Health Consultation

PUBLIC COMMENT VERSION

Evaluation of Contaminants in the Wetlands near Keith Middle School and Soil at New Bedford High School

NEW BEDFORD, MASSACHUSETTS

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
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

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NEW BEDFORD, MASSACHUSETTS

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Summary

Introduction

In 2005, ATSDR received a petition from a citizen of New Bedford, Massachusetts. The petitioner was concerned about plans to build a middle school on a former waste dump. The petitioner asked ATSDR to investigate the property where Keith Middle School (KMS) was proposed to be built and the adjacent wetlands. Construction of KMS started in 2005 and the school was occupied by December 2006. ATSDR accepted the petition and worked with the Massachusetts Department of Public Health (MDPH), the Massachusetts Department of Environmental Protection (MDEP), the United States Environmental Protection Agency (EPA), and the city of New Bedford (the city) to address environmental health concerns from the communities.

The area of concern is part of the Parker Street Waste Site (PSWS) in the city. The site includes KMS, wetlands adjacent to KMS, New Bedford High School (NBHS), Walsh and Andre McCoy athletic fields, residential properties, commercial properties, and an apartment complex. Environmental investigations identified areas contaminated with polychlorinated biphenyls (PCBs) and lead, chemicals of concerns by the petitioner. The source of the contamination at KMS was fill material from the PSWS.

Since 2005, various agencies have conducted numerous investigations and sampling events at KMS and the wetlands adjacent to it. For example, EPA developed a cleanup plan and asked ATSDR to review the plan. ATSDR completed a health consultation that concluded the plan would sufficiently protect public health and addressed petition concern regarding possible PCB exposures during remediation. In 2013, MDPH Bureau of Environmental Health completed two health consultations on the NBHS and the PSWS neighborhood in New Bedford. The health consultations were completed in response to environmental health concerns expressed by staff at NBHS and KMS and by neighbors who live near the schools. Some of the concerns in the 2005 petition were addressed by those activities. This health consultation addresses the petitioner's and community's remaining concerns about PCBs and lead exposures at KMS, the adjacent wetlands, and NBHS.

Conclusions After evaluating the available environmental data, ATSDR reached the following conclusions concerning exposure to PCBs and lead in the wetlands near KMS, NBHS, and KMS.

Conclusion 1 **Past exposure to PCBs and lead in wetland soil/sediment and surface water next to Keith Middle School: ATSDR concludes that incidental ingestion of PCBs and lead contaminated soil/sediment by trespassers is not expected to harm people's health. Because there is no proven safe level of lead in the blood, ATSDR recommends reducing lead exposure wherever possible.**

Basis for Conclusion ATSDR considers that the exposures are past because the areas were remediated and fenced to restrict access. For PCBs exposures, conservative exposure dose calculations for trespassers revealed that PCBs levels were below levels known to result in non-cancer harmful health effects. The estimated highest cancer risk for trespassers (the most sensitive age group of age 6 to 21 years) exposed to the estimated exposure point concentrations (EPC) of PCBs is 2.7E-06. Stated another way, a trespasser who visited the wetlands twice a week for 10 months a year (age 6 to 21 years) has an estimated excess cancer risks less than 3 in 1,000,000. We also interpret this as a low increased lifetime risk of developing cancer. For lead exposures, ATSDR calculated the average lead concentrations in the wetlands and compared site-specific exposure scenarios with the default EPA's Integrated Exposure Uptake and Biokinetic (IEUBK) model assumptions. ATSDR concluded that the exposures were unlikely to cause an increase in blood lead levels.

Conclusion 2 **Past exposure to PCBs and lead in New Bedford High School soil: ATSDR concludes that incidental ingestion of soil by students, teachers and faculty in the NBHS campus is not expected to harm people's health. Because there is no proven safe level of lead in the blood, ATSDR recommends reducing lead exposure wherever possible.**

Basis for Conclusion ATSDR considers that the exposures are past because the areas were remediated. For PCBs exposures, using conservative exposure assumptions, all estimated exposure doses were below levels known to result in non-cancer harmful health effects. The range of excess cancer risks is from 1E-06 to 3E-06. Stated another way, out of 1,000,000 people exposed continuously for an entire lifetime, approximately one to three additional cases of cancer might occur due to the exposure. We also interpret this as a low increased lifetime risk of developing cancer. In addition, as requested by the community, the MDPH conducted blood testing for PCBs on a sample of former teachers and students from both KMS and NBHS during 2009–2010. The results of this study indicated that the participants in the study had serum-PCB concentrations within the typical variation seen in the U.S. population. For lead exposures, ATSDR calculated the average soil lead concentrations in the NBHS areas and compared site-specific exposure scenarios with the default EPA's IEUBK model assumptions. ATSDR concluded that the exposures were unlikely to cause an increase in blood lead levels. However, there is no proven safe level of lead in the blood, ATSDR recommend reducing lead exposure wherever possible.

