shown on Figure 1, Site Locus, and a disposal site map is provided as Figure 2. Site history, description and releases are provided in detail in the Phase II report and this information is briefly summarized below.

The former Brookfield Mill, a four-story wooden structure, was destroyed in a fire in August 2000. The Site is presently devoid of buildings or structures. All that remains of the former four-story mill building is the foundation and some rubble and debris on the old mill footprint. It appears that after the fire, the remnants of the building either collapsed or were demolished, such that they now partially fill the basement. Fill material (sand) also appears to have been placed into the basement void (M&E, 2002). The Site is currently owned by the Town of Brookfield. The Town took ownership of the Site in June 2003, along with the parcel immediately across Mill Street from the Site to the north. The Town constructed a new building to house the Town's Highway Department on the parcel north of Mill Street, and plans to redevelop the Site for Town use following the completion of MCP response actions. There are currently no on-site workers at the disposal site, although the Highway Department uses portions of the former mill property for storage of sand and gravel and other materials.

There is a wetland area located between the CSX railroad tracks and the Quaboag River. This area is owned by the Massachusetts Division of Fisheries and Wildlife (MassWildlife). The abutting property to the east of the former mill property is the location of Spencer Metal Finishing, Inc., a full-service metal finishing company specializing in polishing and buffing, powder coating, and abrasive bead blasting.

1.2 Site Background

The former Brookfield property was assigned Release Tracking Number (RTN) 2-10354 by MassDEP in March 1995 based on conditions discovered during a Limited Site Investigation of the property (Lycott, 1991). On January 3, 2003, a second RTN 2-14601 was assigned by MassDEP following the identification of 120-day reporting conditions identified during a Targeted Brownfields Assessment (M&E, 2002) of the former Brookfield Mill property. The results of soil and groundwater sampling performed as part of the TBA indicated the presence of several metals and polycyclic aromatic hydrocarbons (PAHs) in soil samples at concentrations above their respective reportable concentrations for S-1 category soils. Several field investigations and response actions have been subsequently performed at the former Brookfield Mill property and are summarized in the Phase I Initial Site Investigation Report, Tier Classification, and Phase II Scope of Work (M&E, 2004a and 2004b) and Phase II Comprehensive Site Assessment Report (M&E, 2007). The Site was classified as Tier II in 2004. At the same time, the second RTN 2-14601 was linked to the original RTN 2-10354. RTN 2-14601 is currently listed in MassDEP's site database as closed.

1.3 Review of Site Risks and Conditions

Based on the Phase II report, including the Method 3 Risk Characterization and ecological screening, Site conditions are considered to pose significant risk of harm to human health, safety, and the environment under current and/or future foreseeable Site activities and uses. Significant risk of harm is posed to potential future child residents, primarily attributable to the presence of lead in soil. Significant risk of harm is posed to child recreational users exposed to soil should the Site be developed as a park. Risk of harm to safety is significant under both current and future foreseeable Site conditions due to the presence of visible physical hazards (e.g., unstable slopes, glass, rusted waste).

There have been updates to preferred risk characterization calculation methods since the original Method 3 Risk Characterization was performed in November 2007. These changes have been reviewed with respect to the risk characterization performed for this Site. Calculations methods presented in *ShortForms for Human Health Risk Assessment under the MCP* (September 2008) were utilized to evaluate the results of the calculation changes.

Rather than screening modeled indoor air concentrations versus background concentrations, as was done in the original Method 3 Risk Characterization, all volatile analytes are now included in the indoor air risk characterization (Appendix A; Tables 1 and 2). Two analytes which were previously screened out, C_{11}-C_{22} aromatic hydrocarbon range and 2-methylnaphthalene, are now included in the calculations.

ShortForms for construction worker and residential soil exposures, as well as residential indoor air inhalation, have been included in Appendix A. The calculation methods for all other exposures summarized (Appendix A; Table 3) have not changed since the original risk characterization. Cumulative risks and hazards have increased for the receptors presented. However, none of the changes alter the conclusions of the risk characterization presented in the November 2007 Phase II report.

The future construction worker non-cancer hazard index (HI) has increased to 1, while the excess lifetime cancer risk (ELCR) has increased to 9E-08. Both of these values do not exceed the MassDEP target risk limits of 1 for HIs and 1E-05 for ELCRs.

The future resident chronic non-cancer HI is 50, while the ELCR is 5E-05. The subchronic non-cancer HI is 70. All of these values exceed the MassDEP target risk limits shown above. These exceedances are primarily due to the presence of polychlorinated biphenyls (PCBs), lead, and zinc in soil.

Additionally, the Phase II report indicated that there is evidence that lead concentrations in surface water, via groundwater discharge, may pose a risk of harm to aquatic habitat in the wetland area to the south of the former mill property. This finding was based on a comparison of a modeled surface water exposure point concentration of lead to the Lowest Ambient Water Quality Criteria (LAWQC) for lead. Surface water exposure point concentrations for the downgradient wetland were derived from available groundwater data using a default 10-fold dilution factor. However, groundwater data was limited to upland areas and it was not known whether groundwater impacts extended south of the drainage trench and into the wetlands to the south. Subsequent to the Phase II report, monitoring well installation and groundwater sampling within the wetlands was performed. Additional monitoring wells were installed on February 20, 2009 and groundwater sampling was performed on March 10, 2009. A brief summary of the field activities, boring logs, groundwater sampling logs, a figure showing the locations of the monitoring wells, and the laboratory report are included as Appendix B. No lead was detected in any of the monitoring wells, indicating that groundwater within the wetlands does not appear to be impacted and therefore, discharge of lead-contaminated groundwater to surface water within the wetland does not appear to be a concern.

Site conditions that were identified in the Phase I and Phase II assessments were considered during the review of remedial alternatives. These site conditions include:

- As documented in the Phase II report, the most likely sources of contamination at the Site are building debris and ash from the mill fire. A former underground storage tank (UST) located north of Mill Street and its associated piping have been ruled out as a potential source. Metals are the main contaminant of concern. PAHs may have also been released, however concentrations are generally consistent with MassDEP published background levels for natural soils. It is possible that past disposal practices of former businesses located at the Site may have contributed to elevated metals concentrations. Additionally, some metals may be naturally occurring.

- The extent of soil contamination is limited to the immediate area of the former mill building. Specifically, the Site is defined as an area encompassing the former building footprint and bounded by Mill Street to the north, soil borings MEB-11 and MEB-12 to the west, the drainage trench to the south, and the property boundary to the east (see Figure 2). The vertical extent of soil contamination has been estimated to be limited to the depth of fill and disturbed soils associated with the former building, which ranges from 5 to 10 feet in depth.

- Toxicity characteristic leaching procedure (TCLP) analysis was performed on test pit soil samples in 2002 and several samples exceeded the TCLP regulatory level for lead. Based on this data, Site soils would be considered Resource, Conservation, and Recovery Act (RCRA) characteristic hazardous waste (code D008) for the purpose of off-site disposal.

- Significant rubble and debris (wire, small machinery, timbers, and concrete) are mixed with the contaminated soils, as observed in previous test pits and soil borings.

An estimate of the volume of metals-contaminated soils is provided in Section 1.4, below.

1.4 Volume Estimate

Assuming an average depth of impacted soils of 7.5 feet over an area approximately 325 feet long by 105 feet wide (based on Figure 2), the total impacted volume is estimated to be 9,500 cubic yards. For the purpose of developing the cost estimates presented in Section 4.0, it is assumed that 30% of the impacted volume is comprised of rubble and debris.

2.0 REMEDIAL ACTION OBJECTIVES

Based on the results of the Method 3 Human Health Risk Characterization documented in the Phase II report, risk of harm to safety is significant under both current and future foreseeable Site conditions due to the presence of visible physical hazards (e.g., unstable slopes, glass, rusted waste). Significant risk of harm is posed to potential future child residents and child recreational users exposed to soil should the Site be developed as a park.

The response action performance standards of the MCP require that the Site be cleaned up to background concentrations if feasible. The performance standards also require that the overall mass and volume of contamination be reduced. The feasibility of achieving background and reducing mass and volume of contamination in soil at the Site are discussed in Section 2.1.

For the purpose of this plan, the term "remedial action" includes, but is not necessarily limited to: soil excavation and off-site disposal, in-situ soil stabilization, capping, and/or the implementation of an Activity and Use Limitation (AUL). A list of remedial action objectives is provided in Section 2.2.

2.1 Feasibility of Achieving Background Conditions

The following section evaluates the feasibility of achieving background levels at the Site. This evaluation is consistent with the approach outlined in the MCP and in DEP policy # WSC-04-160 for conducting feasibility evaluations under the MCP. Background concentrations are defined by the MCP as reflecting geologic or ecologic conditions, atmospheric deposition of emissions, ash used as fill, and petroleum residues incidental to the normal operation of motor vehicles. Media impacted by any additional sources would not be representative of background. The MCP requires that the feasibility evaluation include the following:

- Whether the benefits of the remedial actions to achieve or approach background justify the costs or risks associated with those actions;
- Whether technology exists to conduct such remedial actions to achieve background;
- Whether necessary expertise is available or present; or
- Whether there is a facility available to accept waste material for disposal if off-site disposal is the only method available for achieving or approaching background.

As described in the Phase II report (M&E, 2007), background concentrations of metals are exceeded in surface and subsurface soils within the Site. Achieving or approaching background levels would require remediating all soils within the limits of the Site. The only available method that would achieve background

conditions for the Site would be removal and off-site reuse or disposal of the full extent of impacted soils. Removal, transport, and off-site disposal of this volume of soil would be extremely costly, because the soil would be considered RCRA hazardous waste. It is estimated that the disposal cost alone would be $250 per ton of soil or approximately $2.5 million to dispose of an estimated 10,000 tons based on estimates obtained from waste disposal firms. This cost would be more than an order of magnitude greater than the lowest cost alternative, evaluated in Section 4.0, which would also achieve No Significant Risk. As evaluated in Section 4.0, it is possible to reduce the cost of off-site disposal by treating the soil, such that it would no longer be considered RCRA hazardous waste. While this approach would result in some cost savings, the costs are still greater than 20% more than the lowest cost alternative, which would achieve No Significant Risk (see Section 4.0 for detailed evaluation of these alternatives).

Thus, based on the discussions above, it has been determined that the benefits of approaching or achieving background conditions would not outweigh the costs that would be incurred. Therefore, it is not feasible to achieve or approach background levels for soil at the Site.

2.2 Determination of Remedial Action Objectives

Based on the results of the Phase II comprehensive site assessment and risk characterization conducted for the Site (presented in the Phase II report), soil contaminants identified at the Site pose risk to human health under foreseeable future uses and require remediation. In order to best select remediation approaches, criteria are developed based on applicable regulatory requirements and risk-based concentrations of contaminants present at the Site. The remediation criteria are presented as Remedial Action Objectives, shown on Table 2-1.

These remedial action objectives were used to identify potential remedial alternatives. The screening and evaluation of alternatives are presented in Sections 3.0 and 4.0.

Table 2-1
Remedial Action Objectives

MEDIA AND STUDY AREA	REMEDIAL ACTION OBJECTIVES	BASIS FOR RAO
Surface and Subsurface Soil	Prevent future direct exposures to Site soils by child residents and child recreational users.	The Method 3 risk characterization (M&E, 2007) concluded that significant risk of harm is posed to potential future child residents and child recreational users exposed to soil should the Site be developed as a park.
Surface and Subsurface Soil	Remove unstable slopes and prevent direct exposures to glass, rusted wastes, and other debris that may pose a physical hazard.	The Method 3 risk characterization (M&E, 2007) concluded that risk of harm to safety is significant under both current and future foreseeable Site conditions due to the presence of visible physical hazards (e.g., unstable slopes, glass, rusted waste).

3.0 INITIAL SCREENING OF REMEDIAL ALTERNATIVES

The screening of remedial alternatives entails the selection of those activities most likely to be feasible to achieve a permanent or temporary solution (as defined by the MCP) at the Site; those that are compatible for the quantities, concentrations and types of contaminants; and those for which expertise and\or technology exists to implement them.

The following remedial actions were selected as potentially applicable and underwent initial screening for the Site:

- In-situ soil stabilization
- Excavation and off-site disposal
- Excavation, debris removal, and soil reuse on-site
- Excavation, on-site treatment to render soil non-hazardous, and off-site disposal
- Isolation barrier placement, or capping

A brief description of each alternative is provided as follows:

In-situ Soil Stabilization: In-situ stabilization would involve the application of stabilization agents to Site soils to prevent leaching of lead. This alternative is not likely to be feasible because of the large amount of debris (wire, small machinery, timber, and concrete) mixed with the contaminated soils, making it difficult to apply the stabilization agents in place. Also, this action does not reduce lead concentrations in soil and therefore, may not fully address potential human health risks associated with direct exposure to Site soils. Further, this alternative does not address risks to safety related to the presence of debris near the surface and potentially unstable slopes. Therefore, this alternative was not retained for detailed evaluation.

Excavation and Off-Site Disposal: Excavation of the full extent of contaminated soils with off-site disposal as RCRA hazardous waste would achieve a Permanent Solution by addressing human health risks associated with direct contact and risks to safety and would attain background conditions for the Site. Potential risks to safety would be addressed through removal of debris and backfilling with clean soils in such a manner to prevent potentially unstable slopes. However, due to the volume of soil and the high disposal costs for soils classified as RCRA hazardous waste, this alternative is not expected to be cost effective. Therefore, excavation and off-site disposal, without treatment, was not retained for detailed evaluation.

Excavation, Removal and Off-Site Disposal of Debris, and Soil Reuse On-Site: This alternative would involve excavation of Site soils, removal of debris from the soil, and replacement of the soil as backfill. The separated debris would be disposed off-site. This alternative would address risks to safety related to the

presence of debris and potentially unstable slopes. Replacement of Site soils as backfill would not reduce the potential future human health risk associated with direct contact with contaminated soils. Thus, an AUL would be needed to prevent future residential or recreational uses of the Site and achieve a Permanent Solution. Background conditions would not be attained under this alternative. Because the AUL would limit future recreational uses, including use of the Site as park, which is one future use that the property owner has contemplated, this alternative was not retained for detailed evaluation.

Excavation, On-Site Treatment, and Off-Site Disposal: This alternative would involve excavation and on-site stabilization of Site soils and subsequent off-site disposal of the treated soils. On-site stabilization would render the soil non-hazardous and thus, substantially reduce off-site disposal costs. This alternative would achieve a Permanent Solution by addressing human health risks associated with direct contact and risks to safety and would attain background conditions for the Site. Potential risks to safety would be addressed through removal of debris and backfilling with clean soils in such a manner to prevent potentially unstable slopes. This alternative has been retained for detailed evaluation.

Isolation Barrier Placement or Capping: This alternative would involve placement of a clean soil cap across the Site that would provide a barrier to direct contact with impacted soils and debris. Because contaminated soils would be left in place, an AUL would be needed to limit human activities that could breach the cap or expose underlying soils. Background conditions would not be attained under this alternative. This alternative has been retained for detailed evaluation.

4.0 DETAILED EVALUATION OF REMEDIAL ALTERNATIVES

Remediation alternatives that were retained from the initial screening have been evaluated with the criteria listed below.

4.1 Identification of Detailed Evaluation Criteria

Each potentially feasible alternative must be evaluated by criteria specified in the MCP. This section describes each of the alternatives in further detail and presents an evaluation of these alternatives in relation to the applicable criteria. The evaluation criteria are summarized as follows:

Effectiveness. Effectiveness is a measure of the degree to which each alternative is capable of removing or destroying constituents of concern from Site media, and/or preventing exposures to the constituents, such that a condition of No Significant Risk is attained. Alternatives that reuse, recycle, detoxify, or destroy constituents on site are considered to be preferable to alternatives that result in movement of impacted material to an off-site location (MCP 40.0191(3)). Similarly, recycling, reuse, or destruction is judged more effective than disposal.

Reliability. Reliability is a measure of the likelihood that an alternative will be successful in attaining remedial action objectives. Alternatives that use proven technologies and result in removal or destruction of constituents are favored over those that rely on less proven technologies, or on containment methods that require long-term maintenance.

Implementability. Factors that affect the implementability of an alternative include technical complexity; the degree to which the alternative is compatible with other ongoing Site activities; monitoring and access requirements and limitations; availability of personnel, equipment, and materials; availability of off-site treatment/disposal facilities; and likelihood of obtaining any approvals, licenses or permits that may be required. The implementation of any remedial activity may be complicated by the presence of subsurface utilities.

Cost. Estimates of capital cost and operation and maintenance (O&M) annual costs (if appropriate) for each alternative are considered.

Risks. The evaluation of risks for an alternative includes risks that may be present during implementation, ongoing remediation, and post-remediation phases. Risks to the general public, Site workers, and natural resources are considered. Alternatives that involve invasive activities such as excavation, or treatment options that result in emissions or discharges, pose more risk during implementation and remediation than would a natural attenuation or containment-type alternative, but the post-remediation risks are greater for the latter alternatives since more constituents are left on site.

Benefits. Potential benefits of a remedial action alternative include the benefits of restoring natural resources and restoring a property to productive uses. There is value in restoration of this Site.

Timeliness. Timeliness is evaluated by estimating the length of time it takes each alternative to achieve a level of No Significant Risk. Timeliness is important for the Site, however, there are no imminent hazards posed by the Site conditions that require immediate attention.

