Health Consultation

EVALUATION OF SEDIMENT AND SURFACE WATER SAMPLING DATA AT THE NORTHAMPTON SANITARY LANDFILL
NORTHAPTON, HAMPSHIRE COUNTY, MASSACHUSETTS

EPA FACILITY ID: MAR000010512

Prepared by the
Massachusetts Department of Public Health

JULY 9, 2009

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

Evaluation of Sediment and Surface Water Sampling Data at the Northampton Sanitary Landfill

Northampton, Hampshire County, Massachusetts

EPA Facility ID: MAR000010512

Prepared By:

Massachusetts Department of Public Health
Bureau of Environmental Health
Community Assessment Program
Boston, Massachusetts

Under a Cooperative Agreement with:
Public Health Service
Agency for Toxic Substances and Disease Registry
U.S. Department of Health and Human Services
Atlanta, Georgia

TABLE OF CONTENTS

I. SUMMARY 1

II. BACKGROUND AND STATEMENT OF ISSUES 2

III. METHODS OF EVALUATING SEDIMENT AND SURFACE WATER RESULTS 4

IV. SAMPLING AND ANALYSIS 6

V. RESULTS 7

VI. DISCUSSION 9

VII. CONCLUSIONS 11

VIII. PUBLIC HEALTH ACTION PLAN 11

IX. REFERENCES 12

PREPARER 16

CERTIFICATION 17

TABLES 18

FIGURES 23

APPENDICES 27

APPENDIX A 28

APPENDIX B 38

APPENDIX C 47

APPENDIX D 60

LIST OF TABLES

Table 1 Maximum concentrations of constituents detected in sediment samples collected from Hannum Brook, the unnamed stream/southern wetland area, and the stormwater detention basin outlet that exceeded comparison values

Table 2 Maximum concentrations of constituents detected from 2004-2008 in surface water samples collected from Hannum Brook, the unnamed stream/southern wetland area, and the stormwater detention basin outlet that exceeded comparison values

LIST OF FIGURES

Figure 1 Location of the Northampton Sanitary Landfill, Northampton, Massachusetts

Figure 2 Approximate sediment sample locations along Hannum Brook, the unnamed stream/southern wetland area, and the stormwater detention basin outlet

Figure 3 Approximate surface water sample locations along Hannum Brook, the unnamed stream/southern wetland area, and the stormwater detention basin outlet

LIST OF APPENDICES

Appendix A Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment

Appendix B Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment

Appendix C Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water

Appendix D Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water

I. Summary

Introduction:	This health consultation was conducted because residents of Northampton, Massachusetts were concerned about coming into contact with chemicals that may have traveled from the Northampton Sanitary Landfill to sediments and surface water in streams and wetlands downstream of the Landfill. The purpose of this Health Consultation is to determine if touching or incidentally eating or drinking small amounts of sediment and surface water containing chemicals in the streams and wetlands downstream of the Northampton Sanitary Landfill could result in health effects. The top priority of ATSDR/MDPH is to ensure that the community has the best information possible to safeguard its health.
Conclusion :	MDPH concludes that touching and incidentally eating or drinking small amounts of sediments and surface water in streams and wetlands downstream from the Landfill is not expected to result in health effects.
Basis for Decision:	People can come into contact with chemicals in sediments or surface water when they take part in recreational activities in the streams or wetland areas downstream of the Landfill. Based on the available information, levels of chemicals in sediment and surface water that could get into a child's, an adolescent's, or an adult's body during these activities are below levels that would result in health effects. Also, MDPH does not consider the levels of chemicals found in sediment and surface water to present an elevated cancer risk.
Next Steps:	❖ No public health actions are needed related to sediment and surface water in streams and wetlands downstream of the Northampton Sanitary Landfill.
For More Information:	If you have concerns about your health, you should contact your health care provider. You may also call ATSDR at 1-800-CDC-INFO or MDPH at 617-624-5757 and ask for information on the Northampton Sanitary Landfill.

II. Background and Statement of Issues

At the request of concerned residents, the Community Assessment Program (CAP) at the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH), conducted an evaluation of analytical results of sediment and surface water samples collected from Hannum Brook, an unnamed stream, a wetland area, and a stormwater detention basin outlet in the vicinity of the Northampton Sanitary Landfill, located at 170 Glendale Road in Northampton, Massachusetts. This evaluation was initiated based on community concerns about possible environmental exposures, including concerns that substances from the landfill may have migrated from the site via groundwater and stormwater flow to off-site surface water and sediment.

MDPH reviewed the analytical results of surface water samples collected from 2004 through 2008 (5 years) and all sediment samples collected from Hannum Brook, the unnamed stream, the wetland area located south of the landfill (southern wetland area), and the stormwater detention basin outlet. The Massachusetts Department of Environmental Protection (MassDEP) and the City of Northampton provided the laboratory results of a cooperative sediment sampling event completed on July 8, 2008. MDPH conducted a file review at the Northampton Department of Public Works and MassDEP to obtain and review historical sediment and surface water sampling data associated with the Northampton Sanitary Landfill. Additionally, MDPH personnel accompanied a representative from the MassDEP on a site walk of the landfill and the surrounding area, including some sediment sample locations, on December 3, 2008 (Burkhamer 2008a).

The Northampton Sanitary Landfill is owned and operated by the City of Northampton as a municipal solid waste landfill, which accepts waste from 44 municipalities. The landfill began operating as a municipal solid waste landfill in 1969. Prior to 1969, the landfill property was operated as a gravel pit. The 40-acre landfill is located on a 52-acre parcel consisting of upland and wetland areas. The landfill property is bordered by residential properties to the west along Glendale Road; a storm water detention basin located in a former gravel pit owned by the City of Northampton to the north; Hannum

Brook and undeveloped wetland and upland areas to the east; residential properties located along Park Hill Road to the southeast; and Hannum Brook, an unnamed stream, the southern wetland area, and a residential property (238 Glendale Road) located along Glendale Road to the south (Dufresne-Henry 2005) (Figure 1).

Stormwater runoff from the landfill is expected to flow overland in a radial pattern. Stormwater runoff along the northern edge of the landfill property flows into a stormwater detention basin located in the former gravel pit north of the landfill. Water from the detention basin flows northeast through a channel to a wetland area located northeast of the landfill. The landfill property is within the Hannum Brook watershed and all runoff from the property eventually discharges to Hannum Brook (Dufresne-Henry 2005). South of the landfill, groundwater discharges to surface water at the unnamed stream, the southern wetland area, and Hannum Brook (Wagner and Associates 1985; Stantec 2008a and b).

The southern wetland area is located south of and downgradient from the landfill and occupies an irregular-shaped area approximately 5 acres in size (Figure 1) (MassGIS 2007). Groundwater from beneath the landfill property discharges to the southern wetland area (Stantec 2007). A portion of the southern wetland extends onto a wooded area on the eastern end of the 238 Glendale Road property.

The unnamed stream originates in the southern wetland area downstream of the landfill and flows south across a wooded area on the eastern end of the 238 Glendale Road property (Figure 1). At the time of the site visit in December, MDPH personnel estimated that the unnamed stream was 3-6 inches deep. MDPH personnel observed that sediment along the portion of the unnamed stream on the 238 Glendale Road property has a distinct rusty coloration (Burkhamer 2008a and b; MassGIS 2009).

The western half of the 238 Glendale Road property consists of a private residence, a horse barn, several out buildings, flat grassy areas, and a horse paddock. The eastern half of the 238 Glendale Road property is densely wooded and includes a steep slope slanting

down to the unnamed stream/southern wetland area. Thus, conditions are not conducive to frequent access from the residential property to the wetlands area, particularly for young children (Burkhamer 2008a and b; MassGIS 2009).

Hannum Brook originates east of the landfill in the vicinity of the former leachate treatment facility (Figure 1). Stormwater runoff from the landfill property flows into Hannum Brook along its entire length, thus no portion of Hannum Brook is located upstream of the landfill. Due to the predominantly south to southeast groundwater flow direction, the portion of Hannum Brook in the vicinity of the former leachate treatment plant is located cross-gradient from groundwater flow beneath the landfill. North of the former leachate treatment facility Hannum Brook is an intermittent stream (dry part of the year) (Dufresne-Henry 2005; Brown and Caldwell 2008a; Stantec 2008b). From its origin, Hannum Brook flows south to its confluence with the unnamed stream and then Hannum Brook continues approximately 2 miles south to its confluence with the Manhan River in Easthampton (Burkhamer 2008b; MassGIS 2009).

MDPH personnel observed that sediment along the portion of Hannum Brook in the vicinity of Park Hill Road (approximately 1,100 feet south of the landfill) has a slight rusty coloration; however, no rusty coloration was noted in the vicinity of the former leachate treatment facility (Hannum Brook's origin) or along the portion of Hannum Brook in the vicinity of Clark Lane in Easthampton (approximately 3,000 feet south of the landfill). At the time of the site visit, MDPH personnel estimated that Hannum Brook was 6-12 inches deep (Burkhamer 2008a and b; MassGIS 2009).

III. Methods of Evaluating Sediment and Surface Water Results

A screening evaluation was conducted to identify those substances detected in sediment and surface water samples that may need to be considered for further evaluation, to determine whether they may represent a potential health concern.