Conclusion 3

Exposure to PCBs and lead in KMS soil, ground water, and indoor air volatile organic compounds (VOCs): ATSDR concluded that exposures to soil, ground water, and indoor air at KMS are not expected to harm people's health because those exposure pathways are eliminated (i.e., no exposure). This conclusion is based on the continued monitoring and maintenance of the engineering controls put in place to eliminate exposure.

Basis for Conclusion

KMS buildings were built on a 3-foot soil cap and other areas were paved with a geotextile liner with a minimum 2-foot soil cap and an asphalt cover. For landscaped areas, a geotextile liner and a minimum 3-foot soil cap was used. Those measures prevented potential exposures to contaminated soil underground.

Passive ventilation was also installed to allow any sub-slab soil gases to move from beneath the vapor barrier to the vent stacks, which exit through the school's roof. Indoor air samples collected from 2006–2010 indicated that volatile organic compounds (VOCs) were detected at very low concentrations, were below ATSDR's comparison values; and, therefore, not of health concern.

Ground water is not used for drinking water or other purposes at the KMS site. Drinking water sources for KMS and the city are from five ponds located outside of New Bedford, Massachusetts. The water sources are not contaminated.

Next Steps

The city should continue the anticipated activities at the Parker Street Waste Site such as following the city's Long-Term Monitoring and Maintenance Implementation Plan (LTMMIP) and the Activity and Use Limitation to ensure that contamination levels remain below health concern.

Because there is no proven safe level of lead in the blood, ATSDR recommends reducing lead exposure wherever possible by following practices such as washing hands before eating and after being outside, etc.

As needed, ATSDR will update this document according to public comments received, to reflect the most recent sampling results and site remediation activities in relation to any completed or potential exposure pathways identified in this health consultation.

More Information

You can call ATSDR at 1-800-CDC-INFO (www.cdc.gov/info) for more information on the KMS site.

Introduction

In 2005, ATSDR received a petition from a citizen of New Bedford, Massachusetts, who had concerns over plans to build a middle school on a former waste dump. The petitioner asked ATSDR to investigate the property where the Keith Middle School (KMS) was proposed and the adjacent wetlands. ATSDR accepted the petition and worked with the Massachusetts Department of Public Health (MDPH), the Massachusetts Department of Environmental Protection (MDEP), the United States Environmental Protection Agency (EPA), and the city of New Bedford (the city) to address environmental health concerns from the communities. Some of the petitioner's concerns have already been addressed (see list of activities in the following background section). This health consultation addresses concerns from the petitioner and community about soil/sediment polychlorinated biphenyls (PCBs) and lead exposures at KMS, the adjacent wetlands, and New Bedford High School (NBHS). ATSDR continues to collaborate with all agencies on community concerns regarding PCBs, lead, and volatile organic compounds (VOCs) exposures in these areas.

Background

The KMS site is part of the Parker Street Waste Site (PSWS) in the city of New Bedford. PSWS includes KMS, wetlands adjacent to KMS, NBHS, Walsh and Andre McCoy athletic fields, residential properties, commercial properties, and an apartment complex. The EPA, MDEP, MDPH, and the city's Environmental Stewardship Department have conducted numerous investigations and sampling events at PSWS. At the PSWS, the agencies identified areas in soils contaminated with PCBs and lead. In addition, to address community's concern, indoor air samples were collected from KMS buildings. The source of the contamination at KMS was fill material from PSWS, which was formerly located where the present NBHS exists. Since 2005, federal, state, and local government agencies completed several public health actions. The following are some examples of the activities:

- EPA developed a cleanup plan for the KMS site [EPA 2005].
- ATSDR conducted a health consultation that concluded the EPA cleanup plan would be effective to protect public health [ATSDR 2005].
- The city developed the *Long-Term Monitoring and Maintenance Implementation Plan* for KMS, which required regular inspection and sampling of the air, ground water, and soil [BETA 2006c].
- In 2006, the city hired a contractor to remove the top 6 inches of contaminated sediment in the wetlands and to restore the wetlands. In 2009 and 2012, fences were installed to the north and the entire wetland area to prevent exposures of occasional trespassers.
- In 2008, MDPH Bureau of Environmental Health completed an evaluation of indoor air quality conditions at the New Bedford High School.
- The city acquired six properties that were impacted in 2010 and demolished the buildings and fenced the areas to prevent any exposures caused by remediation activities [City of New Bedford Fact Sheet 2012].
- In 2012, EPA and MDEP worked together to define the boundaries of the PSWS site and conducted sampling events and cleanup activities.