Non-Pecuniary Interests (Aesthetics). This criterion considers impacts of the remedial alternative on the aesthetic and historical values of a property and its vicinity. There are no identified historical features, but Site remediation would likely improve the aesthetic value of the property.

4.2 Detailed Evaluation of Alternatives

The remedial activities that were screened as likely to be feasible have been evaluated using the criteria listed above. The alternatives include: 1) excavation with on-site treatment to render the soil non-hazardous and subsequent off-site disposal, and 2) placement of a soil cap.

4.2.1 Excavation, On-Site Treatment, and Off-Site Disposal of Site Soils

Description. This alternative involves excavation of the full extent of contaminated soil for off-site disposal. The soil would undergo stabilization on-site in order to render soil the non-hazardous and thus reduce the disposal costs. After stabilization, the soil would no longer leach lead at levels that exceed the TCLP regulatory level. At that point, the stabilized soil would no longer be classified as hazardous waste. An estimate of the volume of contaminated soils is provided in Section 1.4 of this report. As the material is excavated, rubble and debris would be removed from the soil for off-site disposal as solid waste. It is assumed that the metals stabilization would be performed ex-situ, following separation of the soil from the rubble and debris. The stabilized soil would likely be acceptable for reuse as cover material at a Massachusetts lined landfill. Clean fill would be used to return the Site to surrounding grade. Dust control measures would be implemented and perimeter aire monitoring would be performed during excavation and backfill activities.

Before remedial activities can begin, a Phase IV Remedy Implementation Plan (RIP) must be prepared in accordance with 310 CMR 40.0874. The RIP presents the conceptual design of the remedial action including plans for air monitoring, erosion control and spill control; and includes construction plans and specifications as appropriate that specify how remedial activities will be carried out. The RIP also includes a Health and Safety Plan that will be followed during performance of the remedial action.

Effectiveness. The excavation alternative does not result in on-site re-use, recycling, or destruction of contaminants. Impacted soils are excavated and likely re-used at an off-site lined landfill. Excavation would attain a Permanent Solution for the Site.

Reliability. Excavation and off-site re-use/disposal is a reliable means of removing contamination from the site.

Implementability. The excavation alternative may be complex due to the site location immediately adjacent to Mill Street as well as active railroad tracks. Road traffic may be temporarily impacted during excavation. Space is somewhat limited for staging of equipment and soil and debris stockpiling. Equipment for services to conduct excavation and soil stabilization and services for soil disposal are available locally and regionally.

Cost. The capital cost for this alternative is approximately $1.6 million. It is assumed that no operation and maintenance costs are associated with this alternative. The costs are based on the assumption that the stabilized soil will be acceptable for reuse at a lined landfill. The costs include preparation of MCP submittals. Refer to Appendix C for estimated costs.

Risks. There are potential risks to site workers during excavation because of the presence of soil contaminants and risks of falling. Air monitoring at the site perimeter would be performed for dust to make sure that the dust control measures are effective. Excavation workers will need to wear appropriate personal protective equipment to reduce the potential for exposures to contamination and follow an OSHA-approved health and safety program. The excavation, stabilization, and off-site reuse/disposal would achieve a Condition of No Significant Risk for future exposure scenarios.

Benefits. Excavation provides the potential benefits of removal of contaminant mass and reaching a Condition of No Significant Risk, without the need for an AUL. Remediation would allow the site to be utilized to a greater extent.

Timeliness. Implementation of this alternative would result in achieving a Permanent Solution in a timely manner.

Non-Pecuniary Interests. There are no known non-pecuniary interests related to remediation of the Site beyond visual aesthetic improvements.

4.2.2 Placement of a Soil Cap

Description. This alternative would involve placement of a clean soil cap across the Site that

would provide a barrier to direct contact with impacted soils and debris. Based on the Site boundary, shown in Figure 2, it is estimated that the area to be capped is approximately 330 feet long by 110 feet wide. Because contaminated soils would be left in place, an AUL would be needed to limit human activities that could breach the cap or expose underlying soils.

For the purpose of this plan, it is assumed that the cap will consist of a minimum of 3 feet of soil cover such that the underlying contaminated soils would no longer be considered accessible under the MCP. Some regrading of the existing soil would likely be needed prior to placement of the soil cap in order to tie into the existing grade at the road. For cost purposes, it is assumed that the cap would be constructed of 2 ½ feet of clean fill topped by ½ foot of loam, and a grass cover would be established. The Town of Brookfield would be responsible for maintaining the soil cap and vegetation. Dust control measures would be implemented and perimeter aire monitoring would be performed during excavation and backfill activities.

Other options for capping the Site to prevent exposure to soils and debris are available that the Town may consider depending on the future use of the Site and cost/constructability considerations. For example, an alternative to the soil cap would be to incorporate pavement and an appropriate subgrade material so that the area can be paved and used for parking. An advantage associated with paving the entire cap would be that less that 3 feet of cover material would be needed, which would be less costly. Since the Town of Brookfield has not yet decided on a definite plan for future use of the property, the more costly approach (i.e., the soil cap) has been evaluated here.

Before remedial activities can begin, a Phase IV Remedy Implementation Plan (RIP) must be prepared in accordance with 310 CMR 40.0874. The RIP presents the conceptual design of the remedial action including plans for air monitoring, erosion control and spill control; and includes construction plans and specifications as appropriate that specify how remedial activities will be carried out. The RIP also includes an Operation, Maintenance and Monitoring Plan for remedial actions that require on-going O&M activities; and a Health and Safety Plan that will be followed during performance of the remedial action.

Effectiveness. The capping alternative does not result in on-site re-use, recycling, or destruction of contaminants. The combination of the soil cap and AUL would effectively prevent exposures to contaminated soils and debris. Capping would attain a Permanent Solution for the Site.

Reliability. A soil cap or other type of isolation barrier would require long-term maintenance in order to prevent possible exposure to the underlying contaminated soil. Thus, this alternative is considered less reliable than alternatives that would achieve background conditions. Overall, this

alternative is still expected to be a reliable means of maintaining a condition of No Significant Risk for the Site.

Implementability. The capping alternative may be complex due to the site location immediately adjacent to Mill Street as well as active railroad tracks. Road traffic may be temporarily impacted during regarding and cap construction. Space is somewhat limited for staging of equipment and materials. Equipment for services to construct soil caps is available locally and regionally.

Cost. The capital cost for this alternative is approximately $250,000. The estimated costs for this alternative do not include operation and maintenance costs; however, it is assumed that the town would conduct long-term maintenance of the cap. The costs include preparation of MCP submittals and AUL. Refer to Appendix C for estimated costs. Also, as noted above, there may other potentially less costly options for capping the Site that are not estimated here and depend on the future use of the Site.

Risks. There are potential risks to site workers during capping activities because of the presence of soil contaminants and risks of falling. Air monitoring at the site perimeter should be performed for dust to make sure that the dust control measures are effective. Excavation workers will need to wear appropriate personal protective equipment to reduce the potential for exposures to contamination and follow an OSHA-approved health and safety program. The capping alternative would achieve a condition of No Significant Risk for future exposure scenarios.

Benefits. The combination of capping and application of an AUL on the property would reach a Condition of No Significant Risk for the Site. The disadvantage is that some long-term maintenance would be required to maintain the integrity of the cap.

Timeliness. Implementation of this alternative would result in achieving a Permanent Solution in a timely manner.

Non-Pecuniary Interests. There are no known non-pecuniary interests related to remediation of the Site beyond visual aesthetic improvements.

5.0 SELECTION OF REMEDIAL ACTION ALTERNATIVE

According to Section 40.0859 of the MCP, remedial action alternatives are selected based on the detailed evaluation criteria (Section 4.0), with consideration of whether the alternative is a Permanent Solution, and the degree to which the alternative reduces concentrations of contaminants to background levels. In addition, an Engineered Barrier, cap or other remedial action alternative that relies upon on-site disposal, isolation, or containment of oil and/or hazardous material should not be selected unless the lack of a feasible alternative has been demonstrated.

5.1 Identification of Selected Alternatives

Of the two alternatives evaluated, including 1) excavation, on-site treatment, and off-site disposal, and 2) placement of an isolation barrier or soil cap, both options would achieve a Permanent Solution by addressing human health risks associated with direct contact and risks to safety. The first alternative has the advantage that background conditions would be attained for the Site, whereas the second alternative would require an AUL in order to limit human activities that could breach the cap or expose underlying soils. However, the excavation, on-site treatment, and off-disposal alternative would cost roughly an order of magnitude more to implement than the isolation barrier (or soil cap) alternative.

Therefore, the selected alternative is placement of a cap with an AUL to limit future site activities. Based on the high relative cost of the excavation, on-site treatment, and off-site disposal alternative, it was determined that the benefits of approaching or achieving background conditions would not outweigh the costs that would be incurred.

5.2 Implementation Schedule

The implementation of the each alternative will begin in the Spring of 2010. It is anticipated that a Response Action Outcome Statement (Class A) will be completed and filed before the end of October 2010.

Task	**Schedule**
Prepare remedy implementation documents (Phase IV Remedy Implementation Plan and Operation, Maintenance, and Monitoring Plan)	March 2010
Construct Soil Cap	Summer 2010
Prepare Activity and Use Limitation Submit Phase IV Completion Statement and Class A Response Action Outcome Statement	October 2010

6.0 REFERENCES

Lycott Environmental Research, Inc. (Lycott). 1991. *Phase I Limited Site Investigation, Brookfield Mill, 112-114 Mill Street, Brookfield, MA.* August 1991.

Metcalf & Eddy, Inc. (M&E). 2002. *Targeted Brownfield Assessment Final Report, 54 – 67 Mill Street, Brookfield, Massachusetts*. Prepared for the U.S. Environmental Protection Agency. November 2002.

Metcalf & Eddy, Inc. (M&E) 2004a. *Phase I Initial Site Investigation Report, Mill Street Property, Brookfield, Massachusetts, Release Tracking Numbers (RTNs) 2-14601 and 2-10354,* Prepared for the Town of Brookfield, Massachusetts. January 7, 2004.

Metcalf & Eddy, Inc. (M&E) 2004b. *Conceptual Phase II Scope of Work, Mill Street Property, Brookfield, Massachusetts, Release Tracking Numbers (RTNs) 2-14601 and 2-10354,* Prepared for the Town of Brookfield, Massachusetts. January 7, 2004.

Metcalf & Eddy, Inc. (M&E) 2007. *Phase II Comprehensive Site Assessment Report, Former Brookfield Mill Property, 59-67 Mill Street, Brookfield, Massachusetts, Release Tracking Number (RTN) 2-10354.* November 2007.

7.0 LIMITATIONS

No warranty, whether expressed or implied, is given with respect to this report or any opinions herein. It is expressly understood that this report and opinions expressed herein are based upon site conditions reported to AES/AECOM, observed by AES/AECOM, and as they existed only at the time this Phase III Remedial Action Plan was prepared. Without limiting the foregoing, this report, any opinions or conclusions stated herein, and its attachments are subject to the complete General Statement of Limitations and Conditions provided in Appendix D, which are incorporated by reference into, and are an integral part of, this report submittal. This report has been prepared on behalf of, and for the exclusive use of, the U.S. Environmental Protection Agency. Any use of or reliance on AES/AECOM's report by a third party, even with AES/AECOM's consent, shall be at such party's own risk.