Due to the lack of health-based comparison values for sediment, MDPH compared sediment concentrations to soil comparison values. The screening analysis compared

concentrations of substances detected in sediment samples to health-based comparison values established by the United States Agency for Toxic Substances and Disease Registry (ATSDR) (ATSDR 2008a). If ATSDR soil comparison values were not available, sediment results were compared to U.S. Environmental Protection Agency (EPA) Regional Screening Levels (Oak Ridge National Laboratory 2008). Many constituents analyzed in sediment samples are typically found in soil and sediment, due to either naturally occurring substances in the earth's crust or from man-made activities over decades or centuries (e.g., deposition from fossil fuel use, gasoline). These results were compared to available sources on typical background levels of constituents in soil [i.e. ATSDR, MassDEP, and U. S. Geological Survey (USGS)-published background values] for comparison purposes (ATSDR 1995; MassDEP 2002; Shacklette 1984).

Due to the lack of human-health-based comparison values for surface water, results were compared to Massachusetts standards for public drinking water supplies. Water from Hannum Brook and the unnamed stream is not used as a drinking water source; and thus, comparing surface water results to drinking water comparison values is very conservative (protective of health). If Massachusetts drinking water standards were not available, results were compared to ATSDR drinking water comparison values (ATSDR 2008b). In the absence of both Massachusetts drinking water standards and ATSDR drinking water comparison values, results were compared with EPA Regional Screening Levels for tap water. Sodium results were compared to the Massachusetts drinking water guideline (MassDEP 2008a).

Comparison values are specific concentrations of a chemical for air, soil, or water that are used by health assessors to identify environmental constituents that require further evaluation. These comparison values are developed based on health guidelines and assumed exposure situations that represent conservative estimates of human exposure. Chemical concentrations detected in environmental media that are less than a comparison value are not likely to pose a health threat. However, chemical concentrations detected in environmental media above a comparison value do not necessarily indicate that a health threat is present. In order for a compound to impact one's health, it must not only be

present in the environmental media, but one must also come in contact with the compound. Therefore, if a concentration of a chemical is greater than the appropriate comparison value, the potential for exposure to the chemical should be further evaluated to determine whether exposure is occurring and whether health effects might be possible as a result of that exposure. The factors related to exposures that are unique to the specific situation under investigation need to be considered to determine if an adverse health effect from this chemical could occur.

An exposure pathway is the route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway. Note, however, that a complete exposure pathway does not necessarily mean that a public health hazard exists. Rather, specific exposure conditions, such as the route of exposure and the magnitude, frequency, and duration of exposures need to be examined more closely to evaluate possible health implications of the exposures (ATSDR 2005).

Please note that although sediment samples were analyzed for total petroleum hydrocarbons (TPH) and extractable petroleum hydrocarbons (EPH), these analytical methods do not provide compound-specific data, and hence, cannot be evaluated for health concerns. This Health Consultation focuses on data that quantify compound-specific concentrations that can be evaluated for health concerns, thus, TPH and EPH data are not evaluated in this Health Consultation.

IV. Sampling and Analysis

Sediment samples were collected in 1994 and 1996 as part of a 1997 Final Comprehensive Site Assessment, and in 2007 and 2008 as part of the approval process

for a proposed landfill expansion. Sediment samples have been analyzed for VOCs, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), phenols, metals, and/or cyanide. A total of 33 sediment samples have been collected from locations along Hannum Brook (S-1 through S-5, S-7, S-8, sed-1 through sed-4, and sed-8), the unnamed stream/southern wetland area (S-6, sed-5 through sed-7, Fedora-1, Fedora-2, and Sediment at MW-B), and the outlet channel of the stormwater detention basin (S-10). In most cases, sediment samples have been collected from the same locations multiple times and thus have the same sample names. No portions of Hannum Brook or the unnamed stream/southern wetland area are located upstream from the landfill; thus, no sediment samples have been collected upstream of the landfill (Brown and Caldwell 2008b; Dufresne-Henry 1997; Dufresne-Henry 2005; Gradient 2008; MassDEP 2008b). Figure 2 illustrates the approximate sediment sampling locations.

Surface water samples have been collected periodically since 1980. To best characterize current conditions, surface water samples collected in the last 5 years, 2004 through 2008, were evaluated in this Health Consultation. During that time, surface water samples were collected twice annually and a total of 54 samples were collected from locations along Hannum Brook (S-1, S-3, S-4, S-5, S-7, and S-8), the unnamed stream/southern wetland area (S-6, Fedora-1, and Fedora-2), and the outlet channel of the stormwater detention basin (S-10) In most cases, surface water samples have been collected from the same locations as sediment samples and thus have the same sample names. Similar to sediment samples, no surface water samples have been collected from areas that are upstream and therefore outside the potential influence of the landfill (Brown and Caldwell 2009; Dufresne-Henry 2005; Fuss & O'Neill 2007; Gradient 2008; Stantec 2008a and b) (Figure 3).

V. Results

Seventeen metals (arsenic, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, sodium, titanium, and zinc), cyanide, benzo(a)anthracene, and phenol, were detected in sediment samples (Brown and Caldwell 2008b; Gradient 2008; MassDEP 2008b; Dufresene-Henry 1997). Three metals

(arsenic, iron, and manganese) and one polyaromatic hydrocarbon (benzo(a)anthracene) were selected for further evaluation because they were detected at concentrations above comparison values as well as typical background levels in at least one sediment sample. Most exceedances were detected in sediment samples collected on or adjacent to the 238 Glendale Road property. In addition, iron was detected above comparison values in sediment samples collected along the portion of Hannum Brook north of Park Hill Road. No substances exceeded comparison values in sediment samples collected from areas of Hannum Brook located upstream of the confluence with the unnamed stream or from areas located south of Park Hill Road (Brown and Caldwell 2008b; Dufresne-Henry 1997; Dufresne-Henry 2005; Gradient 2008; MassDEP 2008b). Table 1 summarizes the maximum concentrations of substances detected above comparison values in sediment.

Arsenic (2 out of 33 samples), benzo(a)anthracene (2 out of 5 samples), and manganese (1 out of 30 samples) were detected at concentrations exceeding comparison and background values in sediment samples collected from the unnamed stream/southern wetland area on or adjacent to (east of) the 238 Glendale Road property only. Iron (8 out of 33 samples) was detected at concentrations exceeding comparison and background values in samples collected from the unnamed stream/southern wetland area on the 238 Glendale Road property and Hannum Brook north of Park Hill Road (Brown and Caldwell 2008b; Dufresne-Henry 1997; Dufresne-Henry 2005; Gradient 2008; MassDEP 2008b; Shacklette 1984).

Fourteen metals (arsenic, barium, calcium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, sodium, silver, and zinc), six VOCs (acetone, chlorobenzene, diethyl ether, 1,4-dioxane, methyl ethyl ketone, and 1,2,4-trichlorobenzene), and cyanide were detected in surface water samples from 2004 to 2008. Of these, six metals (arsenic, barium, iron, lead, manganese, and sodium) and one VOC (1,4-dioxane) were selected for further evaluation because they were detected at concentrations above comparison values in surface water samples collected from the unnamed stream/southern wetland area and Hannum Brook. All other substances were detected at concentrations below comparison values (Brown and Caldwell 2009; Fuss &

O'Neill 2007; Gradient 2008; Stantec 2008a and b). Table 2 summarizes the maximum concentrations of substances detected above comparison values in surface water.

Arsenic (2 out of 54 samples), barium (1 out of 54 samples), 1,4-dioxane (2 out of 44 samples), iron (5 out of 54 samples), lead (1 out of 54 samples), and sodium (2 out of 29 samples) were detected at concentrations exceeding comparison values in surface water samples collected from the unnamed stream/southern wetland area located on or adjacent to the 238 Glendale Road property. In addition, manganese (31 out of 54 samples) was detected at concentrations above comparison values in samples collected from the unnamed stream/southern wetland area as well as the portion of Hannum Brook located adjacent to (north of) Park Hill Road (Brown and Caldwell 2009; Fuss & O'Neill 2007; Gradient 2008; Stantec 2008a and b).

VI. Discussion

To evaluate if exposure to constituents in sediment on or near the 238 Glendale Road property or along Park Hill Road could result in adverse health effects, MDPH calculated exposure doses for the four substances (arsenic, benzo(a)anthracene, iron, and manganese) detected in sediments that exceeded ATSDR or EPA comparison values and typical background concentrations (Appendices A and B). MDPH compared calculated exposure doses to ATSDR Chronic Minimal Risk Levels (MRLs) and EPA chronic Reference Doses (RfDs) (ATSDR 2007c). MRLs and RfDs are estimates of daily human exposure to a substance below which non-cancer, adverse health outcomes are unlikely to occur. MRLs and RfDs are set below levels that might cause adverse health effects in most people, including sensitive populations (e.g., children) (ATSDR 2005). Assuming that a child played in sediments 2 days per week during the warmer months of the year (May through September) and incidentally ingested and contacted sediments in areas with the maximum concentration of a particular constituent detected in sediment samples for 10 years, the dose of each constituent evaluated would be below MRLs and RfDs for non-cancer effects. Also, under the same exposure conditions described above, the exposure dose would not result in an unusual cancer risk. MDPH also calculated exposure doses for adolescents and adults coming in contact with sediments 2 days per

week for 6 years and 30 years, respectively. These exposure doses would result in no unusual cancer risk and did not exceed MRLs or RfDs. Therefore, it is unlikely that individuals who contact these sediments would have sufficient exposures to result in adverse health effects.