- In February 2013, MDPH Bureau of Environmental Health completed two health consultations on the NBHS and the PSWS neighborhood in New Bedford. The health consultations were completed in response to environmental health concerns expressed by staff at NBHS and KMS and by neighbors who live near the schools [MDPH, 2013].
- In January 2016, the City released a draft partial permanent solution statement for the NBHS property. This report documented the completion of the remedial activities taken at the NBHS property and implemented an Activity and Use limitation to maintain risk level below health concern.

Detailed investigation and remediation information are available from the city Environmental Stewardship Department website at: (http://www.newbedford-ma.gov/environmental-stewardship/site-assessment-cleanup-projects/parker-street-waste-site/) and from EPA's website at: (http://www.epa.gov/region1/parkerstreet/).

ATSDR began work at KMS in response to a request initiated by EPA Region I's New England office in May 2005. EPA asked ATSDR to review the proposed cleanup plan regarding public health and the occupancy of the planned middle school on the contaminated property. ATSDR completed a health consultation that concluded EPA's plan sufficiently protected public health and addressed concern regarding possible PCB exposures during remediation [ATSDR 2005]. In this health consultation, ATSDR evaluates environmental data collected from KMS, the adjacent wetlands, and NBHS to address the remaining concerns from the petitioner and community about potential exposures to PCB and lead.

Keith Middle School

Keith Middle School is located on a portion of the PSWS in the city of New Bedford. The school (formerly known as McCoy field) comprises approximately 7 acres and is bounded by Hathaway Boulevard to the east, Durfee Street to the north, Summit Street to the west, and Nemasket Street to the south [EPA 2005]. Figures 1 and 2 in Appendix C shows the location of the school.

The former McCoy Field was a recreational facility with three soccer fields. In 1994, fill material from the NBHS location (east of McCoy Site across Hathaway Boulevard) was spread across the McCoy Field. Historic dumping activities of contaminated waste took place at the NBHS site before the high school was built in the early 1970s.

Construction of KMS started in 2005 and the school was occupied by December 2006.

Wetlands

The approximately 5-acre wetlands are located between the east side of Summit Street and the west side of the middle school property, and is bordered to the north by Durfee Street. Figure 2 in Appendix C shows the location of the wetlands.

The wetlands could have been contaminated by migration of contaminants from the former McCoy Field (current location of KMS) through erosion (storm water, melted snow, runoff, and wind deposition of dust) before McCoy Field was paved. Historically, fill material is not known to have been placed in the wetlands [BETA 2005]. Since 2000, several sampling events and remedial actions have been conducted. The southern portion of the wetlands has been remediated, and the most recent sampling indicates no contaminant concentrations above Massachusetts cleanup standards or ATSDR health comparison values (CVs) in the soil or surface water. However, soil and surface water contamination still exists in the northern portion of the wetlands. In December 2009, a fence that surrounds the north portion of the wetland was installed to reduce the potential for exposure to contaminated PCB sediment. In 2012, the entire wetlands area was fenced.

New Bedford High School

The NBHS property is approximately 35 acres located in New Bedford, Massachusetts, on the north side of Parker Street, between Hathaway Boulevard on the west and Liberty Street on the east. NBHS was built in the 1970s. On-site soils at NBHS are contaminated with PCBs and lead. The source of contamination on the NBHS property originated from the old Parker Street Waste Dump, which existed in the same area before the high school was built. Soil sampling conducted on the NBHS campus identified a distinct zone of fill material consisting of ash and undocumented debris. The NBHS building and paved land cover approximately 48% of the NBHS property. The potential soil exposure areas included a children's playing area, a fenced and unfenced playing area, gym areas, a flagpole area, and other areas where students gather.

Discussion

Evaluation Process

ATSDR provides site-specific public health recommendations based on estimating site-specific exposure to chemicals, an evaluation of the toxicological literature, levels of environmental contaminants at a site compared with ATSDR CVs, the characteristics of the exposed population, and the frequency and duration of exposure. This section describes the typical process by which ATSDR evaluates the potential for adverse health effects caused by exposure to site contaminants. See Appendix A and B for more detailed descriptions and terminology.