FIGURES

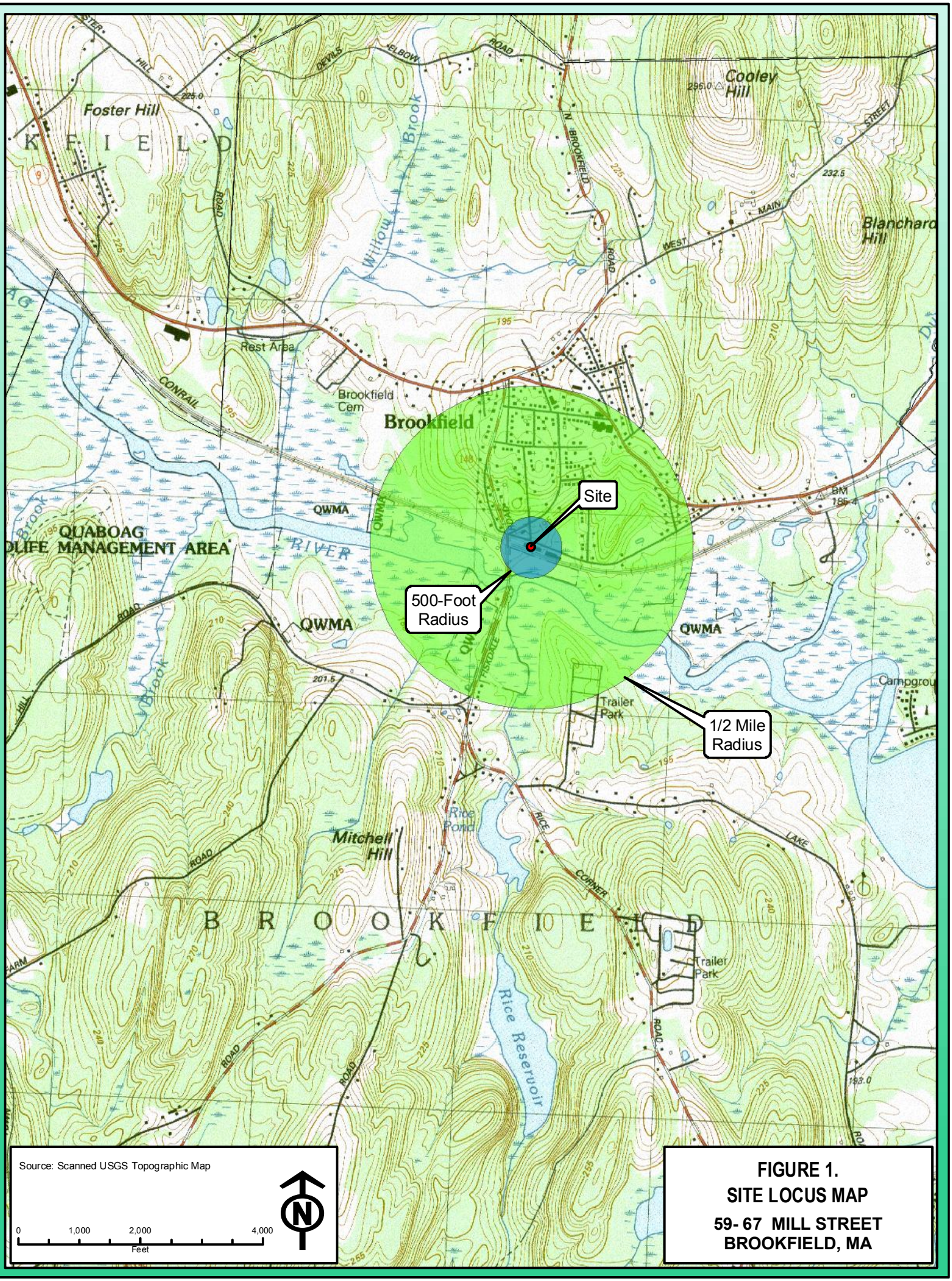

FIGURE 1.
SITE LOCUS MAP
59- 67 MILL STREET
BROOKFIELD, MA

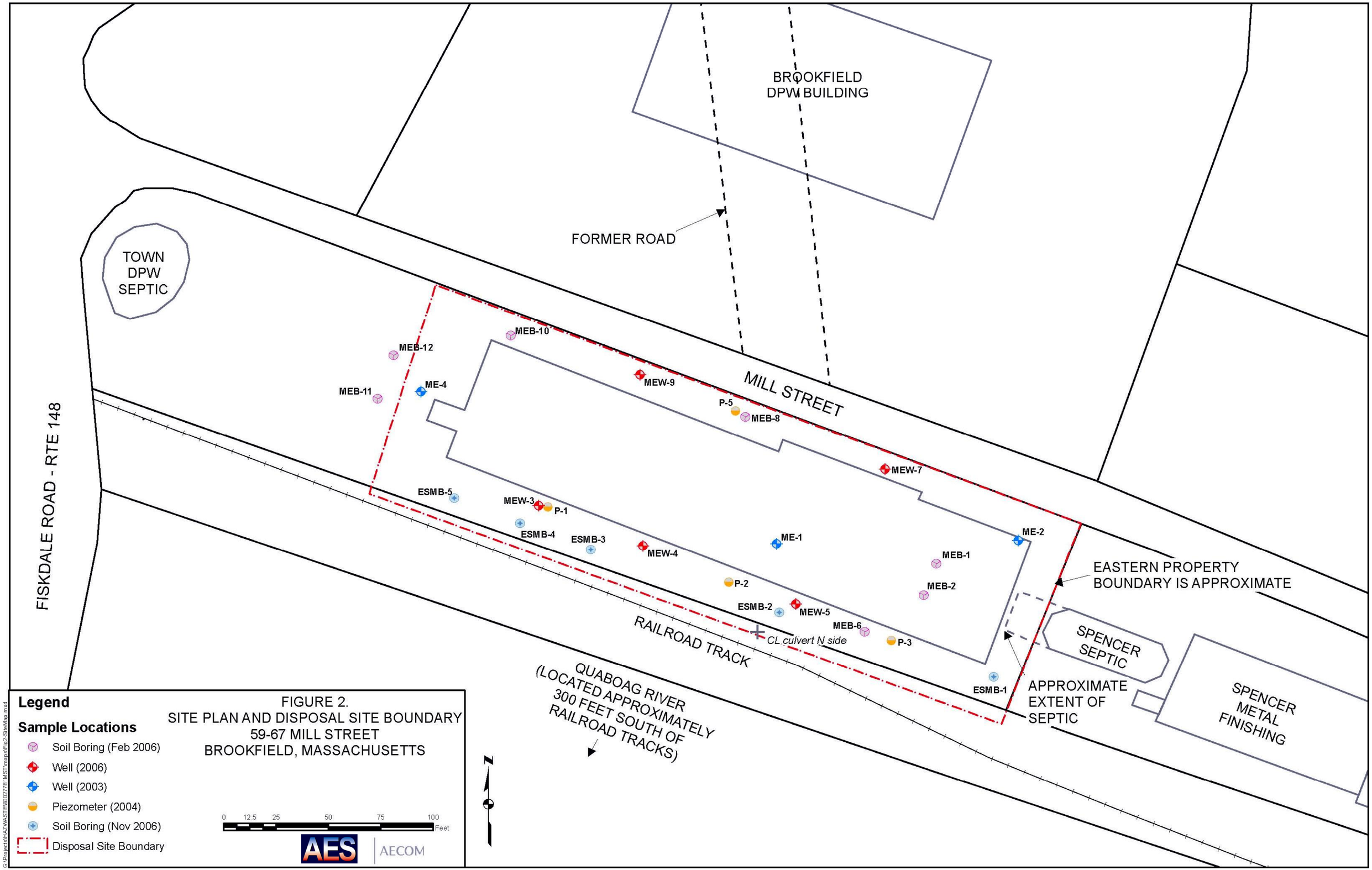

FIGURE 2.
SITE PLAN AND DISPOSAL SITE BOUNDARY
59-67 MILL STREET
BROOKFIELD, MASSACHUSETTS

APPENDIX A

SUPPLEMENTAL RISK CALCULATIONS

TABLE 1
SOIL TO INDOOR AIR - 95% UCL SOIL CONCENTRATIONS
FORMER BROOKFIELD MILL SITE

	Soil EPC	Soil Temp.	Soil Temp.	Henry's Law Constant at ref. temp.	Henry's Law Reference Temp.	Normal Boiling Point	Enthalpy of vaporization at T_S	Critical Temp.	constant	Enthalpy of vaporization at T_S	Gas Constant	Henry's Law Constant at T_S	Gas Constant	Henry's Law Constant
	C_R	T_S	T'_S	H_R	T_R	T_B	$\Delta H_{v,B}$	T_C	n	$\Delta H_{v,TS}$	R_c	H_{TS}	R	H'_{TS}
Units:	µg/kg	°C	K	atm-m³/mol	K	K	cal/mol	K	unitless	cal/mol	cal/mol-K	atm-m³/mol	m³-atm/mol-K	unitless
Formula:	**Input**	(10 for screening)	(T_S + 273.15)	lookup	(lookup+273.15)	lookup	lookup	lookup	(Note 7)	(Note 8)		(Note 9)		H_{TS} / (R * T'_S)
Analyte														
C9-C12 Aliphatics	**5.08E+03**	1.00E+01	2.83E+02	1.56E+00	2.98E+02	NA	NA	NA	NA	NA	1.99E+00	1.56E+00	8.21E-05	6.71E+01
C9-C18 Aliphatics	**5.29E+04**	1.00E+01	2.83E+02	1.66E+00	2.98E+02	NA	NA	NA	NA	NA	1.99E+00	1.66E+00	8.21E-05	7.13E+01
C11-C22 Aromatics	**8.50E+04**	1.00E+01	2.83E+02	7.20E-04	2.98E+02	NA	NA	NA	NA	NA	1.99E+00	7.20E-04	8.21E-05	3.10E-02
2-Methylnaphthalene	**4.29E+02**	1.00E+01	2.83E+02	5.18E-04	2.98E+02	5.14E+02	1.08E+04	7.61E+02	3.84E-01	1.40E+04	1.99E+00	1.49E-04	8.21E-05	6.40E-03
Phenanthrene	**1.03E+03**	1.00E+01	2.83E+02	4.23E-05	2.98E+02	6.13E+02	1.31E+04	8.69E+02	4.06E-01	1.84E+04	1.99E+00	8.16E-06	8.21E-05	3.51E-04

TABLE 1 (continued)
SOIL TO INDOOR AIR - 95% UCL SOIL CONCENTRATIONS
FORMER BROOKFIELD MILL SITE

	Conversion Factor µg/kg to g/g	SCS soil type in vadose zone	Vadose zone soil dry bulk density	Vadose zone soil water-filled porosity	Organic carbon partition coefficient	Vadose zone organic carbon fraction	Soil-water partition coefficient	Vadose zone soil total porosity	Vadose zone soil air-filled porosity	Conversion Factor g/cm^3 to $\mu g/m^3$	Source Vapor Conc.
	Conv01	ST_v	ρ_b	$\theta_{w,v}$	K_{oc}	$f_{oc,v}$	K_d	n_v	$\theta_{a,v}$	Conv03	C_{source}
Units:	µg/kg / g/g	unitless	g/cm^3	cm^3/cm^3	cm^3/g	unitless	cm^3/g	cm^3/cm^3	cm^3/cm^3	g/cm^3 / $\mu g/m^3$	$\mu g/m^3$
Formula:		(Note 11)	lookup	lookup	lookup	(0.002 for screening)	$K_{oc} * f_{oc}$	lookup	$n_v - \theta_{w,v}$		(Note 21)
Analyte											
C9-C12 Aliphatics	1.00E-09	SCL	1.63E+00	1.46E-01	1.50E+05	2.00E-03	3.00E+02	3.84E-01	2.38E-01	1.00E+12	1.10E+06
C9-C18 Aliphatics	1.00E-09	SCL	1.63E+00	1.46E-01	6.80E+05	2.00E-03	1.36E+03	3.84E-01	2.38E-01	1.00E+12	2.75E+06
C11-C22 Aromatics	1.00E-09	SCL	1.63E+00	1.46E-01	5.01E+03	2.00E-03	1.00E+01	3.84E-01	2.38E-01	1.00E+12	2.60E+05
2-Methylnaphthalene	1.00E-09	SCL	1.63E+00	1.46E-01	2.50E+03	2.00E-03	5.00E+00	3.84E-01	2.38E-01	1.00E+12	5.40E+02
Phenanthrene	1.00E-09	SCL	1.63E+00	1.46E-01	1.40E+04	2.00E-03	2.80E+01	3.84E-01	2.38E-01	1.00E+12	1.28E+01

TABLE 1 (continued)
SOIL TO INDOOR AIR - 95% UCL SOIL CONCENTRATIONS
FORMER BROOKFIELD MILL SITE

	Depth below grade to bottom of enclosed space	Depth below grade to contamination	Source Building Separation	Diffusivity in air	Diffusivity in water	Vadose zone Effective Diffusion Coeff.	Total Overall Effective Diffusion Coeff.	Area of Enclosed Space Below Grade	Building Ventilation Rate	Pressure Diff. between soil & enclosed space	Vadose zone soil saturated hydraulic conductivity
	L_F	L_t	L_T	D_a	D_w	D_v^{eff}	D_T^{eff}	A_B	$Q_{building}$	ΔP	$K_{s,v}$
Units:	cm	cm	cm	cm^2/s	cm^2/s	cm^2/s	cm^2/s	cm^2	cm^3/s	$g/cm\text{-}s^2$	cm/hr
Formula:	(15 or 200 for screening)	(400 for screening)	$L_t - L_F$	lookup	lookup	(Note 13)	(Note 4)	(Note 2)	(Note 2a)	(40 for screening)	lookup
Analyte											
C9-C12 Aliphatics	2.00E+02	4.00E+02	2.00E+02	7.00E-02	1.00E-06	3.99E-03	3.99E-03	1.80E+06	2.54E+04	4.00E+01	5.50E-01
C9-C18 Aliphatics	2.00E+02	4.00E+02	2.00E+02	7.00E-02	5.00E-06	3.99E-03	3.99E-03	1.80E+06	2.54E+04	4.00E+01	5.50E-01
C11-C22 Aromatics	2.00E+02	4.00E+02	2.00E+02	6.00E-02	1.00E-06	3.42E-03	3.42E-03	1.80E+06	2.54E+04	4.00E+01	5.50E-01
2-Methylnaphthalene	2.00E+02	4.00E+02	2.00E+02	6.29E-02	7.20E-06	3.59E-03	3.59E-03	1.80E+06	2.54E+04	4.00E+01	5.50E-01
Phenanthrene	2.00E+02	4.00E+02	2.00E+02	3.33E-02	7.47E-06	2.13E-03	2.13E-03	1.80E+06	2.54E+04	4.00E+01	5.50E-01

TABLE 1 (continued)
SOIL TO INDOOR AIR - 95% UCL SOIL CONCENTRATIONS
FORMER BROOKFIELD MILL SITE

	Conversion Factor hr to s	Viscosity of water at 10°C	Viscosity of water at system temp.	Density of water	Acceleration due to gravity	Vadose zone soil intrinsic permeability	Vadose zone residual soil water content	Vadose zone effective total fluid saturation	Vadose zone van Genuchten shape parameter	Vadose zone soil relative air permeability	Vadose zone soil effective vapor permeability
	Conv02	μ_{w-10}	μ_w	ρ_w	g	$k_{i,v}$	$\theta_{r,v}$	S_{te}	M_v	k_{rg}	k_v
Units:	s/hr	g/cm-s	g/cm-s	g/cm^3	cm/s^2	cm^2	cm^3/cm^3	unitless	unitless	unitless	cm^2
Formula:			(Note 16)	(0.999 for screening)		(Note 17)	lookup	(Note 18)	lookup	(Note 19)	(Note 20)
Analyte											
C9-C12 Aliphatics	3.60E+03	1.31E-02	1.31E-02	9.99E-01	9.81E+02	2.04E-09	6.30E-02	2.59E-01	2.48E-01	8.59E-01	1.75E-09
C9-C18 Aliphatics	3.60E+03	1.31E-02	1.31E-02	9.99E-01	9.81E+02	2.04E-09	6.30E-02	2.59E-01	2.48E-01	8.59E-01	1.75E-09
C11-C22 Aromatics	3.60E+03	1.31E-02	1.31E-02	9.99E-01	9.81E+02	2.04E-09	6.30E-02	2.59E-01	2.48E-01	8.59E-01	1.75E-09
2-Methylnaphthalene	3.60E+03	1.31E-02	1.31E-02	9.99E-01	9.81E+02	2.04E-09	6.30E-02	2.59E-01	2.48E-01	8.59E-01	1.75E-09
Phenanthrene	3.60E+03	1.31E-02	1.31E-02	9.99E-01	9.81E+02	2.04E-09	6.30E-02	2.59E-01	2.48E-01	8.59E-01	1.75E-09

TABLE 1 (continued)
SOIL TO INDOOR AIR - 95% UCL SOIL CONCENTRATIONS
FORMER BROOKFIELD MILL SITE

	Floor-wall seam perimeter	Vapor viscosity at avg. soil temp.	Crack depth below grade	Total area of cracks	Crack-to-total area ratio	Equivalent crack radius	Avg. Vapor Flow Rate Into Bldg.	Foundation or Slab Thickness	Crack Effective Diffusion Coeff.	Infinite Source Indoor Attenuation Coeff.	Infinite Source Bldg. Conc.
	X_{crack}	μ_{TS}	Z_{crack}	A_{crack}	η	r_{crack}	Q_{soil}	L_{crack}	D^{crack}	α	$C_{building}$
Units:	cm	g/cm-s	cm	cm^2	unitless	cm	cm^3/s	cm	cm^2/s	unitless	$\mu g/m^3$
Formula:	(4000 for screening)	0.00018*(T_S/298.15)^0.5	(= L_F for screening)	(400 for screening)	A_{crack}/A_B	$\eta(A_B/X_{crack})$	(Note 5)	(10 for screening)	(Note 1)	(Note 6)	C_{source} * α
Analyte											
C9-C12 Aliphatics	4.00E+03	1.75E-04	2.00E+02	4.00E+02	2.22E-04	1.00E-01	1.21E+00	1.00E+01	3.99E-03	4.61E-05	5.07E+01
C9-C18 Aliphatics	4.00E+03	1.75E-04	2.00E+02	4.00E+02	2.22E-04	1.00E-01	1.21E+00	1.00E+01	3.99E-03	4.61E-05	1.27E+02
C11-C22 Aromatics	4.00E+03	1.75E-04	2.00E+02	4.00E+02	2.22E-04	1.00E-01	1.21E+00	1.00E+01	3.42E-03	4.58E-05	1.19E+01
2-Methylnaphthalene	4.00E+03	1.75E-04	2.00E+02	4.00E+02	2.22E-04	1.00E-01	1.21E+00	1.00E+01	3.59E-03	4.59E-05	2.48E-02
Phenanthrene	4.00E+03	1.75E-04	2.00E+02	4.00E+02	2.22E-04	1.00E-01	1.21E+00	1.00E+01	2.13E-03	4.48E-05	5.74E-04

TABLE 1 (continued)
SOIL TO INDOOR AIR - 95% UCL SOIL CONCENTRATIONS
FORMER BROOKFIELD MILL SITE

Notes:

Reference: *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings*, USEPA, June 19, 2003.

(1) Assumed equivalent to D_i^{eff} of soil layer i in contact with the floor

(2) For screening, A_B = 1,000,000 cm^2 for L_F <= 15 cm and A_B = 1,800,000 cm^2 for LF > 15 cm

(2a) For screening, $Q_{building}$ = 25,417 cm^3/s for L_F <= 15 cm and $Q_{building}$ = 16,944 cm^3/s for LF > 15 cm

(3) Purposely left blank

(4) $D_T^{eff} = L_T / (L_T / D_v^{eff})$

(5) $Q_{soil} = (2*\pi*\Delta P*k_v*X_{crack}) / (\mu_{TS}*\ln(2*Z_{crack}/r_{crack}))$

(6) $\alpha = [(D_T^{eff}*A_B/(Q_{building}*L_T))*EXP(Q_{soil}*L_{crack}/(D^{crack}*A_{crack}))]/[EXP(Q_{soil}*L_{crack}/(D^{crack}*A_{crack}))+(D_T^{eff}*A_B/(Q_{building}*L_T))+(D_T^{eff}*A_B/(Q_{soil}*L_T))*(EXP(Q_{soil}*L_{crack}/(D^{crack}*A_{crack}))-1)]$

(7) A function of the ratio T_B/T_C:

T_B/T_C	n
<0.57	0.30
0.57-0.71	$0.74(T_B/T_C)-0.116$
>0.71	0.41

If values are not available for calculation, result is NA.

(8) $\Delta H_{v,TS} = \Delta H_{v,B}*[(1-T_S/T_C)/(1-T_B/T_C)]^n$; if values are not available for calculation, result is NA.

(9) $H_{TS} = EXP[-\Delta H_{v,TS}/R_c*(1/T_S-1/T_R)]*H_R$; if values are not available for calculation, result assumed to be H_R

(10) Purposely left blank

(11) Refer to 12 SCS soil types - if no site-specific information is available, use SCL for screening.

(12) Purposely left blank

(13) $D_v^{eff} = D_a*(\theta_{a,v}^{3.33}/n_v^2)+(D_w/H'_{TS})(\theta_{w,v}^{3.33}/n_v^2)$

(14) Purposely left blank

(15) Purposely left blank

(16) $\mu_w = \mu_{w,10} * (T'_S / 283.15)^{0.5}$

(17) $k_{i,v} = K_{s,v} * 1/Conv02 * \mu_w / (\rho_w * g)$

(18) $S_{te} = (\theta_{w,v} - \theta_{r,v}) / (n_v - \theta_{r,v})$

(19) $k_{rg} = (1 - S_{te})^{0.5} * (1-S_{te}^{1/Mv})^{2Mv}$

(20) $k_v = k_{i,v} * k_{rg}$; note that the model is very sensitive to this parameter and if site-specific values are available, they should be used.

(21) $C_{source} = H'_{TS} * C_R * Conv01 * \rho_b / (\theta_{w,v} + K_d * \rho_b + H'_{TS} * \theta_{a,v}) * Conv02$

TABLE 2. SUMMARY OF MODELED AIR DATA
FORMER BROOKFIELD MILL SITE

	Air Concentrations (ug/m^3)
	Indoor Air EPC
Analyte	
C9-C12 Aliphatics	5.1E+01
C9-C18 Aliphatics	1.3E+02
C11-C22 Aromatics	1.2E+01
2-Methylnaphthalene	2.5E-02
Phenanthrene	5.7E-04

EPC - Exposure Point Concentration

TABLE 3
SUMMARY OF SITE HAZARD INDICES AND EXCESS LIFETIME CANCER RISK ESTIMATES

	FUTURE USE:					
	HI	ELCR	HI	ELCR	HI	
	CONSTRUCTION WORKER		RESIDENT CHILD/ADULT		RESIDENT CHILD (1-2)	
SOIL:						
Incidental Ingestion	7E-01	1E-08	1E+00	5E-07	4E+00	
Dermal Contact	3E-01	1E-08	8E-01	4E-07	1E+00	
Inhalation of Fugitive Dust	2E-01	7E-08	7E-03	5E-08	7E-03	(age 0-7)
Ingestion of Homegrown Fruits	NA	NA	5E+01	4E-05	6E+01	
Total	**1E+00**	**9E-08**	**5E+01**	**5E-05**	**7E+01**	
GROUNDWATER:						
Incidental Ingestion	2E-03	NA	NA	NA	NA	
Dermal Contact	3E-04	NA	NA	NA	NA	
Total	**2E-03**	**NA**	**NA**	**NA**	**NA**	
SURFACE WATER:						
Incidental Ingestion	NA	NA	9E-04	NA	9E-04	(age 0-7)
Dermal Contact	NA	NA	9E-06	NA	9E-06	(age 0-7)
Total	**NA**	**NA**	**9E-04**	**NA**	**9E-04**	
INDOOR/OUTDOOR AIR:						
Soil	7E-06	NA	1E+00	NA	1E+00	(age 0-7)
Total	**7E-06**	**NA**	**1E+00**	**NA**	**1E+00**	
SITE TOTAL	**1E+00**	**9E-08**	**5E+01**	**5E-05**	**7E+01**	

HI - Hazard Index
ELCR - Excess Lifetime Cancer Risk
NA - Not Applicable

Shaded Hazard Indices and Excess Lifetime Cancer Risks are above the MCP risk limits of 1 for HIs and 1E-05 for ELCRs.