To evaluate if exposure to constituents in surface water could result in adverse health effects, MDPH calculated exposure doses for the metals (arsenic, barium, iron, lead, and manganese) and the VOC (1,4 dioxane) that exceeded ATSDR comparison values or MassDEP standards for public drinking water supplies (Appendices C and D). Assuming that a child played in surface water 2 days per week during the warmer months of the year (May through September), incidentally ingested water and contacted water in areas with the maximum concentration of a particular constituent for 10 years, the dose of each constituent evaluated would be below ATSDR MRLs and EPA RfDs for non-cancer effects. Also, under the same exposure conditions described above, the exposure dose would result in no unusual cancer risk. MDPH also calculated exposure doses for adolescents and adults coming in contact with surface water 2 days per week for 6 years and 30 years, respectively. These exposure doses would result in no unusual cancer risk and did not exceed MRLs or RfDs. Therefore, it is unlikely that individuals who contact contaminated surface water would have sufficient exposures to result in adverse health effects.

Sodium is a naturally occurring element found in water and soil. It is an essential mineral that is necessary for the normal functioning of the body and maintenance of body fluids (MDPH 2007). Concentrations of sodium, in two out of 29 surface water samples, exceeded MassDEP drinking water guidelines; however, concentrations of sodium in surface water are unlikely to produce adverse health effects because the guideline value was derived assuming drinking water exposure. Occasional contact with surface water would result in considerably lower exposure opportunities than those associated with drinking water. Thus, sodium in off-site surface water is not reviewed further in this report.

VII. Conclusions

ATSDR requires that overarching conclusion category statements be used to summarize the findings of a health consultation. Conclusion category statements are selected from site-specific conditions such as the degree of public health hazard based on the presence and duration of human exposure, contaminant concentration, the nature of toxic effects associated with site-related contaminants, presence of physical hazards, and community health concerns. Therefore, based on MDPH's evaluation of the available environmental data, MDPH concludes that touching and incidentally eating or drinking small amounts of sediments and surface water in streams and wetlands downstream from the Landfill is not expected to result in health effects. This was because levels of chemicals in sediment and surface water that could get into a child's, an adolescent's, or an adult's body during recreational activities are below levels that would affect their health.

VIII. Public Health Action Plan

The purpose of the Public Health Action Plan is to ensure that this health consultation not only identifies potential public health hazards, but also provides a plan of action designed to mitigate and prevent adverse health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR/MDPH to follow up on this plan to ensure that it is implemented. The public health action to be implemented by ATSDR/MDPH is as follows: upon request, MDPH will evaluate additional environmental data related to the Northampton Sanitary Landfill.

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PREPARER

This document was prepared by the Bureau of Environmental Health of the Massachusetts Department of Public Health. If you have any questions about this document, please contact Suzanne K. Condon, Director of BEH/MDPH at 250 Washington Street, 7th Floor, Boston, MA 02108.

CERTIFICATION

The Health Consultation, *Evaluation of Sediment and Surface Water Sampling Data at the Northampton Sanitary Landfill, Northampton, Hampshire County, Massachusetts,* was prepared by the Massachusetts Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the Health Consultation was initiated. Editorial review was completed by the cooperative agreement partner.

Technical Project Officer, CAT, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this Health Consultation and concurs with its findings.

Alan D. Parker for Alan Yarbrough

Team Lead, CAT, CAPEB, DHAC

Tables

Table 1

Maximum concentrations of constituents detected in sediment samples collected from Hannum Brook, the unnamed stream/southern wetland area, and the stormwater detention basin outlet that exceeded comparison values

Contaminant	Maximum concentration (ppm)	Date of sample	Descriptive location of sample	Soil Background (ppm)	Soil comparison value (ppm)	Number of samples above comparison and background values
Arsenic [1]	110	8/21/07	**Fedora-2** Wetland area on the Fedora property	20 (MassDEP natural soil) <0.1-73 (USGS)	Chronic EMEG (child) = 20 Chronic EMEG (adult) = 200 CREG = 0.5	2 out of 33
Benzo(a)anthracene	5.1	8/21/07	**Fedora-2** Wetland area on the Fedora property	2 (MassDEP natural soil) 0.165 - 0.22 (ATSDR urban soil)	Regional Screening Levels (residential) = 0.15	2 out of 5
Iron	583,000	8/21/07	**Fedora-2** Wetland area on the Fedora property	20,000 (MassDEP natural soil)	Regional Screening Levels (residential) = 55,000	8 out of 33
Manganese	54,600	7/8/08	**SED-6** (Brown and Caldwell) Wetland area on the Fedora property	300 (MassDEP natural soil) 2-7,000 (USGS)	RMEG (child) = 3,000 RMEG (adult) = 40,000	1 out of 30

Notes:

[1] ATSDR recommends using the Chronic Environmental Media Evaluation Guide (EMEG) for a child receptor (20 ppm) as the comparison value for arsenic in soil because the ATSDR Cancer Risk Evaluation Guide (CREG) for arsenic in soil (0.5 ppm) is below typical background levels in soil.

[2] ATSDR and MassDEP comparison values for hexavalent chromium are presented.

MassDEP = Massachusetts Department of Environmental Protection

NA = Not applicable.

ppm = Parts per million.

USGS = United States Geological Survey

Sediment sample results were compared to typical soil background concentrations due to the lack of available typical background concentrations for sediment.

In 2008, total petroleum hydrocarbons (TPH) was detected at concentrations above comparison values in sediment samples; however, TPH analytical results were biased high due to the presence of organic material in the samples. Thus, the Massachusetts Department of Public Health (MDPH) does not consider the 2008 TPH results to be representative of site conditions and TPH results were not evaluated.

Table 1 (Continued)

Data sources:

Brown and Caldwell. 2008. Letter Report to Mr. James Laurila (Northampton Department of Public Works), RE: Private Well Sample Results – 238 Glendale Road. August 6, 2008.
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Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR 2008)
Chronic EMEG (adult/child) = Environmental Media Evaluation Guide (i.e., for adult or childhood exposures greater than 1 year) (ATSDR 2008)
Regional Screening Levels = Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites (Oak Ridge 2008)
RMEG (adult/child) = Reference Dose Media Evaluation Guides (an estimate of a daily exposure to the general public, including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects during a specified duration of exposure) (ATSDR 2008).

Table 2
Maximum concentrations of constituents detected from 2004-2008 in surface water samples collected from Hannum Brook, the unnamed stream/southern wetland area, and the stormwater detention basin outlet that exceeded comparison values

Substance	Maximum Concentration (ppm)	Date of sample	Descriptive location of sample	Drinking Water Comparison value (ppm)	Number of Samples Above Comparison Values
Arsenic	0.24	September 2007	**Fedora-2** Wetland area on the Fedora property	MassDEP MMCL = 0.01	2 out of 54
Barium	8.94	September 2007	**Fedora-2** Wetland area on the Fedora property	MassDEP MMCL = 2	1 out of 54
1,4-Dioxane	0.0045	October 2007	**S-7** Northern end of unnamed stream located on the 238 Glendale Road property	CREG = 0.003	2 out of 44
Iron	2,680	September 2007	**Fedora-2** Wetland area on the Fedora property	EPA Regional Screening Level (tap water) = 26	5 out of 54
Lead	0.314	September 2007	**Fedora-2** Wetland area on the Fedora property	MassDEP MMCL = 0.015	1 out of 54
Manganese	113	September 2007	**Fedora-2** Wetland area on the Fedora property	RMEG (child) = 0.5 RMEG (adult) = 2	31 out of 54
Sodium	30.8	September 2007	**Fedora-1** Wetland area on the Fedora property	Massachusetts Guideline = 20	2 out of 29

Notes:

Due to the lack of human-health-based comparison values for surface water, results were compared to Massachusetts drinking water standards. When a Massachusetts drinking water standard was not available, results were compared to ATSDR drinking water comparison values. In the absence of both a Massachusetts drinking water standard and an ATSDR drinking water comparison value, results were compared with EPA Regional Screening Levels for tap water. Because sodium does not have a Massachusetts drinking water standard, an ATSDR drinking water comparison value, or an EPA Regional Screening Value, sodium results were compared to the Massachusetts drinking water guideline.

Table 2 (Continued)

Data sources:

Brown and Caldwell. 2009. Fall 2008 Water Quality Monitoring, Northampton Sanitary Landfill, Northampton, Massachusetts. January 8, 2009.
Fuss & O'Neill. 2007. Spring 2007 Water Quality Monitoring. May 8, 2007.
Gradient Corporation. 2008. Focused Risk Characterization, Northampton Municipal Landfill, Northampton, Massachusetts. February 28, 2008.
Stantec. 2008. Northampton Sanitary Landfill, April 2008 Water Quality Monitoring and Third Round Phase 5 Hydrogeologic Study. July 7, 2008.
Stantec. 2008. Northampton Sanitary Landfill, January 2008 Water Quality Monitoring and Third Round Phase 5 Hydrogeologic Study. April 25, 2008.