ATSDR evaluates ways that people may be exposed to contaminated media (such as soil or water) to determine potential exposure pathways. Exposure pathways consist of five elements that must be present for exposure to occur—whether that exposure occurred in the past, is occurring now, or might occur in the future. The five elements are: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as ground water); 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).

ATSDR categorizes an exposure pathway as complete, potential, or eliminated. Completed exposure pathways are those for which the five elements are evident, and that indicate that exposure to a contaminant has occurred in the past, is now occurring, or will occur in the future. Potential exposure pathways are those for which exposure seems possible, but one or more of the elements is not clearly defined. Potential pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring now, or could occur in the future. An exposure pathway can be eliminated if at least one of the five elements is missing. Exposure pathways also can be eliminated if the site characteristics make past, current, or future human exposures extremely unlikely.

Identifying a completed exposure pathway does not necessarily mean that health effects will occur. Exposures might be, or might not be, substantive. Therefore, even if exposure has occurred, is now occurring, or is likely to occur in the future, that exposure might not affect human health if the exposure is to contaminants at levels below health concern.

The following text describes in general how ATSDR further evaluated completed exposure pathways to determine whether any potential health effects were associated with exposure to contaminated media.

- When presented with results of comprehensive environmental sampling for chemicals, ATSDR screens the contaminant levels in soil, water, and air for each chemical against CVs. CVs are concentrations of chemicals in the environment (air, water, or soil) below which no adverse human health effects would be expected to occur. If a contaminant is present at a level higher than the media-specific CV, the contaminant is retained for the next step in the evaluation. ATSDR uses the hierarchy described in the ATSDR Public Health Guidance manual to select CVs. [ATSDR 2005].
- After screening the contaminants in soil, water, or air against ATSDR's CVs, ATSDR calculates/estimates exposure doses. An *exposure dose* is the estimated amount of a contaminant to which a person is exposed. We calculate exposure doses under specified exposure situations. Each calculated exposure dose is compared against the corresponding health guideline, typically an ATSDR Minimal Risk Level (MRL) or EPA Reference Dose (RfD) for that chemical. Health guidelines are considered safe doses; that is, if the calculated dose is at or below the health guideline, no non-cancerous adverse health effects would be expected. ATSDR's Exposure Dose Guidance was used for this evaluation [ATSDR 2016].
- If the exposure dose for a chemical is greater than the health guideline, the exposure dose may be refined to reflect more closely the actual exposures that occurred or are occurring at the site. The exposure dose is then compared with known health effect levels identified in ATSDR's toxicological profiles or EPA's Integrated Risk Information System (IRIS). These comparisons are the basis for stating whether the exposure presents a health hazard.

Exposure Pathway Analysis

ATSDR evaluated the following exposure pathways for the site:

Completed Exposure pathways

NBHS Soil Exposures

The NBHS building and paved land cover approximately 48% of the NBHS property. The remainder of the school property where students can contact soil include the following:

- a grassy area in front of the gym for outdoor gym classes,
- a fenced ball playing field behind the gym,
- an unfenced field for practice behind the auditorium; and,
- a grassy outdoor area to the east of the class room buildings “the Houses” [TRC 2011].

Figure 7 in the Appendix C details the exposure areas on the NBHS campus.

Although most of the soil contamination at NBHS was at depths of 1 foot or greater, several areas on campus had elevated levels of PCBs and lead in the soil samples taken from 0-6 inches and 0-12 inches. In general, people are usually exposed to the top few inches (between 0 and 3 inches) of soil. Incidental ingestion from hand-to-mouth activity is the primary route of exposure to contaminants in soil. We assumed students and faculty are exposed to soil contaminants five days a week for 9 months of the year, or 180 days per year. A total of 106 soil samples collected from the areas were available for this evaluation.

Wetlands Area Soil and Sediment Past Exposures

The wetlands sediment and soil are contaminated by the migration of contaminants from the former McCoy Field through erosion (storm water, melted snow, runoff, and wind). In December 2009, a fence was installed around the northern wetlands to prevent access. In August 2012, the entire wetlands area was fenced to further prevent access. However, before the wetlands area was fenced, a trespasser (student, teacher or resident) may have contacted contaminated sediment occasionally. Therefore, a completed exposure pathway to sediment or soils existed for students, staff, faculty, and potential trespassers before the installation of the fences in 2012. ATSDR made the conservative assumption that hypothetically a person trespassed on the wetland over time, beginning in early childhood (aged 6 years or older) and continuing into adulthood (aged 21years or older). We assumed these trespassing events occurred twice weekly for 10 months of the year, or 80 days per year.