Method 3 Risk Assessment for Resident Exposed to Chemicals in Indoor Air - Shortform 2006 (sf06ra)

Index

Tab	
EPCs	Table RA-1: Select chemicals and enter Exposure Point Concentrations (EPCs). Associated risks are presented to the right.
C Eq	Table RA-2: Equations to calculate cancer risks.
NC Eq	Table RA-3: Equations to calculate noncancer risks.
Exp	Table RA-4: Definitions and exposure factors.
Chem	Table RA-5: Chemical-specific data.

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Resident - Indoor Air: Table RA-1 - Plaza
Exposure Point Concentration (EPC)
Based on Resident Ages 1-31 (Cancer) and 1-8 (Noncancer)

ShortForm Version 4-06

Vlookup Version v0808

ELCR (all chemicals) =
HI (all chemicals) = 1E+00

****Do not insert or delete any rows****

Click on empty cell below and select OHM using arrow.

Oil or Hazardous Material	EPC ($\mu g/m^3$)	$ELCR_{air}$	HQ_{air}
Aliphatics C9 to C12	5.1E+01		2.5E-01
Aliphatics C9 to C18	1.3E+02		6.3E-01
Aromatics C11 to C22	1.2E+01		2.4E-01
Methylnaphthalene, 2-	2.5E-02		5.0E-04
Phenanthrene	5.7E-04		1.1E-05

Resident - Indoor Air: Table RA-2
Equations to Calculate Cancer Risk for Resident (Age 1-31 years)

Vlookup Version v0808

Parameter	Value	Units
URF	OHM specific	$(\mu g/m^3)^{-1}$
LADE	age/OHM specific	$\mu g/m^3$
$[OHM]_{air}$	OHM specific	$\mu g/m^3$
EF	1.00	event/day
ED	1	day/event
EP	30	years
$AP_{lifetime}$	70	years

Cancer Risk from Inhalation

$$ELCR_{air} = LADE_{(1\text{-}31)} * URF$$

$$LADE = \frac{[OHM]_{air} * EF * ED * EP}{AP_{lifetime}}$$

Resident - Indoor Air: Table RA-3
Equations to Calculate Noncancer Risk for Resident Child (Age 1-8 years)

Vlookup Version v0808

Noncancer Risk from Inhalation

$$HQ_{air} = \frac{ADE * C}{RfC}$$

$$ADE = \frac{[OHM]_{air} * EF * ED * EP}{AP}$$

Parameter	Value	Units
RfC	OHM specific	mg/m^3
ADE	OHM specific	$\mu g/m^3$
$[OHM]_{soil}$	OHM specific	$\mu g/m^3$
EF	1.00	event/day
ED	1	day/event
EP	7	years
C	0.001	mg/ug
AP	7	year

Resident - Indoor Air: Table RA-4
Definitions and Exposure Factors

Vlookup Version v0808

Parameter	Value	Units	Notes
ELCR - Excess Lifetime Cancer Risk	chemical specific	dimensionless	
URF - Unit Risk Factor	chemical specific	$(\mu g/m^3)^{-1}$	see Table RA-5
LADE - Lifetime Average Daily Exposure	chemical specific	$\mu g/m^3$	see Table RA-2
HQ - Hazard Quotient	chemical specific	dimensionless	
RfC - Reference Concentration	chemical specific	mg/m^3	see Table RA-5
ADE - Average Daily Exposure	chemical specific	$\mu g/m^3$	see Table RA-3
EPC - Exposure Point Concentration	chemical specific	µg/L	see Table RA-1
EF - Exposure Frequency	1.00	event/day	
ED - Exposure Duration	1	day/event	
$EP_{(1-8)}$ - Exposure Period age group 1-8 (noncancer)	7	years	
$EP_{(1-31)}$ - Exposure Period for age group 1-31 (cancer)	30	years	
$AP_{(noncancer)}$ - Averaging Period for noncancer	7	years	
$AP_{(lifetime)}$ - Averaging Period for lifetime	70	years	

Resident - Indoor Air: Table RA-5
Chemical-Specific Data

Vlookup Version v0808

Oil or Hazardous Material	URF $(ug/m^3)^{-1}$	RfC mg/m^3
Aliphatics C9 to C12		2.00E-01
Aliphatics C9 to C18		2.00E-01
Aromatics C11 to C22		5.00E-02
Methylnaphthalene, 2-		5.0E-02
Phenanthrene		5.0E-02

Method 3 Risk Assessment for Resident Exposed to Chemicals in Soil - Shortform 2006 (sf06rs)

Index

Tab	
EPCs	Table RS-1: Select chemicals and enter Exposure Point Concentrations (EPCs). Associated risks are shown to the right.
C Eq	Table RS-2: Equations to calculate cancer risks.
cNC Eq	Table RS-3: Equations to calculate chronic noncancer risks.
scNC Eq	Table RS-4: Equations to calculate subchronic noncancer risks.
Exp	Table RS-5: Definitions and exposure factors.
Produce	Table RS-6: Equations to calculate produce ingestion rate.
Chem	Table RS-7: Chemical-specific data.

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Resident - Soil: Table RS-1 - 1087 Lakeview Avenue
Exposure Point Concentration (EPC)
Based on Resident Ages 1-31 (Cancer), 1-8 (Chronic Noncancer), and 1-2 (Subchronic Noncancer)

ShortForm Version 4-06

Vlookup Version v0808

ELCR (all chemicals) = 4.5E-05
Chronic HI (all chemicals) = 4.9E+01
Subchronic HI (all chemicals) = 6.8E+01

****Do not insert or delete any rows****

Click on empty cell below and select OHM using arrow.

Oil or Hazardous Material	EPC (mg/kg)	$ELCR_{ingestion}$	$ELCR_{dermal}$	$ELCR_{vegetable}$	$ELCR_{total}$	Chronic HQ_{ing}	Chronic HQ_{derm}	Chronic $HQ_{vegetable}$	Chronic HQ_{total}	Subchronic HQ_{ing}	Subchronic HQ_{derm}	Subchronic $HQ_{vegetable}$	Subchronic HQ_{total}
Aliphatics C9 to C12	5.1E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.2E-04	5.2E-04	0.0E+00	6.5E-04	3.4E-05	9.9E-05	0.0E+00	1.3E-04
		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Aliphatics C9 to C18	5.3E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-03	5.5E-03	0.0E+00	6.7E-03	3.5E-04	1.0E-03	0.0E+00	1.4E-03
Aliphatics C19 to C36	2.5E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-04	2.5E-04	0.0E+00	5.5E-04	2.7E-04	1.6E-04	0.0E+00	4.3E-04
Aromatics C11 to C22	8.5E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.5E-03	5.8E-03	0.0E+00	8.3E-03	6.8E-04	1.1E-03	0.0E+00	1.8E-03
		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methylnaphthalene, 2-	4.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.4E-05	2.2E-04	0.0E+00	3.1E-04	2.6E-04	4.2E-04	0.0E+00	6.8E-04
Dibenzo(a,h)anthracene	5.2E-01	4.0E-07	2.9E-07	0.0E+00	6.9E-07	1.2E-05	7.1E-06	0.0E+00	1.9E-05	3.2E-06	1.3E-06	0.0E+00	4.6E-06
		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Polychlorinated biphenyls (PCBs)	1.2E-01	7.9E-08	1.5E-07	4.4E-05	4.4E-05	1.3E-02	2.1E-02	3.7E+00	3.8E+00	1.4E-02	1.6E-02	2.1E+00	2.2E+00
		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Aluminum	1.1E+04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6E-02	2.2E-02	0.0E+00	4.8E-02	7.2E-02	4.2E-02	0.0E+00	1.1E-01
Antimony	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.0E-03	5.1E-03	0.0E+00	1.1E-02	1.7E-02	9.7E-03	0.0E+00	2.6E-02
Barium	1.0E+03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.2E-02	5.2E-03	0.0E+00	1.7E-02	9.6E-02	2.8E-02	0.0E+00	1.2E-01
Beryllium	3.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E-04	9.9E-05	0.0E+00	4.9E-04	4.3E-04	7.5E-05	0.0E+00	5.0E-04
Chromium (total)	2.2E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.8E-02	1.4E-02	5.0E-01	5.3E-01	7.4E-03	3.9E-03	1.1E-01	1.2E-01
Cobalt	9.2E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E-03	9.5E-04	0.0E+00	2.1E-03	3.1E-03	1.8E-03	0.0E+00	4.9E-03
Copper	1.4E+03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.2E-01	3.0E-01	0.0E+00	4.1E-01	3.2E-02	5.6E-02	0.0E+00	8.8E-02
Iron	3.3E+04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.7E-01	3.2E-01	0.0E+00	5.9E-01	7.4E-01	6.1E-01	0.0E+00	1.3E+00
Lead	5.6E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.1E-01	9.3E-02	4.0E+01	4.1E+01	2.5E+00	1.8E-01	5.7E+01	6.0E+01
Manganese	2.4E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.2E-03	9.8E-03	0.0E+00	1.8E-02	2.3E-02	1.9E-02	0.0E+00	4.1E-02
Mercury	6.0E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.8E-03	2.1E-03	0.0E+00	6.9E-03	1.3E-02	3.9E-03	0.0E+00	1.7E-02
Nickel	1.6E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.9E-03	5.7E-03	2.1E-01	2.2E-01	5.2E-03	1.1E-02	3.0E-01	3.2E-01
Selenium	1.3E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.3E-04	1.1E-05	0.0E+00	6.4E-04	1.7E-03	2.0E-05	0.0E+00	1.8E-03
Silver	2.1E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-03	2.1E-03	0.0E+00	3.1E-03	2.8E-03	4.0E-03	0.0E+00	6.8E-03
Thallium	1.3E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E-02	3.4E-03	0.0E+00	4.3E-02	1.1E-02	6.3E-04	0.0E+00	1.1E-02
Vanadium	2.8E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.5E-03	1.9E-03	0.0E+00	9.4E-03	2.1E-02	3.6E-03	0.0E+00	2.4E-02
Zinc	6.4E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.1E-03	8.8E-04	2.3E+00	2.3E+00	1.4E-02	1.7E-03	3.2E+00	3.3E+00

Resident - Soil: Table RS-2
Equations to Calculate Cancer Risk for Resident (Age 1-31 years)

Vlookup Version v0808

Parameter	Value	Units
CSF	OHM specific	$(mg/kg\text{-}day)^{-1}$
LADD	age/OHM specific	mg/kg-day
$[OHM]_{soil}$	OHM specific	mg/kg
$IR_{(1-8)}$	100	mg/day
$IR_{(8-15)}$	50	mg/day
$IR_{(15-31)}$	50	mg/day
$PIR_{(1-8)}$	12,099	mg/day
$PIR_{(8-15)}$	17,809	mg/day
$PIR_{(15-31)}$	24,420	mg/day
$RAF_{c\text{-}ing}$	OHM specific	dimensionless
$RAF_{c\text{-}derm}$	OHM specific	dimensionless
$RAF_{c\text{-}produce}$	OHM specific	dimensionless
$EF_{ing,derm}$	0.412	event/day
$EF_{produce}$	1.00	event/day
ED	1	day/event
$EP_{(1-8)}$	7	years
$EP_{(8-15)}$	7	years
$EP_{(15-31)}$	16	years
C	0.000001	kg/mg
$BW_{(1-8)}$	17.0	kg
$BW_{(8-16)}$	39.9	kg
$BW_{(16-31)}$	58.7	kg
$AP_{(lifetime)}$	70	years
$SA_{(1-8)}$	2431	cm^2 / day
$SA_{(8-15)}$	4427	cm^2 / day
$SA_{(15-31)}$	5653	cm^2 / day
$SAF_{(1-8)}$	0.35	mg/cm^2
$SAF_{(8-15)}$	0.14	mg/cm^2
$SAF_{(15-31)}$	0.13	mg/cm^2
PUF	OHM specific	$(mg/mg)(mg/mg)^{-1}$

Cancer Risk from Ingestion

$$ELCR_{ing} = LADD_{ing(1-31)} * CSF$$

$$LADD_{ing\ (1-31)} = LADD_{ing\ (1-8)} + LADD_{ing\ (8-15)} + LADD_{ing\ (15-31)}$$

$$LADD_{ing\ (age\ group\ x)} = \frac{[OHM]_{soil} * IR_x * RAF_{c\text{-}ing} * EF_{ing} * ED * EP_x * C}{BW_x * AP_{lifetime}}$$

Cancer Risk from Dermal Absorption

$$ELCR_{derm} = LADD_{derm} * CSF$$

$$LADD_{derm\ (1-31)} = LADD_{derm\ (1-8)} + LADD_{derm\ (8-15)} + LADD_{derm\ (15-31)}$$

$$LADD_{derm(age\ group\ x)} = \frac{[OHM]_{soil} * SA_x * RAF_{c\text{-}derm} * SAF_x * EF_{derm} * ED * EP_x * C}{BW_x * AP_{lifetime}}$$

Cancer Risk from Homegrown Produce

$$ELCR_{produce} = LADD_{produce(1-31)} * CSF$$

$$LADD_{produce(1-31)} = LADD_{produce(1-8)} + LADD_{produce(8-15)} + LADD_{produce(15-31)}$$

$$LADD_{produce(age\ x)} = \frac{[OHM_{soil}] * PUF * PIR_x * RAF_{produce} * EF_{produce} * ED * EP_x * C}{BW_x * AP_{lifetime}}$$

Resident - Soil: Table RS-3
Equations to Calculate Chronic Noncancer Risk for Resident Child (Age 1-8 years)

Vlookup Version v0808

Chronic Noncancer Risk from Ingestion

$$HQ_{ing} = \frac{ADD_{ing}}{RfD}$$

$$ADD_{ing} = \frac{[OHM]_{soil} * IR * RAF_{nc\text{-}ing} * EF_{ing} * ED * EP * C}{BW * AP}$$

Chronic Noncancer Risk from Dermal Absorption

$$HQ_{derm} = \frac{ADD_{ing,derm}}{RfD}$$

$$ADD_{derm} = \frac{[OHM]_{soil} * SA * RAF_{nc\text{-}derm} * SAF * EF_{derm} * ED * EP * C}{BW * AP}$$

Chronic Noncancer Risk from Homegrown Produce

$$HQ_{produce} = \frac{ADD_{produce}}{RfD}$$

$$ADD_{produce} = \frac{[OHM_{soil}] * PUF * PIR * RAF_{produce} * EF_{produce} * ED * EP * C}{BW * AP}$$

Parameter	Value	Units
RfD	OHM specific	mg/kg-day
ADD	OHM specific	mg/kg-day
$[OHM]_{soil}$	OHM specific	mg/kg
IR	100	mg/day
PIR	12,099	mg/day
$RAF_{nc\text{-}ing}$	OHM specific	dimensionless
$RAF_{nc\text{-}derm}$	OHM specific	dimensionless
$RAF_{nc\text{-}produce}$	OHM specific	dimensionless
$EF_{ing,derm}$	0.412	event/day
$EF_{produce}$	1.00	event/day
$EF_{cyanide}$	1.00	event/day
ED	1	day/event
EP	7	years
$EP_{cyanide}$	1	day
C	0.000001	kg/mg
BW	17.0	kg
AP	7	year
$AP_{cyanide}$	1	day
SA	2431	cm^2 / day
SAF	0.35	mg/cm^2
PUF	OHM specific	$(mg/mg)(mg/mg)^{-1}$

Cyanide can cause a significant health risk from one-time exposure to concentrations that are often found in the environment. As such, risk is calculated for a single exposure. Thus, for cyanide, the exposure frequency (EF) is 1 event/day, while both the exposure period (EP) and averaging period (AP) are 1 day.