Comparison values (source organization, reference):

CREG = Cancer Risk Evaluation Guide for 1 x 10-6 excess cancer risk (ATSDR 2008)

RMEG (adult/child) = Reference Dose Media Evaluation Guides (an estimate of a daily exposure to the general public, including sensitive subgroups, that is risk of deleterious effects during a specified duration of exposure

EPA RBC = EPA Region 3 Risk Based Concentration for soil (U.S. EPA, U.S. EPA 2006).

Massachusetts Guidance Value = Massachusetts guideline for sodium in public drinking water (MassDEP 2008a).

MassDEP MMCL = Massachusetts Department of Environmental Protection Massachusetts Maximum Contaminant Level.

Figures

Figure 1
Location of the Northampton Sanitary Landfill, Northampton, Massachusetts

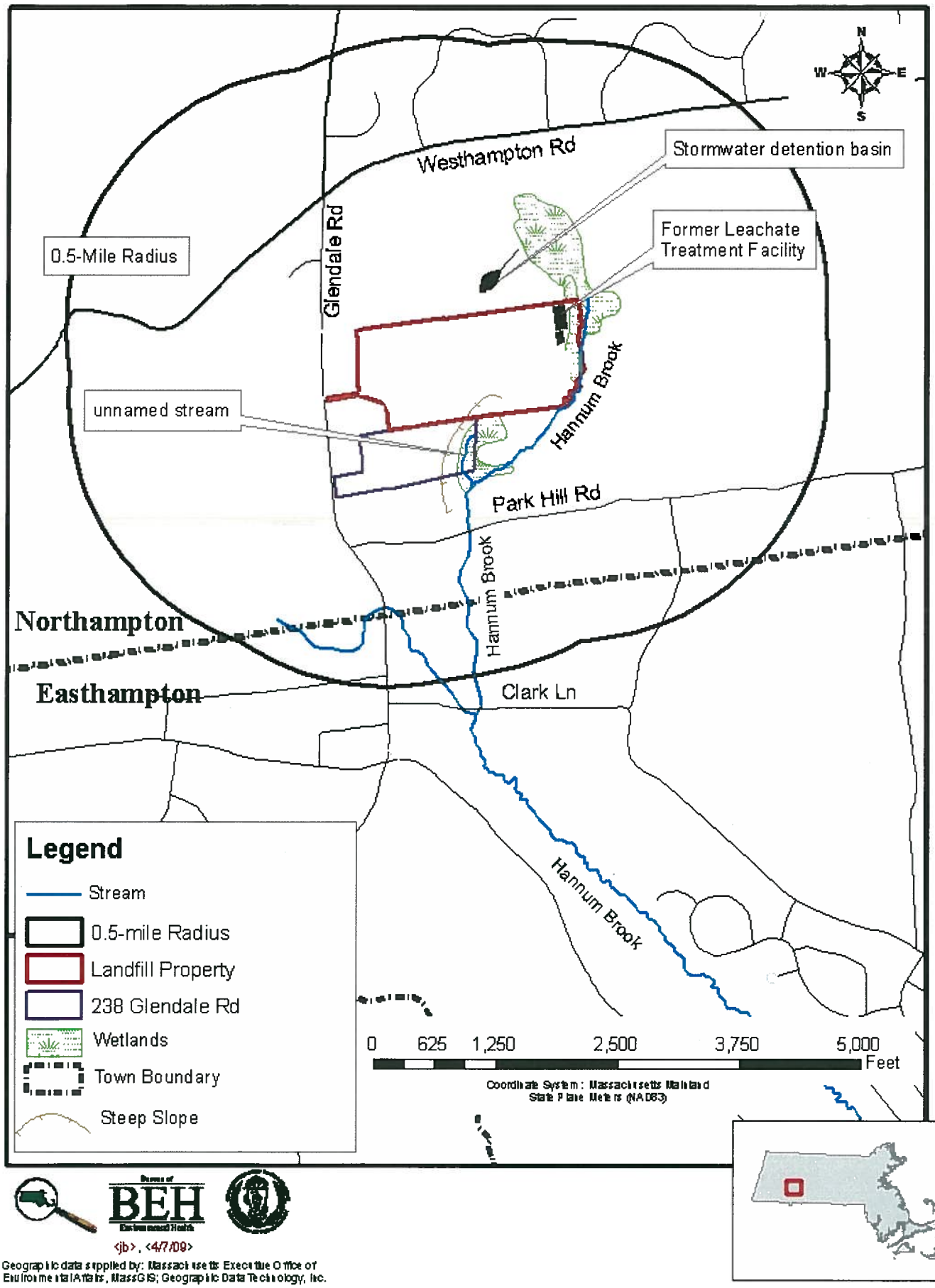
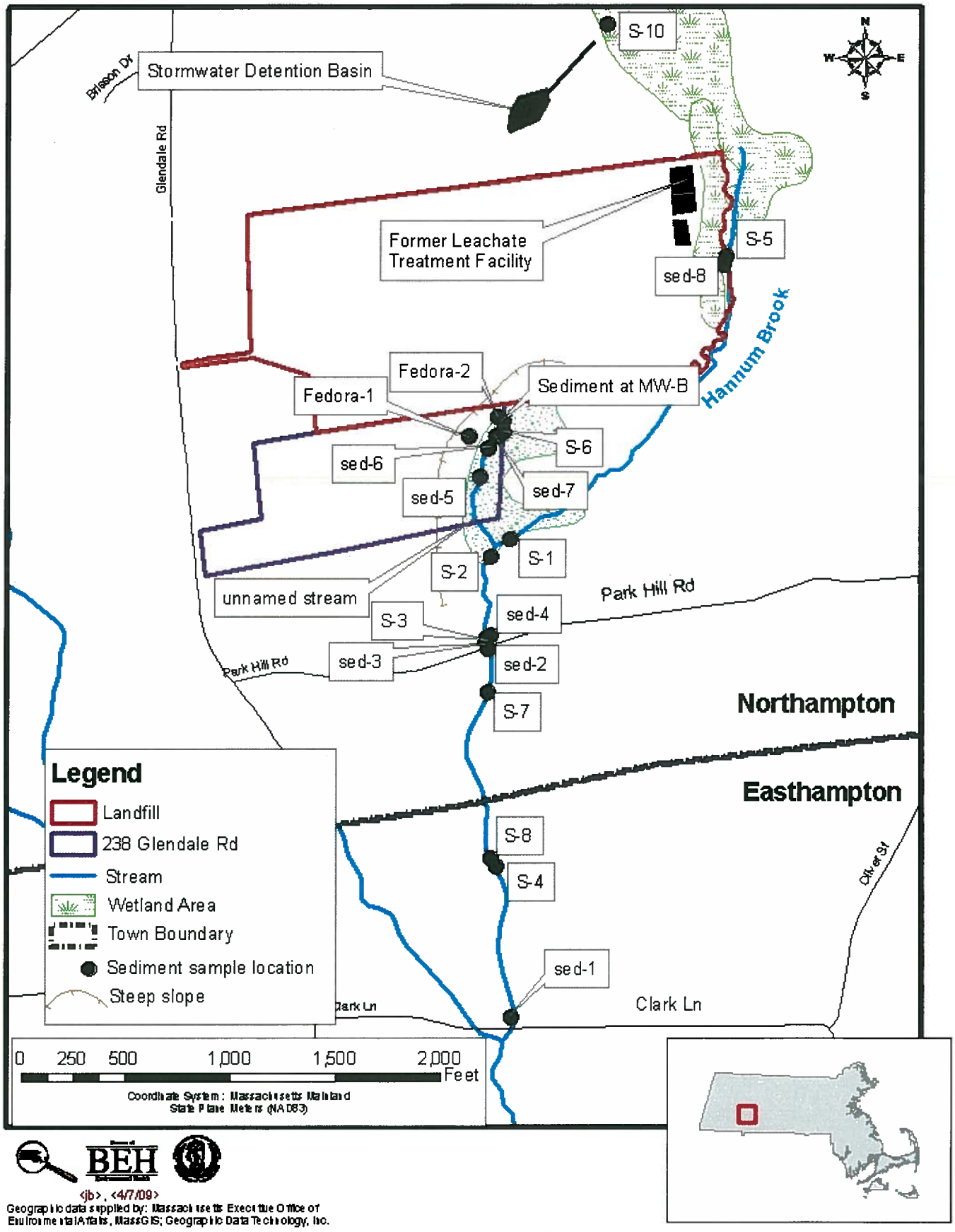


Figure 2

Approximate sediment sample locations along Hannum Brook, the unnamed stream/southern wetland area, and the stormwater detention basin outlet