Wetland Surface Water Past Exposures

Depending on the season, the northern portion of the wetland may contain up to several feet of surface water, whereas the southern portion of the wetland generally does not contain significant amounts of surface water. Before the installation of fence in 2009, trespassers could have been exposed to surface water. Although there were limited surface water samples, analysis indicated that exposure would be minimal because (1) exposure was infrequent and the amount of incidental surface water ingestion was small, (2) chemicals were detected below levels of health concerns from surface water samples, especially with nondetection of PCBs, and (3) the fences surrounding the contaminated area reduced the potential of current and future exposures. See Figure 2 in the Appendix **C** for a detailed depiction of the area.

Eliminated Exposure Pathways

KMS Soil Exposures

Keith Middle School buildings were built on a 3-foot cap made of 1 foot of crushed stone overlaid with 2 feet of gravel. In areas with pavement (sidewalks and parking lots), a geotextile liner and a minimum 2-foot soil cap and an asphalt cover were installed. For landscaped areas, a geotextile liner and a minimum 3-foot soil cap was used. Those measures prevented exposures to contaminated soil underground. Therefore, ATSDR eliminated the soil exposure pathway for the KMS area.

Current Exposures for the Wetlands soil/sediment, surface water, and NBHS soils

In December 2009, a fence was installed around the northern wetlands. In August 2012, the entire wetlands area was fenced. The fences restricted access to the wetlands therefore eliminated the current and future exposures. The city and MDEP have taken preventive measures such as removing or covering the contaminated soil on the NBHS areas. In addition, an Activity and Use Limitation (AUL) has been implemented to minimize potential exposures.

Indoor Air Exposures

Prior to construction of Keith Middle School (KMS), soil gas was sampled in the area where the building was planned. Several VOCs were detected. Although the VOC concentrations were below levels of health concern, to address community concerns and prevent volatile or semi-volatile compounds in the subsurface from migrating into the buildings, the city and the school department decided to install a vapor barrier on top of the soil beneath the concrete floor of the KMS building. Passive ventilation was installed also to allow any sub-slab soil gases to move from beneath the vapor barrier to the vent stacks, which exit through the school's roof. In addition, the city developed a *Long-Term Monitoring and Maintenance Implementation Plan (LTMMIP)* for KMS that required inspection of the cap three times a year to ensure that it was intact and would prevent human exposure to the contaminated soil and fill material underneath [BETA 2006c]. Indoor air samples collected from 2006–2010 were analyzed for PCBs and volatile organic compounds (VOCs). VOCs detected at very low concentrations in the past few years have led to the LTMMIP revision, requiring only sampling for PCBs. Subsequent sampling conducted from 2007 through 2010 occasionally found total xylenes, toluene, and 2- butanone, but the levels were below their respective comparison values. This seems to indicate that the materials (glues, paints, solvents, carpeting, etc.) used during construction of the building were likely the source of the detected VOCs [TRC 2008a]. Therefore, after reviewing indoor air-monitoring sample results collected from March 2006 through August 2012 for KMS, ATSDR eliminated the indoor air exposure pathway for KMS.

In response to concerns expressed by staff at NBHS and KMS and neighbors that live close to the schools, in February 2013, MDPH Bureau of Environmental Health completed two health consultations on the NBHS and the PSWS neighborhood in New Bedford.

The report titled "Health Consultation Evaluation of Indoor Environmental Conditions and Potential Health Impacts, New Bedford High School" has three major components: an indoor air quality assessment of the NBHS including an evaluation of PCB sampling data from inside the high school, a review of information related to health concerns (including cancer) among current and former staff, and an evaluation of serum PCB results from a voluntary testing program that MDPH/BEH offered as a public service. Based on a worst case exposure scenario, the MDPH/BEH exposure assessment indicated that exposure to PCBs at levels detected at NBHS is unlikely to present an unusual cancer risks for students or staff in the short- or long-term. To ensure that cancer risks do not increase, however, the MDPH recommended taking actions to reduce or eliminate opportunities for exposure to PCBs (for example, cleaning, regular operations and maintenance plan, etc.)[MDPH, 2013].