Resident - Soil: Table RS-4
Equations to Calculate Subchronic Noncancer Risk for Resident Child (Age 1-2 years)

Vlookup Version v0808

Subchronic Noncancer Risk from Ingestion

$$HQ_{ing} = \frac{ADD_{ing}}{RfD_{subchronic}}$$

$$ADD_{ing} = \frac{[OHM]_{soil} * IR * RAF_{nc\text{-}ing} * EF_{ing} * ED * EP * C}{BW * AP}$$

Subchronic Noncancer Risk from Dermal Absorption

$$HQ_{derm} = \frac{ADD_{derm}}{RfD_{subchronic}}$$

$$ADD_{derm} = \frac{[OHM]_{soil} * SA * RAF_{nc\text{-}derm} * SAF * EF_{derm} * ED * EP * C}{BW * AP}$$

Subchronic Noncancer Risk from Homegrown Produce

$$HQ_{produce} = \frac{ADD_{produce}}{RfD_{subchronic}}$$

$$ADD_{produce} = \frac{[OHM_{soil}] * PUF * PIR * RAF_{produce} * EF_{produce} * ED * EP * C}{BW * AP}$$

Parameter	Value	Units
RfD	OHM specific	mg/kg-day
ADD	OHM specific	mg/kg-day
$[OHM]_{soil}$	OHM specific	mg/kg
IR	100	mg/day
PIR	10,900	mg/day
$RAF_{nc\text{-}ing}$	OHM specific	dimensionless
$RAF_{nc\text{-}derm}$	OHM specific	dimensionless
$RAF_{nc\text{-}produce}$	OHM specific	dimensionless
$EF_{ing,derm}$	0.714	event/day
$EF_{produce}$	1.00	event/day
$EF_{cyanide}$	1.00	event/day
ED	1	day/event
$EP_{cyanide}$	1	day
EP	0.577	years
C	0.000001	kg/mg
BW	10.7	kg
AP	0.577	year
$AP_{cyanide}$	1	day
SA	1670	cm^2 / day
SAF	0.35	mg/cm^2
PUF	OHM specific	$(mg/mg)(mg/mg)^{-1}$

Cyanide can cause a significant health risk from one-time exposure to concentrations that are often found in the environment. As such, risk is calculated for a single exposure. Thus, for cyanide, the exposure frequency (EF) is 1 event/day, while both the exposure period (EP) and averaging period (AP) are 1 day.

Resident - Soil: Table RS-5
Definitions and Exposure Factors

Vlookup Version v0808

Parameter	Value	Units	Notes
ELCR - Excess Lifetime Cancer Risk	chemical specific	dimensionless	Pathway specific (ing=ingestion, derm=dermal, inh=inhalation)
CSF - Cancer Slope Factor	chemical specific	$(mg/kg\text{-}day)^{-1}$	see Table RS-7
LADD - Lifetime Average Daily Dose	chemical specific	mg/kg-day	Pathway specific
LADE - Lifetime Average Daily Exposure	chemical specific	$\mu g/m^3$	
HQ - Hazard Quotient	chemical specific	dimensionless	Pathway specific (ing=ingestion, derm=dermal, inh=inhalation)
RfD - Reference Dose	chemical specific	mg/kg-day	see Table RS-7
ADD - Average Daily Dose	chemical specific	mg/kg-day	Pathway specific
ADE - Average Daily Exposure	chemical specific	mg/m^3	
EPC - Exposure Point Concentration	chemical specific	mg/kg	
PUF - Plant Uptake Factor	chemical specific	$(mg/mg)(mg/mg)^{-1}$	See Table RS-7; $(mg_{OHM}/mg_{plant})/(mg_{OHM}/mg_{soil})^{-1}$
$IR_{(1-2)}$ - Soil Ingestion Rate for age group 1-2	100	mg/day	MADEP. 2002. Technical Update: Calculation of an Enhanced Soil Ingestion Rate. (http://www.mass.gov/dep/ors/orspubs.htm)
$IR_{(1-8)}$ - Soil Ingestion Rate for age group 1-8	100	mg/day	Ibid
$IR_{(8-15)}$ - Soil Ingestion Rate for age group 8-15	50	mg/day	Ibid
$IR_{(15-31)}$ - Soil Ingestion Rate for age group 15-31	50	mg/day	Ibid
$PIR_{(1-2)}$ = Produce Ingestion Rate for age group 1-2	10,900	mg/day	see Table RS-6
$PIR_{(1-8)}$ = Produce Ingestion Rate for age group 1-8	12,099	mg/day	see Table RS-6
$PIR_{(8-15)}$ = Produce Ingestion Rate for age group 8-15	17,809	mg/day	Ibid
$PIR_{(15-31)}$ = Produce Ingestion Rate for age group 15-31	24,420	mg/day	Ibid
RAF_c - Relative Absorption Factor for Cancer Effects	chemical specific	dimensionless	
$EF_{subchronic}$ - Exposure Frequency for subchronic ingestion or dermal exposure	0.714	event/day	5 days/week
$EF_{chronic}$ - Exposure Frequency for chronic ingestion or dermal exposure	0.412	event/day	5 days/week, 30 weeks/year
EF_{cancer} - Exposure Frequency for cancer, ingestion or dermal exposure	0.412	event/day	5 days/week, 30 weeks/year
$EF_{produce}$ - Exposure Frequency for produce ingestion, cancer and noncancer	1.00	event/day	
$EF_{cyanide}$ - Exposure Frequency for subchronic and chronic non-cancer cyanide	1.00	event/day	
ED - Exposure Duration	1	day/event	
$EP_{(1-2)}$ - Exposure Period for age group 1-2	0.577	years	30 weeks
$EP_{(1-8)}$ - Exposure Period for age group 1-8	7	years	
$EP_{(8-15)}$ - Exposure Period for age group 8-15	7	years	
$EP_{(15-31)}$ - Exposure Period for age group 15-31	16	years	
$EP_{cyanide}$ - Exposure period for cyanide exposure	1	day	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Page 5-5.
$BW_{(1-2)}$ - Body Weight for age group 1-2	10.7	kg	U.S. EPA. 1997. Exposure Factors Handbook. Table 7-7, females.
$BW_{(1-8)}$ - Body Weight for age group 1-8	17.0	kg	Ibid
$BW_{(8-15)}$ - Body Weight for age group 8-15	39.9	kg	Ibid
$BW_{(15-31)}$ - Body Weight for age group 15-31	58.7	kg	Ibid
$AP_{subchronic}$ - Averaging Period for subchronic noncancer	0.577	years	30 weeks
$AP_{chronic}$ - Averaging Period for chronic noncancer	7	years	
AP_{cancer} - Averaging Period for lifetime	70	years	
$AP_{cyanide}$ - Averaging period for assessing cyanide exposure	1	day	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Page 5-5.
$SA_{(1-2)}$ - Surface Area for age group 1-2	1670	cm^2 / day	50th percentile of face (1/3 head), forearms, hands, lower legs, and feet for females MADEP. 1995. Guidance for Disposal Site Risk Characterization. Appendix Table B-2.
$SA_{(1-8)}$ - Surface Area for age group 1-8	2431	cm^2 / day	Ibid
$SA_{(8-15)}$ - Surface Area for age group 8-15	4427	cm^2 / day	Ibid
$SA_{(15-31)}$ - Surface Area for age group 15-31	5653	cm^2 / day	Ibid
$SAF_{(1-2)}$ - Surface Adherence Factor for age group 1-2	0.35	mg/cm^2	All SAFs developed for ShortForm according to procedure outlined in MA DEP Technical Update:
$SAF_{(1-8)}$ - Surface Adherence Factor for age group 1-8	0.35	mg/cm^2	Weighted Skin-Soil Adherence Factors, April 2002
$SAF_{(8-15)}$ - Surface Adherence Factor for age group 8-15	0.14	mg/cm^2	
$SAF_{(15-31)}$ - Surface Adherence Factor for age group 15-31	0.13	mg/cm^2	

Resident - Soil: Table RS-6
Homegrown Produce Ingestion Rate

Data on mean produce ingestion rates (wet weight, ww) in the Northeast was obtained from the 1994-1996 Continuing Survey of Food Intakes by Individuals (USDA). Data for both genders were used for children under 6, while data for males was used for individuals 6 and older. The mean ingestion rates presented in the survey represent the arithmetic average of all individuals surveyed, regardless of whether or not they had consumed the produce item (e.g., an individual that did not consume the produce item was assigned a rate of 0 g/day). To determine the mean ingestion rate for individuals who ate each produce item, the ingestion rate for all individuals (consumers and nonconsumers) was divided by the percentage of individuals who ate the item (Table RS-6A). These mean ingestion rates for the produce consumers were summed to determine the total produce ingestion rate for each age-group and converted to dry weight assuming the produce items were all 90% water.

To convert mean ingestion rates for the age-groups studied in the survey to age-groups used in risk calculations, each age-group ingestion rate from the survey (i.e., 1 - 2 year olds, 3 - 5 year olds, 6 - 11 year olds, 12 - 19 year olds, and 20 - 39 year olds) was weighted according to the number of years spent in the risk calculation age group (i.e., 1 - 8 year olds, 8 - 15 year olds, and 15 - 31 year olds) (Table RS-6B). It was assumed that 25% of produce ingested was home-grown (Table RS-6C).

Table RS-6A

	White Potatoes			Dark-green vegetables			Deep-yellow vegetables		
Age-groups studied in survey	Ingestion Rate for All g/d (ww)	% of individuals that consumed item.	Ingestion Rate for Consumers g/d (ww)	Ingestion Rate for All g/d (ww)	% of individuals that consumed item.	Ingestion Rate for Consumers g/d (ww)	Ingestion Rate for All g/d (ww)	% of individuals that consumed item.	Ingestion Rate for Consumers g/d (ww)
1-2	28	40.3	69.5	6	10.1	59.4	5	12.7	39.4
3-5	30	37.1	80.9	5	6.5	76.9	7	12.7	55.1
6-11	47	44.2	106.3	6	9.1	65.9	2	8.5	23.5
12-19	59	40.3	146.4	2	2.3	87.0	11	15.8	69.6
20-39	76	45.1	168.5	25	14.7	170.1	4	5.7	70.2

	Tomatoes			Lettuce			Green Beans		
Age-groups studied in survey	Ingestion Rate for All g/d (ww)	% of individuals that consumed item.	Ingestion Rate for Consumers g/d (ww)	Ingestion Rate for All g/d (ww)	% of individuals that consumed item.	Ingestion Rate for Consumers g/d (ww)	Ingestion Rate for All g/d (ww)	% of individuals that consumed item.	Ingestion Rate for Consumers g/d (ww)
1-2	10	27.9	35.8	1	6	16.7	7	12.1	57.9
3-5	10	37.1	27.0	4	14	28.6	3	5.7	52.6
6-11	20	42	47.6	8	14.9	53.7	1	2	50.0
12-19	29	45.2	64.2	19	28.7	66.2	2	2.4	83.3
20-39	48	50.9	94.3	18	29.6	60.8	4	3.7	108.1

Table RS-6A (continued)

Age-groups studied in survey	Corn, Green peas, Lima beans Ingestion Rate for All g/d (ww)	% of individuals that consumed item.	Ingestion Rate for Consumers g/d (ww)	Melons, berries Ingestion Rate for All g/d (ww)	% of individuals that consumed item.	Ingestion Rate for Consumers g/d (ww)	Totals Wet Weight WWI g/day	Totals Dry Weight DWI g/day
1-2	12	15	80.0	7	9	77.8	436.4	43.6
3-5	14	21.7	64.5	14	11.6	120.7	506.3	50.6
6-11	9	13.6	66.2	5	5.9	84.7	498.0	49.8
12-19	14	9.9	141.4	17	5	340.0	998.1	99.8
20-39	12	7.3	164.4	6	4.5	133.3	969.7	97.0

Table RS-6B

Age-groups studied in survey	Years spent in age-group for 1-8 year old	Years spent in age-group for 8-15 year old	Years spent in age-group for 15-31 year old
1-2	2		
3-5	3		
6-11	2	4	
12-19		3	4
20-39			12
	7	7	16

Table RS-6C

	Produce Intake, dry weight			
	Child 1-2 years g/day	Child 1-8 years g/day	Child 8-15 years g/day	Adult 15-31 g/day
All Produce:	43.6	48.4	71.2	97.7
Homegrown:	10.9	12.1	17.8	24.4

Resident - Soil: Table RS-7
Chemical-Specific Data

Vlookup Version v0808

Oil or Hazardous Material	CSF $(mg/kg\text{-}day)^{-1}$	$RAF_{c\text{-}ing}$	$RAF_{c\text{-}derm}$	$RAF_{c\text{-}prod}$	Chronic RfD mg/kg-day	Subchronic RfD mg/kg-day	Chronic $RAF_{nc\text{-}ing}$	Chronic $RAF_{nc\text{-}derm}$	Subchronic $RAF_{nc\text{-}ing}$	Subchronic $RAF_{nc\text{-}derm}$	$RAF_{nc\text{-}prod}$	PUF
Aliphatics C9 to C12	0.0E+00	0.00	0.00	0.00	1.0E-01	1.0E+00	1	0.5	1	0.5	0	0
0	0.0E+00	0.00	0.00	0.00	0.0E+00	0.0E+00	0	0	0	0	0	0
Aliphatics C9 to C18	0.0E+00	0.00	0.00	0.00	1.0E-01	1.0E+00	1	0.5	1	0.5	0	0
Aliphatics C19 to C36	0.0E+00	0.00	0.00	0.00	2.0E+00	6.0E+00	1	0.1	1	0.1	0	0
0	0.0E+00	0.00	0.00	0.00	0.0E+00	0.0E+00	0	0	0	0	0	0
Methylnaphthalene, 2-	0.0E+00	0.00	0.00	0.00	4.0E-03	4.0E-03	0.36	0.1	0.36	0.1	0	0
Dibenzo(a,h)anthracene	7.3E+00	0.28	0.02	0.00	3.0E-02	3.0E-01	0.28	0.02	0.28	0.02	0	0
0	0.0E+00	0.00	0.00	0.00	0.0E+00	0.0E+00	0	0	0	0	0	0
Aluminum	0.0E+00	0.00	0.00	0.00	1.0E+00	1.0E+00	1	0.1	1	0.1	0	0
Antimony	0.0E+00	0.00	0.00	0.00	4.0E-04	4.0E-04	1	0.1	1	0.1	0	0
Barium	0.0E+00	0.00	0.00	0.00	2.0E-01	7.0E-02	1	0.05	1	0.05	0	0
Beryllium	0.0E+00	0.00	0.00	0.00	2.0E-03	5.0E-03	1	0.03	1	0.03	0	0
Chromium (total)	0.0E+00	0.00	0.00	0.00	3.0E-03	2.0E-02	1	0.09	1	0.09	1	0.095
Cobalt	0.0E+00	0.00	0.00	0.00	2.0E-02	2.0E-02	1	0.1	1	0.1	0	0
Copper	0.0E+00	0.00	0.00	0.00	3.0E-02	3.0E-01	1	0.3	1	0.3	0	0
Iron	0.0E+00	0.00	0.00	0.00	3.0E-01	3.0E-01	1	0.14	1	0.14	0	0
Lead	0.0E+00	0.00	0.00	0.00	7.5E-04	7.5E-04	0.5	0.006	0.5	0.006	0.5	0.15
Manganese	0.0E+00	0.00	0.00	0.00	7.0E-02	7.0E-02	1	0.14	1	0.14	0	0
Mercury	0.0E+00	0.00	0.00	0.00	3.0E-04	3.0E-04	1	0.05	1	0.05	0	0
Nickel	0.0E+00	0.00	0.00	0.00	2.0E-02	2.0E-02	1	0.35	1	0.35	1	0.38
Selenium	0.0E+00	0.00	0.00	0.00	5.0E-03	5.0E-03	1	0.002	1	0.002	0	0
Silver	0.0E+00	0.00	0.00	0.00	5.0E-03	5.0E-03	1	0.25	1	0.25	0	0
Thallium	0.0E+00	0.00	0.00	0.00	8.0E-05	8.0E-04	1	0.01	1	0.01	0	0
Vanadium	0.0E+00	0.00	0.00	0.00	9.0E-03	9.0E-03	1	0.03	1	0.03	0	0
Zinc	0.0E+00	0.00	0.00	0.00	3.0E-01	3.0E-01	1	0.02	1	0.02	1	1.5

Method 3 Risk Assessment for Chemicals in Soil - Construction Worker Shortform 2008 (sf08cw)

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C Eq	Table CW-2: Equations to calculate cancer risks.
NC Eq	Table CW-3: Equations to calculate noncancer risks.
Exp	Table CW-4: Definitions and exposure factors.
Chem	Table CW-5: Chemical-specific data.

Spreadsheets designed by Andrew Friedmann, MassDEP

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Construction Worker - Soil: Table CW-1 - 1095 Lakeview Ave.
Exposure Point Concentration (EPC) and Risk
Based on Construction Worker 18-25 years of age

ShortForm Version 08-08

Vlookup Version v0808

ELCR (all chemicals) = 9.5E-08
HI (all chemicals) = 1.2E+00

****Do not insert or delete any rows****

Click on empty cell below and select OHM using arrow.