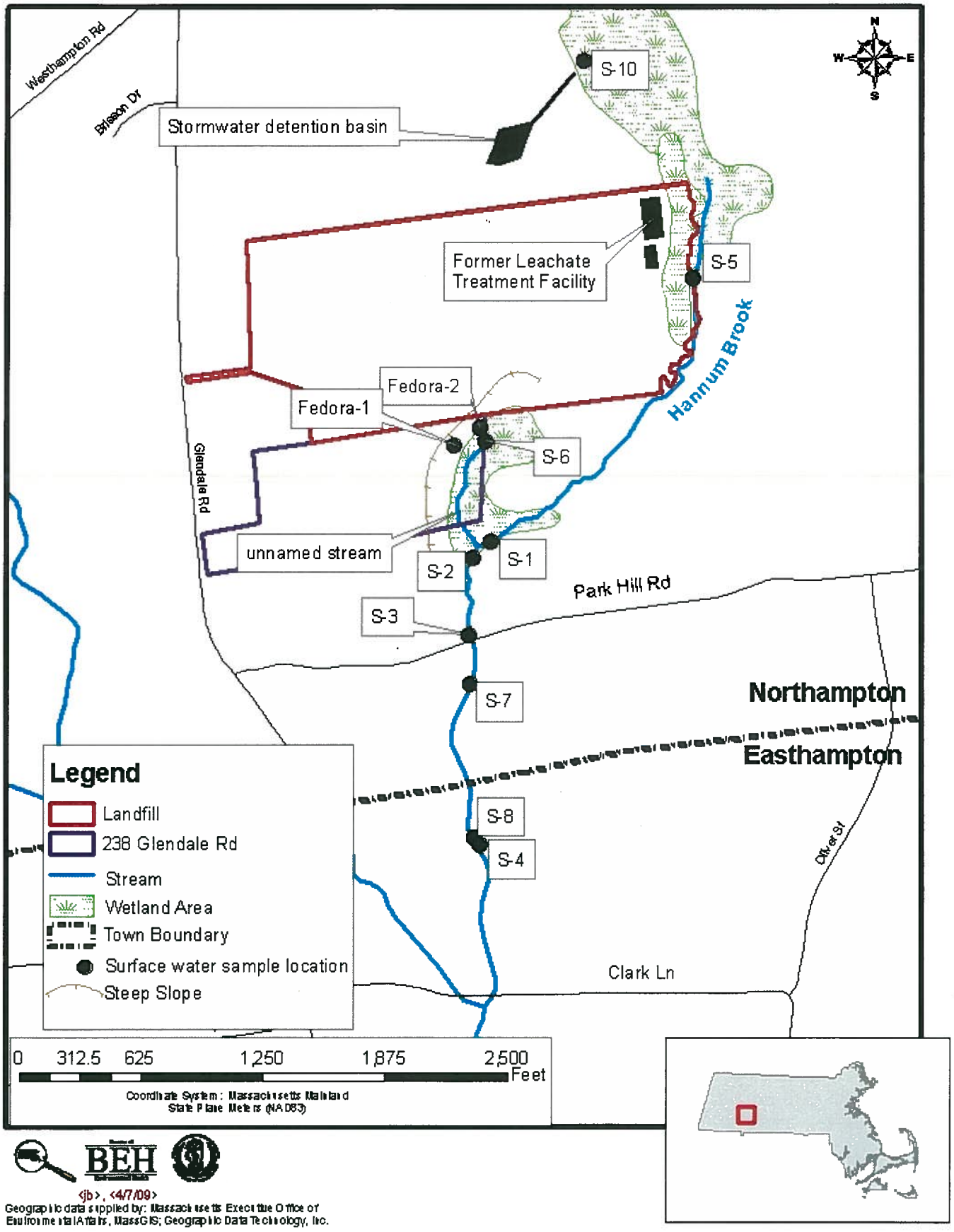
BEH

<jb>, <4/7/09>

Geographic data supplied by: Massachusetts Executive Office of Environmental Affairs, MassGIS; Geographic Data Technology, Inc.

Figure 3

Approximate surface water sample locations along Hannum Brook, the unnamed stream/southern wetland area, and the stormwater detention basin outlet



BEH

<jb>, <4/7/09>

Geographic data supplied by: Massachusetts Executive Office of Environmental Affairs, MassGIS; Geographic Data Technology, Inc.

Appendices

Appendix A

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

Exposure Dose and Cancer Risk Calculation Formulas:

Noncancer Health Effects Exposure Factor:

$$NC\_EF = \frac{F \times ED}{ED \times 365\,\text{days}}$$

Noncancer Health Effects Exposure Dose (Ingestion):

$$NC\_D = \frac{[C]_{sediment} \times IR \times NC\_EF \times CF}{BW}$$

Cancer Effects Exposure Factor:

$$C\_EF = \frac{F \times ED}{70\ \text{years} \times 365\,\text{days}}$$

Cancer Effects Exposure Dose (Ingestion):

$$C\_D = \frac{[C]_{sediment} \times IR \times C\_EF \times CF}{BW}$$

Cancer Risk:

$$CR = C\_D \times CSF$$

Where:

NC_EF = Noncancer Exposure Factor (unitless)

F = Frequency of Exposure (days/year)

ED = Years of Exposure (years)

NC_D = Noncancer Exposure Dose (mg/kg/day)

$[C]_{sediment}$ = Maximum Analyte Concentration in Sediment (mg/kg)

IR = Sediment Ingestion Rate (mg/day)

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

CF	= Conversion Factor (kg/mg)
BW	= Body Weight (kg)
C_EF	= Cancer Exposure Factor (unitless)
C_D	= Cancer Exposure Dose (mg/kg/day)
CR	= Cancer Risk (unitless)
CSF	= Cancer Slope Factor ($mg/kg/day^{-1}$)

Assumptions:

1) The receptors evaluated were a child, an adolescent, and an adult.
2) The maximum concentration of arsenic, benzo(a)anthracene, iron, and manganese detected in off-site sediment was assumed as the sediment concentration.
3) The amount of sediment ingested was assumed to be 200 milligrams per day for the child and adolescent receptors and 100 milligrams per day for the adult receptor.
4) The exposure factor was determined assuming the receptors were exposed to site sediment 2 days per week, for 22 weeks per year over a 10 year time period for a child receptor, a 6 year time period for an adolescent receptor, and a 30 year time period for an adult receptor.
5) The average body weight of the receptors was assumed to be as follows: child = 30 kilograms; adolescent = 50 kilograms; and adult = 70 kilograms.

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

1. Ingestion of Off-Site Sediment Containing Arsenic Exposure Dose and Cancer Risk Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adult)} = \frac{110\ \text{mg/kg} \times 100\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{70\ \text{kg}} = 0.000019\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.052$$

$$\text{Cancer Effects Exposure Dose (Ingestion Adult)} = \frac{110\ \text{mg/kg} \times 100\ \text{mg/day} \times 0.052 \times 10^{-6}\ \text{kg/mg}}{70\ \text{kg}} = 0.0000081\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000812 \times 1.5 = 0.000012$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescent)} = \frac{110\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{50\ \text{kg}} = 0.000053\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.01$$

$$\text{Cancer Effects Exposure Dose (Ingestion Adolescent)} = \frac{110\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.01 \times 10^{-6}\ \text{kg/mg}}{50\ \text{kg}} = 0.0000045\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.0000045 \times 1.5 = 0.0000068$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{110\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{30\ \text{kg}} = 0.000088\ \text{mg/kg/day}$$

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

$$\text{Cancer Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.017$$

$$\text{Cancer Effects Exposure Dose (Ingestion Child)} = \frac{110\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.017 \times 10^{-6}\ \text{kg/mg}}{30\ \text{kg}} = 0.000013\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.000013 \times 1.5 = 0.000019$$

NOTES:

1. The ATSDR Chronic MRL for Arsenic is 0.0003 mg/kg/day.

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

2. Ingestion of Off-Site Sediment Containing Benzo(a)anthracene Exposure Dose and Cancer Risk Calculations

a. Adult

$$\text{Cancer Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.052$$

$$\text{Cancer Effects Exposure Dose (Ingestion Adult)} = \frac{5.1\ \text{mg/kg} \times 100\ \text{mg/day} \times 0.052 \times 10^{-6}\ \text{kg/mg}}{70\ \text{kg}} = 0.00000038\ \text{mg/kg/day}$$

$$\text{Cancer Risk (Adult)} = 0.00000038 \times 7.3 = 0.0000027$$

b. Adolescent

$$\text{Cancer Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.01$$

$$\text{Cancer Effects Exposure Dose (Ingestion Adolescent)} = \frac{5.1\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.01 \times 10^{-6}\ \text{kg/mg}}{50\ \text{kg}} = 0.00000021\ \text{mg/kg/day}$$

$$\text{Cancer Risk (Adolescent)} = 0.00000021 \times 7.3 = 0.0000015$$

c. Child

$$\text{Cancer Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.017$$

$$\text{Cancer Effects Exposure Dose (Ingestion Child)} = \frac{5.1\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.017 \times 10^{-6}\ \text{kg/mg}}{30\ \text{kg}} = 0.00000059\ \text{mg/kg/day}$$

$$\text{Cancer Risk (Child)} = 0.00000059 \times 7.3 = 0.0000043$$

NOTES:

1. Noncancer health effects have been documented in animals exposed to polycyclic aromatic hydrocarbons (PAHs), including benzo(a)anthracene; however, insufficient evidence exists supporting similar health effects

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

in humans as a result of exposure to PAHs; thus, no ATSRD MRL or EPA RfD has been developed for PAHs, including benzo(a)anthracene. Due to the lack of evidence for noncancer health effects in humans, a noncancer exposure dose was not calculated for benzo(a)anthracene.