The report titled "Health Consultation: Evaluation of Serum PCB Levels and Cancer Incidence Data, Parker Street Waste Site Neighborhood" [MDPH, 2013] summarized serum PCB results for neighbors of the site and a review of cancer incidence for the five census tracts around the site and for the city as a whole.

The links to the above MDPH reports are:

http://www.mass.gov/eohhs/docs/dph/environmental/investigations/new-bedford/2013/nbhs-qa-feb-2013.pdf
http://www.mass.gov/eohhs/docs/dph/environmental/investigations/new-bedford/2013/parker-street-waste-site-report-feb-2013.pdf

KMS Ground Water Exposures

Ground water is not used for drinking water or other purposes at the KMS site. The ground water samples collected at KMS were from monitoring wells. Ground water sampling is being conducted to determine if contaminants in the subsoils are affecting the ground water. Drinking water sources for KMS and the city are from five ponds located outside of New Bedford, Massachusetts [City of New Bedford 2013]. Because faculty, staff, and students do not use or come in contact with ground water at KMS, this exposure pathway is eliminated. Table 1 below is a summary of the exposure pathway analysis.

Table 1 Exposure Pathways Analysis for Keith Middle School Contamination Site							
Exposure Pathway	***Exposure Pathway Elements***					***Time Frame***	***Comments***
	Sources of Contamination	***Fate and Transport***	***Point of Exposure***	***Exposed Population***	***Route of Exposure***		
Wetlands soil and sediment	Releases from Parker Street Waste Dump	Migration of contaminant from fill material to wetlands soil/sediment through erosion	Wetlands	Residents in the area who trespass the area	Dermal Ingestion	Past	Completed exposure pathway before the installation of fences in 2012
Wetlands surface water	Releases from Parker Street Waste Dump	Migration of contaminant from fill material to wetlands soil/sediment through erosion	Wetlands	Residents in the area who trespass the area	Dermal Ingestion	Past	Completed exposure pathway before the installation of fences in 2009
NBHS soil exposures	Parker Street Waste Dump	Contaminants in fill materials from the waste dump	School campus	Students, teachers, and faculty	Dermal Ingestion Inhalation	Past	Completed exposure pathway
KMS soils	Parker Street Waste Dump	Contaminants in fill materials from the waste dump	School campus	Students, teachers, and faculty	Dermal Ingestion Inhalation	Past Current Future	Potential – unsure if exposure actually occurred Eliminated – no exposure due to pavement and soil cap
KMS and NBHS Indoor air	Release from contaminated fill materials	Migration of subsurface waste vapors into indoor air	Enclosed structures over contaminated soil or ground water	Students, teachers, and faculty	Inhalation	Past Current Future	Eliminated – very low concentrations of VOCs indicated by soil gas and indoor monitoring

Table 1 Exposure Pathways Analysis for Keith Middle School Contamination Site							
Exposure Pathway	***Exposure Pathway Elements***					***Time Frame***	***Comments***
	Sources of Contamination	***Fate and Transport***	***Point of Exposure***	***Exposed Population***	***Route of Exposure***		
Wetlands soil and sediment NBHS soils	Releases from Parker Street Waste Dump	Migration of contaminants from fill material to wetlands soil/sediment through erosion	Wetlands School campus	Residents in the area who trespass the area	Dermal Ingestion	Current Future	Eliminated – Installed fences around wetlands and removed/covered contaminated area at NBHS

Environmental Contamination

After identifying the completed exposure pathways, ATSDR further evaluates those contaminants present at levels above the CVs to determine whether they may be a health hazard, given the specific exposure situations at this site. ATSDR reviewed surface water, sediment and soil data from 2000 to 2011 for the wetlands adjacent to KMS and for the NBHS property.

Wetlands Soil and Sediment Contamination

Soil and sediment sampling from the wetlands started in 2000 and showed that PCB concentrations ranged from non-detect to 18.4 parts per million (ppm) in soil and sediment [BETA 2005].

In 2004 and 2005, the BETA Group Inc. personnel collected additional soil and sediment samples. Soil and sediment sample showed PCB (11.8 ppm maximum) and lead (810 ppm maximum) [BETA 2005].

In 2006, a contractor for the BETA Group, Inc. excavated 6 inches of PCB-contaminated sediment from areas of the wetlands where the PCBs concentrations exceeded 1 ppm. In 2008, sampling identified elevated PCB levels with a maximum concentration of 16.6 ppm in the north portion of the wetlands.