Oil or Hazardous Material (OHM)	EPC (mg/kg)	ELCR ingestion	ELCR dermal	ELCR inhalation GI	ELCR inhalation pulmonary	$ELCR_{total}$	Subchronic HQ_{ing}	Subchronic HQ_{derm}	Subchronic HQ_{inh-GI}	Subchronic HQ_{inh}	HQ_{total}
Aliphatics C9 to C12	5.1E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.3E-06	3.2E-05	1.6E-07	3.2E-07	3.8E-05
		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Aliphatics C9 to C18	5.3E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.5E-05	3.3E-04	1.7E-06	3.3E-06	4.0E-04
Aliphatics C19 to C36	2.5E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.0E-05	5.1E-05	1.3E-06	0.0E+00	1.0E-04
Aromatics C11 to C22	8.5E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-04	3.5E-04	3.3E-06	6.3E-06	4.9E-04
		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Methylnaphthalene, 2-	4.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.8E-05	1.3E-04	1.2E-06	3.2E-08	1.8E-04
Dibenzo(a,h)anthracene	5.2E-01	9.3E-09	6.7E-09	2.4E-10	2.9E-10	1.7E-08	6.0E-07	4.3E-07	1.5E-08	3.9E-08	1.1E-06
		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Polychlorinated biphenyls (PCBs)	1.2E-01	1.9E-09	3.5E-09	4.8E-11	3.3E-12	5.4E-09	2.6E-03	4.9E-03	6.8E-05	2.3E-04	7.8E-03
		0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Aluminum	1.1E+04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-02	1.3E-02	3.4E-04	0.0E+00	2.7E-02
Antimony	1.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.1E-03	3.1E-03	8.0E-05	3.7E-06	6.2E-03
Barium	1.0E+03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.8E-02	8.9E-03	4.6E-04	7.5E-03	3.5E-02
Beryllium	3.2E-01	0.0E+00	0.0E+00	0.0E+00	2.0E-10	2.0E-10	7.9E-05	2.4E-05	2.0E-06	5.9E-04	7.0E-04
Chromium (total)	2.2E+01	0.0E+00	0.0E+00	0.0E+00	7.0E-08	7.0E-08	1.4E-03	1.2E-03	3.5E-05	2.7E-03	5.4E-03
Cobalt	9.2E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.7E-04	5.7E-04	1.5E-05	0.0E+00	1.2E-03
Copper	1.4E+03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.9E-03	1.8E-02	1.5E-04	0.0E+00	2.4E-02
Iron	3.3E+04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-01	1.9E-01	3.5E-03	0.0E+00	3.3E-01
Lead	5.6E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E-01	5.6E-02	1.2E-02	2.1E-02	5.5E-01
Manganese	2.4E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.2E-03	5.9E-03	1.1E-04	1.8E-01	1.9E-01
Mercury	6.0E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.4E-03	1.2E-03	6.3E-05	7.4E-05	3.8E-03
Nickel	1.6E+01	0.0E+00	0.0E+00	0.0E+00	2.0E-09	2.0E-09	9.7E-04	3.4E-03	2.5E-05	5.9E-04	5.0E-03
Selenium	1.3E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.2E-04	6.5E-06	8.3E-06	1.6E-05	3.5E-04
Silver	2.1E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.1E-04	1.3E-03	1.3E-05	5.5E-04	2.4E-03
Thallium	1.3E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-03	2.0E-04	5.2E-05	3.5E-03	5.7E-03
Vanadium	2.8E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.8E-03	1.2E-03	9.9E-05	1.0E-03	6.1E-03
Zinc	6.4E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.6E-03	5.3E-04	6.8E-05	1.7E-02	2.0E-02

Construction Worker - Soil: Table CW-2
Equations to Calculate Cancer Risk for Construction Worker

Cancer Risk from Ingestion

$$ELCR_{ing} = LADD_{ing} * CSF_{oral}$$

$$LADD_{ing} = \frac{EPC * IR * RAF_{c\text{-}ing} * EF * ED_{ing} * EP * C1}{BW * AP_{lifetime}}$$

Cancer Risk from Dermal Absorption

$$ELCR_{derm} = LADD_{derm} * CSF_{oral}$$

$$LADD_{derm} = \frac{EPC * SA * AF * RAF_{c\text{-}derm} * EF * ED_{derm} * EP * C1}{BW * AP_{lifetime}}$$

Cancer Risk from Particulate Inhalation - Gastrointestinal Absorption

$$ELCR_{inh\text{-}GI} = LADD_{inh\text{-}GI} * CSF_{oral}$$

$$LADD_{inh\text{-}GI} = \frac{EPC * RCAF_{inh\text{-}gi} * PM_{10} * VR_{work} * RAF_{c\text{-}ing} * EF * ED_{inh} * EP * C2 * C3 * C4}{BW * AP_{lifetime}}$$

Cancer Risk from Particulate Inhalation - Pulmonary Absorption

$$ELCR_{inh} = LADD_{inh} * CSF_{inhalation}$$

$$LADD = \frac{EPC * RCAF_{inh} * PM_{10} * VR_{work} * RAF_{c\text{-}inh} * EF * ED_{inh} * EP * C2 * C3 * C4}{BW * AP_{lifetime}}$$

Parameter	Value	Units
CSF	OHM-specific	$(mg/kg\text{-}day)^{-1}$
LADD	age/OHM-specific	mg/kg-day
EPC	OHM-specific	mg/kg
IR	100	mg/day
$RAF_{c\text{-}ing}$	OHM-specific	dimensionless
$RAF_{c\text{-}derm}$	OHM-specific	dimensionless
$RAF_{c\text{-}inh}$	OHM-specific	dimensionless
EF	0.714	event/day
$ED_{ing\ \&\ derm}$	1	day/event
ED_{inh}	0.333	day/event
EP	182	days
C1	1.0E-06	kg/mg
C2	1.0E-09	kg/µg
C3	1440	min/days
C4	1.0E-03	m^3/L
BW	58.0	kg
$AP_{(lifetime)}$	25,550	days
VR_{work}	60	L/min
AF	0.29	mg/cm^2
SA	3473	cm^2/day
$RCAF_{inh\text{-}gi}$	1.5	dimensionless
$RCAF_{inh}$	0.5	dimensionless
PM_{10}	60	$\mu g/m^3$

Construction Worker - Soil: Table CW-3
Equations to Calculate Noncancer Risk for Construction Worker

#REF!

Noncancer Risk from Ingestion

$$HQ_{ing} = \frac{ADD_{ing}}{RfD_{oral\text{-}subchronic}}$$

$$ADD_{ing} = \frac{EPC * IR * RAF_{nc\text{-}ing} * EF * ED_{ing} * EP * C1}{BW * AP_{noncancer}}$$

Noncancer Risk from Dermal Absorption

$$HQ_{derm} = \frac{ADD_{derm}}{RfD_{oral\text{-}subchronic}}$$

$$ADD_{dermal} = \frac{EPC * SA * AF * RAF_{nc\text{-}derm} * EF * ED_{dermal} * EP * C1}{BW * AP_{noncancer}}$$

Noncancer Risk from Particulate Inhalation - Gastrointestinal Absorption

$$HQ_{inh\text{-}GI} = \frac{ADD_{inh\text{-}GI}}{RfD_{oral\text{-}subchronic}}$$

$$ADD_{inh\text{-}GI} = \frac{EPC * RCAF_{inh\text{-}gi} * PM_{10} * VR_{work} * RAF_{nc\text{-}ing} * EF * ED_{inh} * EP * C2 * C3 * C4}{BW * AP_{noncancer}}$$

Noncancer Risk from Particulate Inhalation - Pulmonary Absorption

$$HQ_{inh} = \frac{ADD}{RfD_{inhalation\text{-}subchronic}}$$

$$ADD_{inh} = \frac{EPC_{soil} * RCAF_{inh} * PM_{10} * VR_{work} * RAF_{nc\text{-}inh} * EF * ED_{inh} * EP * C2 * C3 * C4}{BW * AP_{noncancer}}$$

Parameter	Value	Units
RfD	OHM-specific	mg/kg-day
ADD	OHM-specific	mg/kg-day
EPC	OHM-specific	mg/kg
IR	100	mg/day
$RAF_{nc\text{-}ing}$	OHM-specific	dimensionless
$RAF_{nc\text{-}derm}$	OHM-specific	dimensionless
$RAF_{nc\text{-}inh}$	OHM-specific	dimensionless
EF	0.714	event/day
$EF_{cyanide}$	1	event/day
$ED_{ing\ \&\ derm}$	1	day/event
ED_{inh}	0.333	day/event
EP	182	days
$EP_{cyanide}$	1.00	day
C1	1.0E-06	kg/mg
C2	1.0E-09	kg/µg
C3	1440	min/days
C4	1.0E-03	m^3/L
BW	58.0	kg
$AP_{noncancer}$	182	days
$AP_{cyanide}$	1	day
VR_{work}	60	L/min
AF	0.29	mg/cm^2
SA	3473	cm^2/day
$RCAF_{inh\text{-}gi}$	1.5	dimensionless
$RCAF_{inh}$	0.5	dimensionless
PM10	60	$\mu g/m^3$

Cyanide can cause a significant health risk from a one-time exposure to concentrations that are often found in the environment. As such, risk is calculated for a single exposure. Thus, for cyanide, the exposure frequency (EF) is 1 event/day, while both the exposure period (EP) and averaging period (AP) are 1 day.

Construction Worker - Soil: Table CW-4
Definitions and Exposure Factors

#REF!

Parameter	Value	Units	Notes
ELCR - Excess Lifetime Cancer Risk	chemical specific	dimensionless	Pathway specific (ing =ingestion, derm=dermal, inh=inhalation)
HI - Hazard Index	chemical specific	dimensionless	Pathway specific (ing =ingestion, derm=dermal, inh=inhalation)
CSF - Cancer Slope Factor	chemical specific	$(mg/kg\text{-}day)^{-1}$	see Table CW-5.
RfD - Reference Dose	chemical specific	mg/kg-day	see Table CW-5.
LADD - Lifetime Average Daily Dose	chemical specific	mg/kg-day	Pathway specific. See Table CW-2.
ADD - Average Daily Dose	chemical specific	mg/kg-day	Pathway specific. See Table CW-3.
EPC - Exposure Point Concentration	chemical specific	µg/L	see Table CW-1.
IR - Soil Ingestion Rate	100	mg/day	MADEP. 2002. Technical Update: Calculation of an Enhanced Soil Ingestion Rate. (http://www.mass.gov/dep/ors/orspubs.htm).
RAF_c - Relative Absorption Factor for Cancer Effects	chemical specific	dimensionless	Pathway specific - see Table CW-5.
RAF_{nc} - Relative Absorption Factor for Noncancer Effects	chemical specific	dimensionless	Pathway specific - see Table CW-5.
EF - Exposure Frequency	0.714	event/day	5 events (days) / 7 events (days) in a week; MADEP 1995 Guidance for Disposal Site Risk Characterization pg B-38.
$EF_{cyanide}$ - Exposure Frequency for Cyanide Exposures	1.00	event/day	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Page 5-5.
$ED_{ingt,derm}$ - Exposure Duration for ingestion or dermal exposure	1	day/event	
ED_{inh} - Exposure Duration for inhalation exposure	0.333	day/event	Represents 8 hours / event.
EP - Exposure Period	182	days	6 months; MADEP 1995 Guidance for Disposal Site Risk Characterization.
$EP_{cyanide}$ - Exposure period for cyanide exposure	1	day	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Page 5-5.
BW - Body Weight	58.0	kg	U.S. EPA. 1997. Exposure Factors Handbook. Table 7-7, Females, ages 18 - 25.
$AP_{(lifetime)}$ - Averaging Period for lifetime	25,550	days	Represents 70 years
$AP_{(noncancer)}$ - Averaging Period for noncancer	182	days	6 months; MADEP 1995 Guidance for Disposal Site Risk Characterization.
$AP_{cyanide}$ - Averaging period for assessing cyanide exposure	1	day	MADEP. 1995. Guidance for Disposal Site Risk Characterization. Page 5-5.
AF - Adherence Factor	0.29	mg/cm^2	MA DEP. 2002 Technical Update: Weighted Skin-Soil Adherence Factors. (http://www.mass.gov/dep/ors/orspubs.htm)
VR_{work} - Ventilation Rate during work (heavy exertion)	60	L/min	Table B-4 MADEP 1995 Guidance for Disposal Site Risk Characterization.
SA - Surface Area	3473	cm^2/day	MADEP. 1995. Guidance for Disposal Site Risk Characterization. 50th percentile for females. Appendix Table B-2.
$RCAF_{inh-gi}$ - Relative Concentration Adjustment Factor, gastrointestinal	1.5	dimensionless	MADEP 2007. Characterization of Risks Due to Inhalation of Particulates by Construction Workers
$RCAF_{inh}$ - Relative Concentration Adjustment Factor, inhalation	0.5	dimensionless	MADEP 2002. Characterization of Risks Due to Inhalation of Particulates by Construction Workers
PM10 - Concentration of PM_{10}	60	$\mu g/m^3$	MADEP 1995 Guidance for Disposal Site Risk Characterization pg B-11

Construction Worker - Soil: Table CW-5
Chemical-Specific Data

#REF!

Oil or Hazardous Material	Oral CSF $(mg/kg\text{-}day)^{-1}$	$RAF_{c\text{-}ing}$	$RAF_{c\text{-}derm}$	$RAF_{c\text{-}inh}$	Inhalation CSF $(mg/kg\text{-}day)^{-1}$	Subchronic Oral RfD mg/kg-day	Subchronic $RAF_{nc\text{-}ing}$	Subchronic $RAF_{nc\text{-}derm}$	Subchronic $RAF_{nc\text{-}inh}$	Subchronic Inhalation RfD
Aliphatics C9 to C12	0.0E+00	0	0	0	0.0E+00	1.0E+00	1	0.5	1	1.7E-01
0	0.0E+00	0	0	0	0.0E+00	0.0E+00	0	0	0	0.0E+00
Aliphatics C9 to C18	0.0E+00	0	0	0	0.0E+00	1.0E+00	1	0.5	1	1.7E-01
Aliphatics C19 to C36	0.0E+00	0	0	0	0.0E+00	6.0E+00	1	0.1		0.0E+00
Aromatics C11 to C22	0.0E+00	0	0	0	0.0E+00	3.0E-01	0.36	0.1	1	1.4E-01
0	0.0E+00	0	0	0	0.0E+00	0.0E+00	0	0	0	0.0E+00
Methylnaphthalene, 2-	0.0E+00	0	0	0	0.0E+00	4.0E-03	0.36	0.1	1	1.4E-01
Dibenzo(a,h)anthracene	7.300E+00	0.28	0.02	1.00	7.3E+00	3.0E-01	0.28	0.02	1	1.4E-01
0	0.0E+00	0	0	0	0.0E+00	0.0E+00	0	0	0	0.0E+00
Polychlorinated biphenyls (PCBs)	2.0E+00	0.85	0.16	1	3.5E-01	5.0E-05	0.85	0.16	1	5.7E-06
0	0.0E+00	0	0	0	0.0E+00	0.0E+00	0	0	0	0.0E+00
Aluminum	0.0E+00	0	0	0	0.0E+00	1.0E+00	1	0.1	1	0.0E+00
Antimony	0.0E+00	0	0	0	0.0E+00	4.0E-04	1	0.1	1	2.9E-03
Barium	0.0E+00	0	0	0	0.0E+00	7.0E-02	1	0.05	1	1.4E-03
Beryllium	0.0E+00	0	0	0	8.4E+00	5.0E-03	1	0.03	1	5.7E-06
Chromium (total)	0.0E+00	0	0	0	4.2E+01	2.0E-02	1	0.09	1	8.6E-05
Cobalt	0.0E+00	0	0	0	0.0E+00	2.0E-02	1	0.1	1	0.0E+00
Copper	0.0E+00	0	0	0	0.0E+00	3.0E-01	1	0.3	1	0.0E+00
Iron	0.0E+00	0	0	0	0.0E+00	3.0E-01	1	0.14	1	0.0E+00
Lead	0.0E+00	0	0	0	0.0E+00	7.5E-04	0.5	0.006	1	2.9E-04
Manganese	0.0E+00	0	0	0	0.0E+00	7.0E-02	1	0.14	1	1.4E-05
Mercury	0.0E+00	0	0	0	0.0E+00	3.0E-04	1	0.05	1	8.6E-05
Nickel	0.0E+00	0	0	0	1.7E+00	2.0E-02	1	0.35	1	2.9E-04
Selenium	0.0E+00	0	0	0	0.0E+00	5.0E-03	1	0.002	1	8.6E-04
Silver	0.0E+00	0	0	0	0.0E+00	5.0E-03	1	0.25	1	4.0E-05
Thallium	0.0E+00	0	0	0	0.0E+00	8.0E-04	1	0.01	1	4.0E-06
Vanadium	0.0E+00	0	0	0	0.0E+00	9.0E-03	1	0.03	1	2.9E-04
Zinc	0.0E+00	0	0	0	0.0E+00	3.0E-01	1	0.02	1	4.0E-04

APPENDIX B

SUPPLEMENTAL GROUNDWATER SAMPLING DOCUMENTATION AND LABORATORY REPORT

Summary of Supplemental Groundwater Sampling Field Activities

Soil Boring and Monitoring Well Installation, February 20, 2009

On February 20, 2009, AES provided oversight for the installation of five soil borings that were completed as monitoring wells. Soil borings were advanced by Drilex Environmental (Drilex) of West Boylston using a track-mounted direct push machine (Geoprobe 6610). Each soil boring was advanced to a depth of 10 feet below grade surface (bgs) and monitoring wells were installed to depths of between 6.5 and 10 feet bgs. Monitoring wells were constructed of 1-inch PVC with 5-foot screens and named AES-1 through AES-5. Soil boring logs for the five monitoring wells are attached.

Groundwater Sampling, March 9, 2009

A groundwater sampling event was conducted on March 9, 2009. Groundwater samples were collected from monitoring wells AES-1, AES-3, AES-4, AES-5 using low-flow sampling techniques. Disposable tubing was discarded between sampling locations. Groundwater from each monitoring well was monitored for temperature, specific conductivity, oxidation/reduction potential, dissolved oxygen, and turbidity. Monitoring information, which included total volume of water removed and depth to water, was recorded in approximate 5-minute intervals and continued until values stabilized for monitoring well AES-5 and until one hour had passed without stabilization in monitoring well AES-1. Because of poor recharge conditions in monitoring wells AES-3 and AES-4, a grab sample was collected because a state of equilibrium could not be achieved and the wells pumped dry. Groundwater from monitoring well AES-2 was not sampled because of poor recharge conditions.