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

3. Ingestion of Off-Site Sediment Containing Iron Exposure Dose and Cancer Risk Calculations

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adults)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adults)} = \frac{583{,}000\ \text{mg/kg} \times 100\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{70\ \text{kg}} = 0.1\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescents)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescents)} = \frac{583{,}000\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{50\ \text{kg}} = 0.28\ \text{mg/kg/day}$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{583{,}000\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{30\ \text{kg}} = 0.47\ \text{mg/kg/day}$$

NOTES:

1. The provisional EPA Chronic RfD for iron is 0.7 mg/kg/day.
2. The EPA has not classified iron with respect to its cancer causing potential and has not developed an EPA Oral Cancer Slope Factor for iron. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for iron.

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

Ingestion of Off-Site Sediment Containing Manganese Exposure Dose and Cancer Risk Calculations

d. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adults)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adults)} = \frac{54{,}600\ \text{mg/kg} \times 100\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{70\ \text{kg}} = 0.0094\ \text{mg/kg/day}$$

e. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescents)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescent)} = \frac{54{,}600\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{50\ \text{kg}} = 0.026\ \text{mg/kg/day}$$

f. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{54{,}600\ \text{mg/kg} \times 200\ \text{mg/day} \times 0.12 \times 10^{-6}\ \text{kg/mg}}{30\ \text{kg}} = 0.044\ \text{mg/kg/day}$$

NOTES:

1. There is no ATSDR MRL available for manganese. The Chronic EPA RfD for manganese is 0.05 mg/kg/day.
2. The EPA concluded that existing scientific information cannot determine whether or not exposure to excess manganese can cause cancer; thus, no EPA Oral Cancer Slope Factor has been developed for manganese.

APPENDIX A

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for manganese.

Appendix B

APPENDIX B

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

Noncancer Health Effects Exposure Factor:

$$NC\_EF = \frac{F \times ED}{ED \times 365\,days}$$

Noncancer Health Effects Exposure Dose (Dermal Contact):

$$NC\_D = \frac{[C]_{sediment} \times A \times AF \times CF \times NC\_EF}{BW}$$

Cancer Effects Exposure Factor:

$$C\_EF = \frac{F \times ED}{70\ years \times 365\,days}$$

Cancer Effects Exposure Dose (Dermal Contact):

$$C\_D = \frac{[C]_{sediment} \times A \times AF \times CF \times C\_EF}{BW}$$

Cancer Risk:

$$CR = C\_D \times CSF$$

Where:

NC_EF = Noncancer Exposure Factor (unitless)

F = Frequency of Exposure (days/year)

ED = Years of Exposure (years)

NC_D = Noncancer Exposure Dose (mg/kg/day)

$[C]_{sediment}$ = Maximum Analyte Concentration in Sediment (mg/kg)

A = Soil adhered (mg)

AF = Absorbtion Factor (Dermal) (unitless)

APPENDIX B

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

CF = Conversion Factor (kg/mg)

BW = Body Weight (kg)

C_EF = Cancer Exposure Factor (unitless)

C_D = Cancer Exposure Dose (mg/kg/day)

CR = Cancer Risk (unitless)

CSF = Cancer Slope Factor ($mg/kg/day^{-1}$)

Assumptions:

1) The receptors evaluated were a child, an adolescent, and an adult.
2) The maximum concentration of arsenic, benzo(a)anthracene, iron, and manganese detected in off-site sediment was assumed as the sediment concentration.
3) The exposure factor was determined assuming the receptors were exposed to off-site sediment 2 days per week, for 22 weeks per year over a 10 year time period for a child receptor, a 6 year time period for an adolescent receptor, and a 30 year time period for an adult receptor.
4) The soil adhered was assumed to be 525 mg for a child, 299 mg for an adolescent, and 326 mg for an adult.
5) The average body weight of the receptors was assumed to be as follows: child = 30 kilograms; adolescent = 50 kilograms; and adult = 70 kilograms.

APPENDIX B

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

1) Dermal Contact with Off-Site Sediment Containing Arsenic Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Dermal Adult)} = \frac{110\ \text{mg/kg} \times 326\ \text{mg} \times 0.03 \times 10^{-6}\ \text{kg/mg} \times 0.12}{70\ \text{kg}} = 0.0000019\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.052$$

$$\text{Cancer Health Effects Exposure Dose (Dermal Adult)} = \frac{110\ \text{mg/kg} \times 326\ \text{mg} \times 0.03 \times 10^{-6}\ \text{kg/mg} \times 0.052}{70\ \text{kg}} = 0.00000079\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000079 \times 1.5 = 0.0000012$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescents)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Dermal Adolescent)} = \frac{110\ \text{mg/kg} \times 299\ \text{mg} \times 0.03 \times 10^{-6}\ \text{kg/mg} \times 0.12}{50\ \text{kg}} = 0.0000024\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.01$$

$$\text{Cancer Health Effects Exposure Dose (Dermal Adolescent)} = \frac{110\ \text{mg/kg} \times 326\ \text{mg} \times 0.03 \times 10^{-6}\ \text{kg/mg} \times 0.014}{50\ \text{kg}} = 0.00000027\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000027 \times 1.5 = 0.00000041$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

APPENDIX B

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

$$\text{Noncancer Health Effects Exposure Dose (Dermal Child)} = \frac{110\ \text{mg/kg} \times 525\ \text{mg} \times 0.03 \times 10^{-6}\ \text{kg/mg} \times 0.12}{30\ \text{kg}} = 0.000007\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.017$$

$$\text{Cancer Effects Exposure Dose (Dermal Child)} = \frac{110\ \text{mg/kg} \times 525\ \text{mg} \times 0.03 \times 10^{-6}\ \text{kg/mg} \times 0.017}{30\ \text{kg}} = 0.00000099\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000099 \times 1.5 = 0.0000015$$

NOTES:

1. The ATSDR Chronic MRL for Arsenic is 0.0003 mg/kg/day.

APPENDIX B

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

2) Dermal Contact with Off-Site Sediment Containing Benzo(a)anthracene Exposure Dose and Cancer Risk Calculations:

a. Adult

$$\text{Cancer Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.052$$

$$\text{Cancer Health Effects Exposure Dose (Dermal Adult)} = \frac{5.1\ \text{mg/kg} \times 326\ \text{mg} \times 0.13 \times 10^{-6}\ \text{kg/mg} \times 0.052}{70\ \text{kg}} = 0.00000016\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000016 \times 0.73 = 0.00000012$$

b. Adolescent

$$\text{Cancer Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.014$$

$$\text{Cancer Health Effects Exposure Dose (Dermal Adolescent)} = \frac{5.1\ \text{mg/kg} \times 299\ \text{mg} \times 0.13 \times 10^{-6}\ \text{kg/mg} \times 0.014}{50\ \text{kg}} = 0.0000000555\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.000000055 \times 0.73 = 0.00000004$$

c. Child

$$\text{Cancer Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.017$$

$$\text{Cancer Effects Exposure Dose (Dermal Child)} = \frac{5.1\ \text{mg/kg} \times 525\ \text{mg} \times 0.13 \times 10^{-6}\ \text{kg/mg} \times 0.017}{30\ \text{kg}} = 0.0000002\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.0000002 \times 0.73 = 0.00000015$$

NOTES

1. Noncancer health effects have been documented in animals exposed to polycyclic aromatic hydrocarbons (PAHs), including benzo(a)anthracene; however, insufficient evidence exists supporting similar health effects in humans as a result of exposure to PAHs; thus, no ATSRD MRL or EPA RfD has been developed

APPENDIX B

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

for PAHs, including benzo(a)anthracene. Due to the lack of evidence for noncancer health effects in humans, a noncancer exposure dose was not calculated for benzo(a)anthracene.

APPENDIX B

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

3) Dermal Contact with Off-Site Sediment Containing Iron Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Dermal Adult)} = \frac{583{,}000\ \text{mg/kg} \times 326\ \text{mg} \times 0.001 \times 10^{-6}\ \text{kg/mg} \times 0.12}{70\ \text{kg}} = 0.00033\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescents)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Dose (Dermal Adolescent)} = \frac{583{,}000\ \text{mg/kg} \times 299\ \text{mg} \times 0.001 \times 10^{-6}\ \text{kg/mg} \times 0.12}{50\ \text{kg}} = 0.00042\ \text{mg/kg/day}$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Dermal Child)} = \frac{583{,}000\ \text{mg/kg} \times 525\ \text{mg} \times 0.001 \times 10^{-6}\ \text{kg/mg} \times 0.12}{30\ \text{kg}} = 0.0012\ \text{mg/kg/day}$$

NOTES:

1. The provisional EPA Chronic RfD for iron is 0.7 mg/kg/day.
2. The EPA has not classified iron with respect to its cancer causing potential. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for iron.