In the spring of 2007, a slope failure occurred near the southwestern corner of the wetland area and was repaired in the summer of 2008. In June 2008, one (SD-03) of the four sediment samples analyzed indicated a PCB level of 16.6 ppm, whereas the other three samples had no detectable PCB levels. To confirm the PCB level in the sample, six additional samples were collected in the area adjacent to the original sample. Confirmatory sampling indicated that the samples collected 5 feet to the north and west of the SD-03 sample contained PCBs (Figure 4).

Between May and December 2008, approximately 155 surface sediment and soil samples were collected from the wetlands area. This period provided the largest number of samples and was the most representative of the sampling conducted in the wetland area because samples were collected from the northern and southern portions of the wetland area [TRC 2012]. Those samples showed PCB concentrations ranging from 0.1 ppm to 33.5 ppm [TRC 2008a, TRC 2008b]. The maximum concentration of PCBs was at the SD-03 sampling location, just north of the land bridge in the northern portion of the wetlands; see Figure 4 in Appendix C for the location.

In March 2009, the highest concentration of PCBs (838 ppm) was detected in the northern wetland area at sample location ERC–SED-11A. Additional samples near this sample had PCB concentrations ranging from 5.5 ppm to 805 ppm [TRC 2009]. This sample location also contained the maximum concentration of lead (1,020 ppm) detected in the wetland sediment.

To summarize, from 2007 to 2011, a total of 356 sediment and 187 soil samples were collected from the wetlands area. All of the sediment samples were analyzed for PCBs, and most (152/187) of the soil samples were analyzed for PCBs. Out of the 356 sediment samples, 77 were analyzed for lead, and roughly half (90/187) of the soil samples were analyzed for lead [TRC 2012].

Table 2 lists the ranges of PCB and lead concentrations found in sediment and soil samples analyzed between 2004 and 2011. Concentrations are listed in ppm and samples collected from 0-6 inches and 0-12 inches are included in the summary. Because of the depth of these sediment and soil samples (i.e., 0-6 inches and 0-12 inches), the concentration of PCBs and lead in the top few inches that a trespasser would likely contact could be higher or lower.

Table 2. Keith Middle School Wetland Soil/Sediment Contaminant Concentration Ranges (PPM)

Contaminant	2004	2005	2006	2007*	2008*	2009	2010	2011 *	CV
Lead	7.3-810	1.7-658	7.5-409	1.98-52.1	NA	4.7-1,020	13-760	NA	**
Total PCB ***	ND-11.8	ND-9.4	ND-8.9	ND-0.7	ND-33.5	ND-838	ND-23.8	ND	0.4 CREG

*Many of the samples collected in 2007 were not analyzed for metals and the 2008 and 2011 samples were not analyzed for lead.
**ATSDR does not have a comparison value for lead. Massachusetts clean up standard for residential lead is 300 parts per million.
*** Total PCBs included Aroclor 1248, Aroclor 1254, and Aroclor 1260.
CREG: ATSDR's Cancer Risk Evaluation Guide for continuous residential exposure (lifetime).
CV: comparison value
NA: not analyzed
ND: non-detect

NBHS Soil Contamination

ATSDR reviewed soil-sampling data collected from the high school property from 2004 through 2006 and from 2008 through 2009. Between 2004 and 2006, BETA, the city contractor at the time, sampled soil from 343 boring locations (depths greater than 12 inches) and 12 near-surface locations (0-12 inches) [BETA 2006a]. The limited number of near-surface samples were not representative of the entire NBHS grounds. In addition, near-soil samples of 0 to 12 inches may over- or underestimate the concentration at the surface that persons contact. Therefore, ATSDR focused its review and analysis on the samples collected from 2008 through 2009 by TRC, the city's current contractor for the PSWS cleanup. During 2008–2009, TRC collected 167 NBHS soil samples (0-6 inches) for lead, and 180 soil samples (0-6 inches) for PCBs. The table 3 lists the ranges of PCBs and lead levels for soil samples at the NBHS [TRC 2011].

Table 3. New Bedford High School Soil (0-6 inches) Contaminant Concentration Ranges from 2008 and 2009 (mg/kg)

Contaminant	2008 Range	Average Concentration	2009 Range	Average Concentration	Comparison Value
Lead	ND-363	54	ND-990	135.6	*
PCBs	ND-4.2	0.2	ND-45.9	1.6	0.4 CREG

* ATSDR does not have a comparison value for lead. Massachusetts clean up standard for residential lead is 300 mg/kg.
CREG: ATSDR's Cancer Risk Evaluation Guide for continuous residential exposure (lifetime)
ND: non-detect

TRC divided the NBHS site into 11 different potential exposure areas to characterize site risk and to determine additional areas in need of remedial actions [TRC 2011]. The 11 areas are designated as HS-1 to HS-11 on Figure 7 in the Appendix C.