Groundwater from monitoring wells was observed to have some silt ranging in color from brown in AES-1, grey in AES-2, AES-3, and AES-4, to orange brown in AES-5. Sheens were not observed during sampling activities. Purge water was returned to the point of generation after samples were collected.

Groundwater samples were collected in pre-cleaned laboratory containers (500-ml plastic bottles) and were stored in a cooler, on ice, and transported to the laboratory the same day. Samples were sent to ESS Laboratory in Cranston, Rhode Island for lead analysis.

FIGURE 1.
AERIAL PHOTO AND SITE PLAN
59-67 MILL STREET
BROOKFIELD, MASSACHUSETTS

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AES Advanced Environmental Solutions, Inc.

BORING LOG

Site:	Mill Street	Page 1 of 1				**Boring/Well #: AES-1**
	Brookfield, MA		**Feet BGS**			**Construction Material** / **Symbol**
		Riser	0	to	1.5	PVC
Date:	2/20/2009	Screen	1.5	to	6.5	20 Schedule Slotted Screen PVC
Client:	Metcalf and Eddy	Backfill		to		
Driller:	Drilex	Seal	0	to	1	
Inspector:	MvdB	Sandpack	1	to	10	Silica Sand

Depth (feet BGS)	Sample	Blow Counts per 6"	Recovery (feet)	Detail 1" Well	Soil Description	TVOCs (ppm/v)	TVOC depth (ft)
0-5		NA	3.5'		0.0'-0.8': Dark grey, fine to medium SAND, little Silt (organic material mixed in), dry. 0.8'-1.0': Red brick, dry. 1.0'-2.0': Brown, very fine to fine SAND, little Silt, moist. 2.1'-3.4': Light brown, fine to coarse SAND, trace Silt, moist. 3.4'-3.5': Greenish brown CLAY, wet.		
5-10			3.2'		0.0'-1.1': Brown, fine to coarse SAND, trace Silt, trace Gravel, wet. 1.1'-3.2' Greenish brown CLAY, wet.		
10-15					Bottom of boring @ 10'. Well set at 6.5' due to collapsed borehole.		
15-20							
20-25	2						
25-30							
30-35							
35-40							
40-45							
45-50							
50-55							

Miscellaneous Data		Portion	Percent			Sampling Protocol
Depth to Water (ft):	~3'	And	35	to	50	Method: Direct Push
Drilling Method:	Geoprobe	Some	20	to	35	Interval: Continuous
Drill Rig Model	Trackmounted 6610	Little	10	to	20	Sampler Size: 2" x 5' Acetate sleeve.

Total Borehole Depth: 10 Feet

AES Advanced Environmental Solutions, Inc.

BORING LOG

Site:	Mill Street	Page 1 of 1				**Boring/Well #: AES-2**
	Brookfield, MA		**Feet BGS**			**Construction Material** / **Symbol**
		Riser	0	to	2	PVC
Date:	2/20/2009	Screen	2	to	7	20 Schedule Slotted Screen PVC
Client:	Metcalf and Eddy	Backfill		to		
Driller:	Drilex	Seal	0	to	1	
Inspector:	MvdB	Sandpack	1	to	10	Silica Sand

Depth (feet BGS)	Sample	Blow Counts per 6"	Recovery (feet)	Detail 1" Well	Soil Description	TVOCs (ppm/v)	TVOC depth (ft)
0-5		NA	2'		0.0'-1.5': Dark brown, very fine to medium SAND, trace Silt, dry. 1.5'-1.6': Rock. 1.6'-2.0': Greenish brown CLAY, wet.		
5-10			4.2'		0.0'-4.2': Greenish brown CLAY, wet.		
10-15					Bottom of boring @ 10'. Well set at 7' due to collapsed borehole.		
15-20							
20-25	2						
25-30							
30-35							
35-40							
40-45							
45-50							
50-55							

Miscellaneous Data		Portion	Percent			Sampling Protocol
Depth to Water (ft):	~4'	And	35	to	50	Method: Direct Push
Drilling Method:	Geoprobe	Some	20	to	35	Interval: Continuous
Drill Rig Model	Trackmounted 6610	Little	10	to	20	Sampler Size: 2" x 5' Acetate sleeve.

Total Borehole Depth: 10 Feet

AES Advanced Environmental Solutions, Inc.

BORING LOG

Site:	Mill Street	Page 1 of 1				**Boring/Well #: AES-3**
	Brookfield, MA		**Feet BGS**			**Construction Material** / **Symbol**
		Riser	0	to	2	PVC
Date:	2/20/2009	Screen	2	to	7	20 Schedule Slotted Screen PVC
Client:	Metcalf and Eddy	Backfill		to		
Driller:	Drilex	Seal	0	to	1	
Inspector:	MvdB	Sandpack	1	to	10	Silica Sand

Depth (feet BGS)	Sample	Blow Counts per 6"	Recovery (feet)	Soil Description	TVOCs (ppm/v)	TVOC depth (ft)
0-5		NA	3.1'	0.0'-1.3': Black, fine to coarse SAND, trace Silt, trace Gravel, dry. 1.3'-2.8': Orange brown, fine to coarse SAND, little Silt, moist. 2.8'-3.2': Greenish brown CLAY, wet.		
5-10			4.4'	0.0'-2.6': Greenish brown CLAY, wet. 2.6'-3.8': Grey, very fine to fine SAND, trace Silt, wet. 3.8'-4.4': Brown, fine to coarse SAND, little Gravel, trace Silt.		
10-15				Bottom of boring @ 10'. Well set at 7' due to collapsed borehole.		
15-20						
20-25	2					
25-30						
30-35						
35-40						
40-45						
45-50						
50-55						

Detail 1" Well

Miscellaneous Data		Portion	Percent			Sampling Protocol
Depth to Water (ft):	~4'	And	35	to	50	Method: Direct Push
Drilling Method:	Geoprobe	Some	20	to	35	Interval: Continuous
Drill Rig Model	Trackmounted 6610	Little	10	to	20	Sampler Size: 2" x 5' Acetate sleeve.

Total Borehole Depth: 10 Feet

AES Advanced Environmental Solutions, Inc.

BORING LOG

Site:	Mill Street	Page 1 of 1				**Boring/Well #: AES-4**
	Brookfield, MA		**Feet BGS**			**Construction Material** / **Symbol**
		Riser	0	to	4	PVC
Date:	2/20/2009	Screen	4	to	9	20 Schedule Slotted Screen PVC
Client:	Metcalf and Eddy	Backfill		to		
Driller:	Drilex	Seal	0	to	1	
Inspector:	MvdB	Sandpack	1	to	10	Silica Sand

Depth (feet BGS)	Sample	Blow Counts per 6"	Recovery (feet)	Detail 1" Well	Soil Description	TVOCs (ppm/v)	TVOC depth (ft)
0-5		NA	3.1'		0.0'-2.2': Black, very fine to fine SAND, trace Silt, trace Gravel, damp. 2.2'-3.1': Orange brown, fine SAND, moist.		
5-10			5'		0.0'-2.7': Brown, very fine to medium SAND, little Silt, trace Gravel, wet. 2.7'-4.2': Greenish brown CLAY, wet. 4.2'-5.0': Grey, very fine to fine SAND, , trace Silt, trace Gravel.		
10-15					Bottom of boring @ 10'. Well set at 9' due to collapsed borehole.		
15-20							
20-25	2						
25-30							
30-35							
35-40							
40-45							
45-50							
50-55							

Miscellaneous Data		Portion	Percent			Sampling Protocol
Depth to Water (ft):	~5'	And	35	to	50	Method: Direct Push
Drilling Method:	Geoprobe	Some	20	to	35	Interval: Continuous
Drill Rig Model	Trackmounted 6610	Little	10	to	20	Sampler Size: 2" x 5' Acetate sleeve.

Total Borehole Depth: 10 Feet

AES Advanced Environmental Solutions, Inc.

BORING LOG

Site:	Mill Street	Page 1 of 1				**Boring/Well #: AES-5**
	Brookfield, MA		**Feet BGS**			**Construction Material** / **Symbol**
		Riser	0	to	4	PVC
Date:	2/20/2009	Screen	4	to	9	20 Schedule Slotted Screen PVC
Client:	Metcalf and Eddy	Backfill		to		
Driller:	Drilex	Seal	0	to	1	
Inspector:	MvdB	Sandpack	1	to	10	Silica Sand

Depth (feet BGS)	Sample	Blow Counts per 6"	Recovery (feet)	Detail 1" Well	Soil Description	TVOCs (ppm/v)	TVOC depth (ft)
0-5		NA	1.7		0.0'-1.2': Black, very fine to fine SAND, trace Silt, trace Gravel, damp. 1.2'-1.7': Brown, fine to medium SAND, trace Silt, trace Gravel, moist.		
5-10			3.5'		0.0'-1.7': Brown, fine to coarse SAND, little Silt, trace Gravel, wet. 1.7'-2.5': Brown silty CLAY, wet. 2.5'-3.5': Brown, very fine to medium SAND, little Sit, trace Gravel, wet.		
10-15					Bottom of boring @ 10'. Well set at 10'.		
15-20							
20-25	2						
25-30							
30-35							
35-40							
40-45							
45-50							
50-55							

Miscellaneous Data		Portion	Percent			Sampling Protocol
Depth to Water (ft):	~5'	And	35	to	50	Method: Direct Push
Drilling Method:	Geoprobe	Some	20	to	35	Interval: Continuous
Drill Rig Model	Trackmounted 6610	Little	10	to	20	Sampler Size: 2" x 5' Acetate sleeve.

Total Borehole Depth: 10 Feet

Figure 2. **Ground Water Sampling Log**

Project _____ **Site** _____ **Well No.** AES-5 **Date** 3/9/09

Well Depth ~10' **Screen Length** 5' **Well Diameter** 1" **Casing Type** PVC

Sampling Device geopump **Tubing type** 1/4" **Water Level** ~~3.45~~ 6.67

Measuring Point TOC **Other Infor** start at 13:30

Sampling Personnel MudB

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc	ORP	DTW	Notes
13:45	6.28	6.74	0.173	10.79	1162.7		182.0	8.31	
13:50	6.27	6.86	0.173	10.60	1164.6		194.4	8.15	
13:55	~~7.00~~ 6.27	7.00	0.177	10.52	1165.7		195.4	8.06	
14:00	6.25	7.29	0.175	10.39	174.5		206.5	7.94	
14:04	6.25	6.81	0.177	10.40	144.2		202.6	8.15	
14:08	6.25	7.03	0.175	10.33	140.6		220.8	8.15	
14:12	6.24	6.98	0.175	10.31	132.7		214.8	8.18	
14:16	6.25	6.95	0.175	10.16	130.8		214.8	8.18	

Type of Samples Collected

1x Pb diss ft + 1x Pb diss nft @ 14:20

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

Purged ~2 gals

or. br. silty H_2O

Figure 2. **Ground Water Sampling Log**

Project Brookfield **Site** _____ **Well No.** AES-3 **Date** 3/10/09
Well Depth _____ **Screen Length** 5ft **Well Diameter** 1" **Casing Type** PVC
Sampling Device GeoPump **Tubing type** 1/4" Teflon **Water Level** 4.20 - 1.93 = 2.27
Measuring Point TOC **Other Infor** _____

Sampling Personnel Kelly Meiler

0900

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc	DTW	ORP	Notes
14:15	6.44	5.61	0.164	2.96	1450.8		4.20	23.5	
14:20	6.64	6.16	0.166	1.09	1697.4	8.9		-5.6	
14:25	6.79	6.70	0.167	0.72	1705.9	5.9		-24.4	
14:30	6.86	6.83	0.167	2.03	1707.4	15.9	8.32	-27.2	
14:35	Well ran dry. Wait 10 min for recharge								
14:45	6.87	7.92	0.172	1.99	1713.2	17.6	5.34	-21.9	
14:50	6.89	6.71	0.167	1.71	1257.1	13.1	6.56	-29.9	
14:55	6.90	6.53	0.165	2.07	881.1	17.7	7.13	-27.6	
15:00	Well ran dry. Wait for recharge						7.80		
Well pumped dry repeatedly. Collected grab									
sample @ 15.10.									

Type of Samples Collected

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

Purged water is grayish
Purged approximately 1.5 gallons

Figure 2. **Ground Water Sampling Log**

Project Brookfield **Site** _____ **Well No.** AES-1 **Date** 3-10-04
Well Depth ≈ 10' **Screen Length** 5' **Well Diameter** 1" **Casing Type** PVC
Sampling Device Geopump **Tubing type** 1/4" Teflon **Water Level** 2.28
Measuring Point TOC **Other Infor** _____

Sampling Personnel Kelly A. Meiler

Time	pH	Temp	Cond. (ms/cm)	Dis.O_2 (%DO)	Turb.	[ ]Conc	DTW	ORP	Notes
11:34	6.05	5.03	0.229	61.1	1133.5		5.61	105.0	
YSI equipment failure									
12:07	5.94	5.20	0.114	15.93	35.1	115.6	5.35	62.7	
12:11	6.02	4.90	0.111	14.28	19.6	111.2		64.2	
12:15	6.06	4.77	0.111	13.16	11.5	102.1	5.35	66.9	
12:20	6.10	4.74	0.111	11.51	13.5	89.3		68.6	
12:25	6.13	4.73	0.110	9.86	7.3	76.5	5.35	71.2	
12:30	6.13	4.69	0.110	9.70	10.5	75.2		72.5	
12:35	6.14	4.97	0.111	9.41	7.8	73.6	5.33	75.4	
12:40	6.14	5.21	0.112	9.31	14.1	73.3		78.0	
12:45	6.15	5.29	0.112	9.23	10.4	72.8	5.35	80.0	
12:50	6.15	5.05	0.111	9.12	8.1	71.5		82.6	
12:55	6.15	4.99	0.110	9.04	5.6	70.8	5.35	84.7	
13:00	6.16	4.94	0.110	9.04	5.8	70.7		85.7	
13:05	6.16	4.88	0.110	9.02	5.7	70.5	5.35	86.9	

Type of Samples Collected _____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

Purged appx. 3 gallons, Returned to point of generation.

Sampled for dissolved Pb @ 13:07 orange/brown water.

Figure 2. **Ground Water Sampling Log**

Project _____ **Site** Brookfield **Well No.** AES-4 **Date** 3/10/09

Well Depth 9' **Screen Length** 4' **Well Diameter** 1" **Casing Type** pvc

Sampling Device geopump **Tubing type** 1/4" **Water Level** 5.85

Measuring Point _____ **Other Infor** Start time 14:40

Sampling Personnel _____

Time	pH	Temp	Cond.	Dis.O_2	Turb.	~~[ ]Conc~~ ORP	DTW		Notes
14:50	6.60	6.19	0.306	5.35	1154.0	107.1	11.62		
Purged approx. 1.5 gallons returned to point of generation. Insufficient recharge.									

Type of Samples Collected

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

Sampled @ 15:15 for Pb.

2.45

Figure 2. **Ground Water Sampling Log**

Project Brookfield **Site** _____ **Well No.** AES-2 **Date** 3/9/09

Well Depth _____ **Screen Length** 5' **Well Diameter** 1" **Casing Type** PVC

Sampling Device Geo pump **Tubing type** 1/4" Teflon **Water Level** _____

Measuring Point TOC **Other Infor** _____

Sampling Personnel Kelly A. Meiler

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc	DTW		Notes
							4.40		

Type of Samples Collected Purged appx. 1 gallon. Stopped pump because there was to much air in tubing.

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

H_2O level appears to be stabalizing after pump stopped.

~~Grab Sampled because of insufficient~~

ESS Laboratory

Division of Thielsch Engineering, Inc.

CERTIFICATE OF ANALYSIS

PROJECT NARRATIVE

Mike Bingham
Advanced Environmental Solutions, Inc.
90 Madison Street, Suite 605
Worcester, MA 01608

RE: Brookfield
ESS Laboratory Work Order Number: 0903117

This signed Certificate of Analysis is our approved release of your analytical results. These results are only representative of sample aliquots received at the laboratory. ESS Laboratory expects its clients to follow all regulatory sampling guidelines. Beginning with this Project Narrative, the entire report has been paginated. The ESS Laboratory Certifications sheet is the final report page. This report should not be copied except in full without the approval of the laboratory. Samples will be disposed of thirty days after the final report has been delivered. If you have any questions or concerns, please feel free to call our Customer Service Department.

Laurel Stoddard
Laboratory Director

Digitally signed by Laurel Stoddard
Date: 2009.03.12 11:58:58 -04'00'

Analytical Summary
The project as described above has been analyzed in accordance with the ESS Quality Assurance Plan. This plan utilizes the following methodologies: US EPA SW-846, US EPA Methods for Chemical Analysis of Water and Wastes per 40 CFR Part 136, APHA Standard Methods for the Examination of Water and Wastewater, American Society for Testing and Materials (ASTM), and other recognized methodologies. The analyses with these noted observations are in conformance to the Quality Assurance Plan. In chromatographic analysis, manual integration may be used instead of automated integration because it produces more accurate results.

ESS Laboratory certifies that the test results meet the requirements of NELAC, except where noted within this project narrative.