APPENDIX B

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Sediment
Northampton Sanitary Landfill
Northampton, Massachusetts

4) Dermal Contact with Off-Site Sediment Containing Manganese Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Dermal Adult)} = \frac{54{,}600\ \text{mg/kg} \times 326\ \text{mg} \times 0.001 \times 10^{-6}\ \text{kg/mg} \times 0.12}{70\ \text{kg}} = 0.000031\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescents)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Dose (Dermal Adolescent)} = \frac{54{,}600\ \text{mg/kg} \times 299\ \text{mg} \times 0.001 \times 10^{-6}\ \text{kg/mg} \times 0.12}{50\ \text{kg}} = 0.000039\ \text{mg/kg/day}$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.121$$

$$\text{Noncancer Health Effects Exposure Dose (Dermal Child)} = \frac{54{,}600\ \text{mg/kg} \times 525\ \text{mg} \times 0.001 \times 10^{-6}\ \text{kg/mg} \times 0.12}{30\ \text{kg}} = 0.00012\ \text{mg/kg/day}$$

NOTES:

1. There is no ATSDR MRL available for manganese. The Chronic EPA RfD for manganese is 0.05 mg/kg/day.
2. The EPA concluded that existing scientific information cannot determine whether or not exposure to excess manganese can cause cancer; thus, no EPA Oral Cancer Slope Factor has been developed for manganese. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for manganese.

Appendix C

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

Exposure Dose and Cancer Risk Calculation Formulas:

Noncancer Health Effects Exposure Factor:

$$NC\_EF = \frac{F \times ED}{ED \times 365\ days}$$

Noncancer Health Effects Exposure Dose (Ingestion):

$$NC\_D = \frac{[C]_{surface\ water} \times IR \times NC\_EF}{BW}$$

Cancer Effects Exposure Factor:

$$C\_EF = \frac{F \times ED}{70\ years \times 365\ days}$$

Cancer Effects Exposure Dose (Ingestion):

$$C\_D = \frac{[C]_{surface\ water} \times IR \times C\_EF}{BW}$$

Cancer Risk:

$$CR = C\_D \times CSF$$

Where:

NC_EF = Noncancer Exposure Factor (unitless)

F = Frequency of Exposure (days/year)

ED = Years of Exposure (years)

NC_D = Noncancer Exposure Dose (mg/kg/day)

$[C]_{surface\ water}$ = Maximum Analyte Concentration in Surface Water (mg/L)

IR = Surface Water Ingestion Rate (L/day)

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

BW = Body Weight (kg)

C_EF = Cancer Exposure Factor (unitless)

C_D = Cancer Exposure Dose (mg/kg/day)

CR = Cancer Risk (unitless)

CSF = Cancer Slope Factor ($mg/kg/day^{-1}$)

Assumptions:

1) The receptors evaluated were a child, an adolescent, and an adult.
2) The maximum concentration of arsenic, barium, 1,4-dioxane, iron, lead, and manganese detected in off-site surface water was assumed as the surface water concentration.
3) The amount of surface water ingested was assumed to be 0.05 liters per day.
4) The exposure factor was determined assuming the receptors were exposed to off-site surface water 2 days per week, for 22 weeks per year over a 10 year time period for a child receptor, a 6 year time period for an adolescent receptor, and a 30 year time period for an adult receptor.
5) The average body weight of the receptors was assumed to be as follows: child = 30 kilograms; adolescent = 50 kilograms; and adult = 70 kilograms.

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

1) Ingestion of Off-Site Surface Water Containing Arsenic Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adult)} = \frac{0.24\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{70\ \text{kg}} = 0.000021\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.052$$

$$\text{Cancer Effects Exposure Dose (Ingestion Adult)} = \frac{0.24\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.052}{70\ \text{kg}} = 0.0000089\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.0000089 \times 1.5 = 0.000013$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescent)} = \frac{0.24\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{50\ \text{kg}} = 0.000029\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.01$$

$$\text{Cancer Effects Exposure Dose (Ingestion Adolescent)} = \frac{0.24\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.01}{50\ \text{kg}} = 0.0000025\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.0000025 \times 1.5 = 0.0000037$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{0.24\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{30\ \text{kg}} = 0.000048\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.017$$

$$\text{Cancer Effects Exposure Dose (Ingestion Child)} = \frac{0.24\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.017}{30\ \text{kg}} = 0.0000069\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.0000069 \times 1.5 = 0.00001$$

NOTES:

1. The ATSDR Chronic MRL for Arsenic is 0.0003 mg/kg/day.

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

2) Ingestion of Off-Site Surface Water Containing Barium Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adult)} = \frac{8.94\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{70\ \text{kg}} = 0.00077\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescent)} = \frac{8.94\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{50\ \text{kg}} = 0.0011\ \text{mg/kg/day}$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{8.94\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{30\ \text{kg}} = 0.0018\ \text{mg/kg/day}$$

NOTES:

1. The ATSDR Chronic MRL for Barium is 0.2 mg/kg/day.

2. The EPA has not classified barium with respect to its cancer causing potential and has not developed an EPA Oral Cancer Slope Factor. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for barium.

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

3) Ingestion of Off-Site Surface Water Containing 1,4-Dioxane Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adult)} = \frac{0.0045\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{70\ \text{kg}} = 0.00000039\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.052$$

$$\text{Cancer Effects Exposure Dose (Ingestion Adult)} = \frac{0.0045\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.052}{70\ \text{kg}} = 0.00000017\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000017 \times 1.5 = 0.0000000018$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescent)} = \frac{0.0045\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{50\ \text{kg}} = 0.00000054\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.01$$

$$\text{Cancer Effects Exposure Dose (Ingestion Adolescent)} = \frac{0.0045\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.01}{50\ \text{kg}} = 0.000000046\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.000000046 \times 1.5 = 0.00000000051$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{0.0045\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{30\ \text{kg}} = 0.0000009\ \text{mg/kg/day}$$

$$\text{Cancer Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{70\ \text{years} \times 365\ \text{days}} = 0.017$$

$$\text{Cancer Effects Exposure Dose (Ingestion Child)} = \frac{0.0045\ \text{mg/kg} \times 0.05\ \text{L/day} \times 0.017}{30\ \text{kg}} = 0.00000013\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000013 \times 1.5 = 0.0000000014$$

NOTES:

1. The ATSDR Chronic MRL for 1,4-Dioxane is 0.1 mg/kg/day.

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

4) Ingestion of Off-Site Surface Water Containing Iron Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adult)} = \frac{2{,}680\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{70\ \text{kg}} = 0.23\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescent)} = \frac{2{,}680\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{50\ \text{kg}} = 0.32\ \text{mg/kg/day}$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{2{,}680\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{30\ \text{kg}} = 0.54\ \text{mg/kg/day}$$

NOTES:

1. The provisional EPA Chronic RfD for iron is 0.7 mg/kg/day.

2. The EPA has not classified iron with respect to its cancer causing potential and has not developed an EPA Oral Cancer Slope Factor for iron. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for iron.

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

5) Ingestion of Off-Site Surface Water Containing Lead Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adult)} = \frac{0.314\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{70\ \text{kg}} = 0.000027\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescent)} = \frac{0.314\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{50\ \text{kg}} = 0.000038\ \text{mg/kg/day}$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{0.314\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{30\ \text{kg}} = 0.000063\ \text{mg/kg/day}$$

NOTES:

1. There is no ATSDR MRL or EPA RfD available for Lead. The calculated exposure dose for lead was input into the US Environmental Protection Agency's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows® (IEUBKwin32, Lead Model Version 1.0, Build 264) to estimate blood lead (PbB) levels in children exposed to lead-contaminated media. The IEUBK model results indicated that

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

exposure to the maximum concentration of lead in surface water would not result in exposures exceeding EPA cleanup guidelines.

2. The EPA has categorized lead as a probable human carcinogen; however, they have concluded that existing scientific information cannot determine whether or not exposure to lead can cause cancer in humans; thus, no EPA Oral Cancer Slope Factor has been developed for lead. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for lead.

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

6) Ingestion of Off-Site Surface Water Containing Manganese Exposure Dose and Cancer Risk Calculations:

a. Adult

$$\text{Noncancer Health Effects Exposure Factor (Adult)} = \frac{44\ \text{days/year} \times 30\ \text{years}}{30\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adult)} = \frac{113\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{70\ \text{kg}} = 0.0097\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Noncancer Health Effects Exposure Factor (Adolescent)} = \frac{44\ \text{days/year} \times 6\ \text{years}}{6\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Adolescent)} = \frac{113\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{50\ \text{kg}} = 0.014\ \text{mg/kg/day}$$

c. Child

$$\text{Noncancer Health Effects Exposure Factor (Child)} = \frac{44\ \text{days/year} \times 10\ \text{years}}{10\ \text{years} \times 365\ \text{days}} = 0.12$$

$$\text{Noncancer Health Effects Exposure Dose (Ingestion Child)} = \frac{113\ \text{mg/L} \times 0.05\ \text{L/day} \times 0.12}{30\ \text{kg}} = 0.023\ \text{mg/kg/day}$$

NOTES:

1. There is no ATSDR MRL available for manganese. The Chronic EPA RfD for manganese is 0.05 mg/kg/day.
2. The EPA concluded that existing scientific information cannot determine whether or not exposure to excess manganese can cause cancer; thus, no EPA Oral Cancer Slope Factor has been developed for manganese.

APPENDIX C

Exposure Dose and Cancer Risk Calculations for Exposure via Ingestion to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for manganese.