To achieve CAM compliance for MCP data, ESS laboratory has performed and reviewed all QA/QC Requirements and Performance Standards listed in each method. Holding times and preservation have also been reviewed. All CAM requirements have been achieved unless noted in the project narrative.

Each method has been set-up in the laboratory to reach required MCP standards. The methods for aqueous VOA and Soil Methanol VOA have known limitations for certain analytes. The regulatory standards may not be achieved due to these limitations. In addition, for all methods, matrix interferences, dilutions, and %Solids may elevate method reporting limits above regulatory standards. ESS Laboratory can provide, upon request, a Data Checker (regulatory standard comparison spreadsheet) electronic deliverable which will highlight these exceedances.

Sample Receipt
The following samples were received on March 10, 2009 for the analyses specified on the enclosed Chain of Custody Record.
Question F: All samples for Metals were analyzed for a subset of the required MCP list per the client's request.

Laboratory ID	Matrix	Client Sample ID
0903117-01	Ground Water	AES-1

0903117-02	Ground Water	AES-3
0903117-03	Ground Water	AES-4
0903117-04	Ground Water	AES-5
0903117-05	Ground Water	FB-1

ESS Laboratory

Division of Thielsch Engineering, Inc.

CERTIFICATE OF ANALYSIS

Client Name: Advanced Environmental Solutions, Inc.
Client Project ID: Brookfield

ESS Laboratory Work Order: 0903117

PROJECT NARRATIVE

No unusual observations noted.

End of Project Narrative.

ESS Laboratory

Division of Thielsch Engineering, Inc.

CERTIFICATE OF ANALYSIS

Client Name: Advanced Environmental Solutions, Inc.
Client Project ID: Brookfield

ESS Laboratory Work Order: 0903117

MADEP MCP Response Action Analytical Report Certification Form

MADEP RTN*: _____

This form provides certification for the following data set:
0903117-01 through 0903117-05

Sample Matricies:	(x) Ground Water	( ) Soil/Sediment	( ) Drinking Water	( ) Other:_____	
MCP SW-846 Methods Used	8260B ( )	8151A ( )	8330 ( )	6010B ( )	7470A/1A ( )
	8270C ( )	8081A ( )	VPH ( )	6020 ( )	9014M** ( )
	8082 ( )	8021B ( )	EPH ( )	7000 S*** (x)	7196A ( )

As specified in MADEP Compendium of Analytical Methods (Check all that apply)

* List Release Tracking Number (RTN), if known. 7421-PB
** M-SW-846 9014 or MADEP Physiologically Available Cyanide (PAC) Method
*** S - SW - 846 Methods 7000 Series - List individual method and analyte

An affirmative response to questions A, B, C and D is required for "Presumptive Certainty" status

A	Were all samples received by the laboratory in a condition consistent with that described on the Chain-of-Custody documentation for the data set?	Yes	No*
B	Were all QA/QC procedures required for the specified analytical method(s) included in this report followed, including the requirement to note and discuss in a narrative QC data that did not meet appropriate performance standards or guidelines?	Yes	No*
C	Does the data included in the report meet all the requirements for "Presumptive Certainty" as described in Section 2.0 (a), (b), (c) and (d) of the MADEP document CAM VII A, "Quality Assurance and Quality Control Guidelines for the Acquisition and Reporting of Analytical Data"?	Yes	No*
D	***VPH and EPH methods only:*** Was the VPH and EPH method conducted without significant modifications (see Section 11.3 of respective Methods)?	Yes	No*

A response to questions E and F below required for "Presumptive Certainty" status

E	Were all QC performance standards and recommendations for the specific methods achieved?	Yes	No*
F	Were results for all analyte-list compounds/elements for the specified method(s) reported?	Yes	No*

****All negative responses must be addressed in an attached Environmental Laboratory Case Narrative.***

I, the undersigned, attest under the pains and penalties of perjury that, based upon my personal inquiry of those responsible for obtaining the information, the material contained in this analytical report is, to the best of my knowledge and belief, accurate and complete.

Signature: _____ Date: March 11, 2009

Printed Name: Laurel Stoddard Position: Laboratory Director

ESS Laboratory

Division of Thielsch Engineering, Inc.

CERTIFICATE OF ANALYSIS

Client Name: Advanced Environmental Solutions, Inc.
Client Project ID: Brookfield

ESS Laboratory Work Order: 0903117

3005A/6000/7000 Dissolved Metals

Client Sample ID: AES-1
Date Sampled: 03/10/09 13:07
Percent Solids: N/A

ESS Laboratory Sample ID: 0903117-01
Sample Matrix: Ground Water

Analyte	Results	Units	MRL	MA GW1	Method	DF	Analyst	Analyzed	I/V	F/V
Lead	ND	ug/L	2.5	15	7421	1	SVD	03/11/09	100	50

Client Sample ID: AES-3
Date Sampled: 03/10/09 15:10
Percent Solids: N/A

ESS Laboratory Sample ID: 0903117-02
Sample Matrix: Ground Water

Analyte	Results	Units	MRL	MA GW1	Method	DF	Analyst	Analyzed	I/V	F/V
Lead	ND	ug/L	2.5	15	7421	1	SVD	03/11/09	100	50

Client Sample ID: AES-4
Date Sampled: 03/10/09 15:15
Percent Solids: N/A

ESS Laboratory Sample ID: 0903117-03
Sample Matrix: Ground Water

Analyte	Results	Units	MRL	MA GW1	Method	DF	Analyst	Analyzed	I/V	F/V
Lead	ND	ug/L	2.5	15	7421	1	SVD	03/11/09	100	50

Client Sample ID: AES-5
Date Sampled: 03/10/09 14:20
Percent Solids: N/A

ESS Laboratory Sample ID: 0903117-04
Sample Matrix: Ground Water

Analyte	Results	Units	MRL	MA GW1	Method	DF	Analyst	Analyzed	I/V	F/V
Lead	ND	ug/L	2.5	15	7421	1	SVD	03/11/09	100	50

Client Sample ID: FB-1
Date Sampled: 03/10/09 15:20
Percent Solids: N/A

ESS Laboratory Sample ID: 0903117-05
Sample Matrix: Ground Water

Analyte	Results	Units	MRL	MA GW1	Method	DF	Analyst	Analyzed	I/V	F/V
Lead	ND	ug/L	2.5	15	7421	1	SVD	03/11/09	100	50

CERTIFICATE OF ANALYSIS

Client Name: Advanced Environmental Solutions, Inc.
Client Project ID: Brookfield
ESS Laboratory Work Order: 0903117

Quality Control Data

Analyte	Result	MRL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Qualifier
3005A/6000/7000 Dissolved Metals										
Batch BC91012 - 3005A										
Blank										
Lead	ND	2.5	ug/L							
LCS										
Lead	10.9	2.5	ug/L	10.00		109	80-120			
LCS Dup										
Lead	10.4	2.5	ug/L	10.00		104	80-120	5	20	

CERTIFICATE OF ANALYSIS

Client Name: Advanced Environmental Solutions, Inc.
Client Project ID: Brookfield ESS Laboratory Work Order: 0903117

Notes and Definitions

U	Analyte included in the analysis, but not detected
ND	Analyte NOT DETECTED above the detection limit
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MDL	Method Detection Limit
MRL	Method Reporting Limit
I/V	Initial Volume
F/V	Final Volume
§	Subcontracted analysis; see attached report
1	Range result excludes concentrations of surrogates and/or internal standards eluting in that range.
2	Range result excludes concentrations of target analytes eluting in that range.
3	Range result excludes the concentration of the C9-C10 aromatic range.
Avg	Results reported as a mathematical average.

CERTIFICATE OF ANALYSIS

Client Name: Advanced Environmental Solutions, Inc.
Client Project ID: Brookfield ESS Laboratory Work Order: 0903117

ESS LABORATORY CERTIFICATIONS

U.S. Army Corps of Engineers
Soil and Water

Rhode Island: A-179
Potable and Non Potable Water
http://www.health.ri.gov/labs/waterlabs-instate.php

Connecticut: PH-0750
Potable and Non Potable Water, Solid and Hazardous Waste
http://www.ct.gov/dph/lib/dph/environmental_health/environmental_laboratories/pdf/out_state.pdf

Maine: RI002
Potable and Non Potable Water
http://www.maine.gov/dep/blwq/topic/vessel/lab_list.pdf

Massachusetts: M-RI002
Potable and Non Potable Water
http://public.dep.state.ma.us/labcert/labcert.aspx

New Hampshire (NELAP accredited): 242405
Potable and Non PotableWater
http://www4.egov.nh.gov/des/nhelap/namesearch.asp

New York (NELAP accredited): 11313
Potable and Non Potable Water, Solid and Hazardous Waste
http://www.wadsworth.org/labcert/elap/comm.html

United States Department of Agriculture
Soil Permit: S-54210

New Jersey (NELAP accredited): RI002
Potable and Non Potable Water, Solid and Hazardous Waste
http://www.nj.gov/dep/oqa/certlabs.htm

Maryland: 301
Potable Water
http://www.mde.state.md.us/assets/document/wsp_labs

South Carolina: 78003
Volatile Organic Compounds in Potable Water

ESS Laboratory

Division of Thielsch Engineering, Inc.
185 Frances Avenue, Cranston, RI 02910-2211
Tel. (401) 461-7181 Fax (401) 461-4486
www.esslaboratory.com

CHAIN OF CUSTODY

Page 1 of 1

Turn Time ___ Standard Other X 1-day
If faster than 5 days, prior approval by laboratory is required # ___
State where samples were collected from: (MA) RI CT NH NJ NY ME Other ___
Is this project for any of the following: MA-(MCP) Navy USACE Other ___

Reporting Limits: GW | JEL 3/11/09
ESS LAB PROJECT ID: 0903117
Electronic Deliverable X Yes ___ No
Format: Excel ___ Access X PDF ___ Other ___

Co. Name	Project #	Project Name (20 Char. or less)
Advanced Environ. Solutions	9002	Brookfield

Contact Person: Michael Bingham
Address: 90 Madison ST
City: Worcester State: MA Zip: 01608 PO#:
Telephone #: 508 363-4882 Fax #: Email Address: Mibingham @

Write Required Analysis

ESS LAB Sample#	Date	Collection Time	COMP	GRAB	MATRIX	Sample Identification (20 Char. or less)	Pres Code	Number of Containers	Type of Containers	Dissolved Lead (GFAA 7421)
AES-1	3-10-09	13:07		X	GW			2		X
AES-3	3-10-09	15:10		X	GW			2		X
AES-4	3-10-09	15:15		X	GW			2		X
AES-5	3-10-09	14:20		X	GW			2		X
FB-1	3-10-09	15:20		X	GW			1		X

Container Type: P-Poly G-Glass S-Sterile V-VOA
Matrix: S-Soil SD-Solid D-Sludge WW-Waste Water GW-Ground Water SW-Surface Water DW-Drinking Water O-Oil W-Wipes F-Filters

Cooler Present ✓ Yes ___ No
Seals Intact ___ Yes ___ No NA: ✓
Cooler Temp: 3.0°C
Internal Use Only [ ] Pickup [ ] Technicians ___

Preservation Code: 1- NP, 2- HCl, 3- H_2SO_4, 4- HNO_3, 5- NaOH, 6- MeOH, 7- Asorbic Acid, 8- ZnAct, 9- ___
Sampled by: MVDB, KAM
Comments: Please hold field-filtered samples until AES has reviewed results

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Kelly A Merle	3/10/09 4:35	Ralph Banks	3/10/09 16:35	Ralph Banks	3/10/09 17:40	[signature]	3/10/9 17:40
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time

*By circling MA-MCP, client acknowledges samples were collected in accordance with MADEP CAM VII A

Please fax all changes to Chain of Custody in writing.

1 (White) Lab Copy 2 (Yellow) Client Receipt

10/26/04 A

APPENDIX C

ESTIMATED COSTS FOR REMEDIAL ALTERNATIVES

Table C-1. Planning Level Cost Estimate for Soil Stabilization and Off-Site Disposal Option and MCP Compliance Activities

Tasks and subtasks	Estimated Qty	Unit	Unit cost	Subtotal cost
DISPOSAL SITE SOIL REMEDIATION				
- SOIL STABILIZATION AND OFF-SITE DISPOSAL OPTION				
Mobilization and site preparation	1	ls	$7,500	$7,500
Dust control allowance	1	ls	$5,000	$5,000
Excavate, screen debris, and treat soil using metals stabilization technology	14,250	ton	$35	$498,750
Load, transport, and dispose debris off-site	4,275	tons	$85	$363,375
Confirmatory analyses of stabilized soil	14	ea	$150	$2,100
Load, transport, and reuse stabilized soil off-site (landfill cover)	10,000	ton	$55	$550,000
Backfill excavation with clean soil	9,500	cy	$15	$142,500
Subtotal:				**$1,569,225**
ENGINEERING, OVERSIGHT, AND MCP COMPLIANCE				
Phase IV plan (remedial action implementation)	120	hr	$100	$12,000
Remediation Design Plans and Specifications (for bidding)	80	hr	$100	$8,000
Permitting (wetlands) and coordination with conservation commission	40	hr	$100	$4,000
Oversight of Site Soil Remediation	4	weeks	$1,000	$4,000
Bills of Lading for Debris and Stabilized Soil Transport/Disposal	2	ls	$1,000	$2,000
Final Inspection and Phase IV Completion Report	50	hr	$100	$5,000
Response Action Outcome Statement	75	hr	$100	$7,500
Subtotal:				**$42,500**
Total:				**$1,611,725**

Notes:

- Quantities are based on estimated disposal site boundary and estimated average depth former building basement [estimated to be 325 feet long by 105 feet wide and 7.5 feet deep].
- Unit cost assumes that stabilized soil will be classified as non-hazardous and suitable for reuse at a lined landfill

Table C-2. Planning Level Cost Estimate for Soil Cap Option and MCP Compliance Activities

Tasks and subtasks	Estimated Qty	Unit	Unit cost	Subtotal cost
DISPOSAL SITE SOIL REMEDIATION:				
-SOIL CAP OPTION				
Mobilization and Site Preparation	1	ls	$8,000	$8,000
Dust control allowance	1	ls	$5,000	$5,000
Install erosion controls around site	900	ft	$9	$8,100
Regrade site in preparation of soil cap (0.83 acres)	1	ls	$20,000	$20,000
Debris removal and disposal allowance	500	cy	$50	$25,000
Furnish/ Install Common Fill (2.5 ft thick, 330 ft long, 110 ft wide - plus 20% for bulk)	4,000	cy	$15	$60,000
Sedimentation basin construction allowance	1	ls	$25,000	$25,000
Furnish and Install Topsoil and Seed (6 inches thick; plus 20% for bulk)	800	cy	$30	$24,000
Curbing and fencing allowance	1	ls	$15,000	$15,000
Subtotal:				**$190,100**
ENGINEERING, OVERSIGHT, AND MCP COMPLIANCE				
Phase IV plan (remedial action implementation)	120	hr	$100	$12,000
Remediation design and specifications (for bidding)	80	hr	$100	$8,000
Permitting (wetlands) and coordination with conservation commission	40	hr	$100	$4,000
Site survey and development of site grading plans	50	hr	$100	$5,000
Allowance for engineering oversight of cap construction	1	ls	$5,000	$5,000
As-built Construction, Final Inspection, and Phase IV Completion reports	75	hr	$100	$7,500
Filing of Activity and Use Limitation	50	hr	$150	$7,500
Response Action Outcome Statement	75	hr	$100	$7,500
Subtotal:				**$56,500**
Total:				**$246,600**

Notes:

- Quantities are based on estimated disposal site boundary and estimated average depth former building basement [estimated to be 325 feet long by 105 feet wide and 7.5 feet deep].

APPENDIX D

STATEMENT OF LIMITATIONS

STATEMENT OF LIMITATIONS

The data presented and the opinions expressed in this report are qualified as follows:

1. The sole purpose of the investigation and of this report is to assess the physical characteristics of the Site with respect to the presence or absence in the environment of oil or hazardous materials and substances as defined in the applicable state and federal environmental laws and regulations and to gather information regarding current and past environmental conditions at the Site.

2. Advanced Environmental Solutions (AES) and AECOM Environment (AECOM) derived the data in this report primarily from visual inspections, examination of records in the public domain, interviews with individuals with information about the Site, and a limited number of subsurface explorations made on the dates indicated. The passage of time, manifestation of latent conditions or occurrence of future events may require further exploration at the Site, analysis of the data, and reevaluation of the findings, observations, and conclusions expressed in the report.

3. In preparing this report, AES and AECOM have relied upon and presumed accurate certain information (or the absence thereof) about the Site and adjacent properties provided by governmental officials and agencies, the Client, and others identified herein. Except as otherwise stated in the report, AES and AECOM have not attempted to verify the accuracy or completeness of any such information.

4. The data reported and the findings, observations, and conclusions expressed in the report are limited by the Scope of Services, including the extent of subsurface exploration and other tests. The Scope of Services was defined by the requests of the Client, the time and budgetary constraints imposed by the Client, and the availability of access to the Site.

5. Because of the limitations stated above, the findings, observations, and conclusions expressed by AES and AECOM in this report are not, and should not be considered, an opinion concerning the compliance of any past or present owner or operator of the site with any federal, state or local law or regulation. No warranty or guarantee, whether express or implied, is made with respect to the data reported or findings, observations, and conclusions expressed in this report. Further, such data, findings observations, and conclusions are based solely upon site conditions in existence at the time of investigation.

6. This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the Agreement and the provisions thereof.