Appendix D

APPENDIX D

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

Exposure Dose and Cancer Risk Calculation Formulas:

Noncancer Health Effects Exposure Dose (Dermal Contact):

$$DDw = \frac{[C]_{surface\ water} \times P \times SA \times ET \times 1\,liter}{BW \times 1{,}000\,cm^3}$$

Cancer Risk:

$$CR = DDw \times CSF$$

Where:

DDw	= Dermal Absorbed Dose from water (mg/kg/day)
$[C]_{surface\ water}$	= Maximum Analyte Concentration in Surface Water (mg/L)
P	= Permeability Constant (cm/hr)
SA	= Exposed Body Surface Area (cm^2)
ET	= Exposure Time (hr/day)
BW	= Body Weight (kg)
1 liter/1,000 cm^2	= Volumetric conversion constants

Assumptions:

1) The receptors evaluated were a child, an adolescent, and an adult.
2) The maximum concentration of arsenic, barium, 1,4-dioxane, iron, lead, and manganese detected in off-site surface water was assumed as the surface water concentration.
3) The Permeability Constant for arsenic, barium, iron, and manganese is 0.001 cm/hr; lead is 0.0001 cm/hr; and 1,4-dioxane is 0.00033 cm/hr.

APPENDIX D

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

4) The exposed body surface area was assumed to be the forearms, hands, lower legs, and feet of a child (4,308 cm^2), adolescent (6,170 cm^2), or adult male (6,170 cm^2).

5) The exposure time was assumed to be 1 hour per day.

6) The average body weight of the receptors was assumed to be as follows: child = 30 kilograms; adolescent = 50 kilograms; and adult = 70 kilograms.

APPENDIX D

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

1) Dermal Contact with Off-Site Surface Water Containing Arsenic Exposure Dose and Cancer Risk Calculations:

a. Adult

$$\text{Exposure Dose (Dermal)} = \frac{0.24\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 6{,}170\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{70\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.000021\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.000021 \times 1.5 = 0.000032$$

b. Adolescent

$$\text{Exposure Dose (Dermal)} = \frac{0.24\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 6{,}170\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{50\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.00003\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00003 \times 1.5 = 0.000044$$

c. Child

$$\text{Exposure Dose (Dermal)} = \frac{0.24\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 4{,}308\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{30\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.000034\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.000034 \times 1.5 = 0.000052$$

NOTES:

1. The ATSDR Chronic MRL for Arsenic is 0.0003 mg/kg/day.

APPENDIX D

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

2) Dermal Contact with Off-Site Surface Water Containing Barium Exposure Dose and Cancer Risk Calculations:

a. Adult

$$\text{Exposure Dose (Dermal)} = \frac{8.94\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 6{,}170\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{70\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.00079\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Exposure Dose (Dermal)} = \frac{8.94\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 6{,}170\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{50\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.0011\ \text{mg/kg/day}$$

c. Child

$$\text{Exposure Dose (Dermal)} = \frac{8.94\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 4{,}308\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{30\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.0013\ \text{mg/kg/day}$$

NOTES:

1. The ATSDR Chronic MRL for Barium is 0.2 mg/kg/day.

2. The EPA has not classified barium with respect to its cancer causing potential and has not developed an EPA Oral Cancer Slope Factor for barium. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for barium.

APPENDIX D

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

3) Dermal Contact with Off-Site Surface Water Containing 1,4-Dioxane Exposure Dose and Cancer Risk Calculations:

a. Adult

$$\text{Exposure Dose (Dermal)} = \frac{0.0045\ \text{mg/L} \times 0.00033\ \text{cm/hr} \times 6{,}170\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{70\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.00000013\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000013 \times 0.011 = 0.0000000014$$

b. Adolescent

$$\text{Exposure Dose (Dermal)} = \frac{0.0045\ \text{mg/L} \times 0.00033\ \text{cm/hr} \times 6{,}170\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{50\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.00000018\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000018 \times 0.011 = 0.000000002$$

c. Child

$$\text{Exposure Dose (Dermal)} = \frac{0.0045\ \text{mg/L} \times 0.00033\ \text{cm/hr} \times 4{,}308\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{30\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.00000021\ \text{mg/kg/day}$$

$$\text{Cancer Risk} = 0.00000021 \times 0.011 = 0.0000000023$$

NOTES:

1. The ATSDR Chronic MRL for 1,4-Dioxane is 0.1 mg/kg/day.

APPENDIX D

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

4) Dermal Contact with Off-Site Surface Water Containing Iron Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Exposure Dose (Dermal)} = \frac{2{,}680\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 6{,}170\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{70\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.24\ \text{mg/kg/day}$$

b. Adolescent

$$\text{Exposure Dose (Dermal)} = \frac{2{,}680\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 6{,}170\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{50\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.33\ \text{mg/kg/day}$$

c. Child

$$\text{Exposure Dose (Dermal)} = \frac{2{,}680\ \text{mg/L} \times 0.001\ \text{cm/hr} \times 4{,}308\ \text{cm}^2 \times 1\ \text{hr/day} \times 1\ \text{L}}{30\ \text{kg} \times 1{,}000\ \text{cm}^3} = 0.38\ \text{mg/kg/day}$$

NOTES:

1. The provisional EPA Chronic RfD for iron is 0.7 mg/kg/day.

2. The EPA has not classified iron with respect to its cancer causing potential and has not developed an EPA Oral Cancer Slope Factor for iron. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for iron.

APPENDIX D

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

5) Dermal Contact with Off-Site Surface Water Containing Lead Exposure Dose and Cancer Risk

Calculations:

a. Adult

$$\text{Exposure Dose (Dermal)} = \frac{0.314\,\text{mg/L} \times 0.0001\,\text{cm/hr} \times 6{,}170\,\text{cm}^2 \times 1\,\text{hr/day} \times 1\,\text{L}}{70\,\text{kg} \times 1{,}000\,\text{cm}^3} = 0.0000028\,\text{mg/kg/day}$$

b. Adolescent

$$\text{Exposure Dose (Dermal)} = \frac{0.314\,\text{mg/L} \times 0.0001\,\text{cm/hr} \times 6{,}170\,\text{cm}^2 \times 1\,\text{hr/day} \times 1\,\text{L}}{50\,\text{kg} \times 1{,}000\,\text{cm}^3} = 0.0000039\,\text{mg/kg/day}$$

c. Child

$$\text{Exposure Dose (Dermal)} = \frac{0.314\,\text{mg/L} \times 0.0001\,\text{cm/hr} \times 4{,}308\,\text{cm}^2 \times 1\,\text{hr/day} \times 1\,\text{L}}{30\,\text{kg} \times 1{,}000\,\text{cm}^3} = 0.0000045\,\text{mg/kg/day}$$

NOTES:

1. There is no ATSDR MRL or EPA RfD available for Lead. The calculated exposure dose for lead was input into the US Environmental Protection Agency's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows® (IEUBKwin32, Lead Model Version 1.0, Build 264) to estimate blood lead (PbB) levels in children exposed to lead-contaminated media. The IEUBK model results indicated that exposure to the maximum concentration of lead in surface water would not result in exposures exceeding EPA cleanup guidelines.
2. The EPA has categorized lead as a probable human carcinogen; however, they have concluded that existing scientific information cannot determine whether or not exposure to lead can cause cancer in humans; thus, no EPA Oral Cancer Slope Factor has been developed for lead. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for lead.

APPENDIX D

Exposure Dose and Cancer Risk Calculations for Dermal Exposure to Off-Site Surface Water
Northampton Sanitary Landfill
Northampton, Massachusetts

6) Dermal Contact with Off-Site Surface Water Containing Manganese Exposure Dose and Cancer Risk Calculations:

a. Adult

$$\text{Exposure Dose (Dermal)} = \frac{113\,\text{mg/L} \times 0.001\,\text{cm/hr} \times 6{,}170\,\text{cm}^2 \times 1\,\text{hr/day} \times 1\,\text{L}}{70\,\text{kg} \times 1{,}000\,\text{cm}^3} = 0.01\,\text{mg/kg/day}$$

b. Adolescent

$$\text{Exposure Dose (Dermal)} = \frac{113\,\text{mg/L} \times 0.001\,\text{cm/hr} \times 6{,}170\,\text{cm}^2 \times 1\,\text{hr/day} \times 1\,\text{L}}{50\,\text{kg} \times 1{,}000\,\text{cm}^3} = 0.014\,\text{mg/kg/day}$$

c. Child

$$\text{Exposure Dose (Dermal)} = \frac{113\,\text{mg/L} \times 0.001\,\text{cm/hr} \times 4{,}308\,\text{cm}^2 \times 1\,\text{hr/day} \times 1\,\text{L}}{30\,\text{kg} \times 1{,}000\,\text{cm}^3} = 0.016\,\text{mg/kg/day}$$

NOTES:

1. There is no ATSDR MRL available for manganese. The Chronic EPA RfD for manganese is 0.05 mg/kg/day.
2. The EPA concluded that existing scientific information cannot determine whether or not exposure to excess manganese can cause cancer; thus, no EPA Oral Cancer Slope Factor has been developed for manganese. Due to the lack of evidence for cancer health effects in humans, cancer risk was not calculated for manganese.