Public Health Implications

ATSDR further evaluated the completed exposure pathways to determine whether any potential health effects were associated with exposure to contaminants at the site. For chemicals exceeding comparison values (PCBs and lead at this site), ATSDR calculates estimated exposure doses (the amount of contaminant to which a person ingests) and cancer risks.

To estimate exposure doses, ATSDR made several assumptions. Assumptions are based on default values from ATSDR's Public Health Guidance Manual [ATSDR 2005], ATSDR's Exposure Dose Guidance [ATSDR 2016], EPA's Exposure Assessment Handbook [USEPA 2011], Child-Specific Exposure Factors Handbook [USEPA 2008], or professional judgment. When available, site-specific information was used. Appropriate exposure point concentrations (EPCs) were used to calculate exposure doses. EPCs are the representative contaminant concentrations within an area to which people are exposed. Each calculated exposure dose is compared against the corresponding health guideline. If the calculated exposure dose for a chemical is greater than the health guideline, the exposure dose may be refined to reflect more closely actual exposures that occurred or are occurring at the site. See Appendix A for a detailed discussion of ATSDR's evaluation process and chemical information. See Appendix D for determining the EPCs, the dose calculation assumptions, and results.

PCBs exposures at wetlands and NBHS

(1) PCB exposure at both northern and southern wetlands

ATSDR used an on-site trespasser scenario to evaluate past exposure to PCBs found in the wetlands. The trespasser was assumed to engage in general recreational activities such as walking, hiking, and playing. ATSDR does not have default exposure factors for human trespassers, thus, we used site-specific judgment to estimate appropriate exposure inputs that would not underestimate exposures. The exposure assessment assumes that hypothetically a person trespassed on the wetland over time, beginning in early childhood (aged 6 years or older) and continuing into adulthood (aged 21years or older). We assumed these trespassing events occurred twice weekly for 10 months of the year, or 80 days per year. A total of 350 soil and sediment samples collected from this site from 2004 to 2010 were available for this evaluation. Concentrations of PCBs ranged from non-detect to 838 mg/kg. Soil samples were collected at depths of 0- 6 inches and 0-12 inches at wetlands. In general, ATSDR considers that people are only exposed to the top few inches of soil. If all the contamination measure in these 0-12 inches samples was present in the top 3 inches, and the contaminated soil was averaged with 9 additional inches of clean soil, the soil contamination might actually be 4 times as high as measured. Therefore, we multiplied the results of samples collected at 0 -12 inches by 4 to represent the exposure. For the same reason, we multiplied the results of samples collected at 0 - 6 inches by 2 to represent the exposure. To determine the appropriate EPCs, ATSDR used EPA's ProUCL program to calculate the 95% Upper Confidence Level (95% UCL) of the mean. The 95% UCL is the value calculated for a random data set that equals or exceeds the true mean 95% of the time. Using the multiplied soil results, the ProUCL estimated an EPC of 15.2 mg/kg in soil/sediment. Using the above exposure assumptions and ATSDR's default exposure parameters for different age groups, we calculate exposure doses and evaluated non-cancerous effects and estimated potential cancer risks. Appendix C, Tables 4 and 5, summarizes the dose and cancer risk calculation results (see Appendix D for a detailed discussion of ATSDR's dose calculation).

For non-cancerous effects, total doses for most age groups are lower than ATSDR's chronic MRL of 0.00002 mg/kg/day for PCBs except for one age group (6 <11 year) with high soil intake rate (95^{th} percentile soil ingestion rate). The highest dose for this age group is equal to the MRL. The chronic oral MRL is based on a LOAEL of 0.005 mg/kg/day for immunological effects in adult monkeys and an uncertainty factor of 300 was applied. Therefore, ATSDR considers that non-cancerous effects would not be expected for this exposure because (1) conservative exposure assumptions were used for dose estimation, (2) the oral ingestion estimated dose of 0.00002 for the most sensitive age group equals the chronic MRL, and (3) the oral ingestion estimated dose is much lower than the doses that resulted in adverse health effects in studies.

The excess cancer risks for trespassers (the most sensitive age group of children 6 to 21 years) exposed to the estimated EPC for PCBs is 2.7E-06. Stated another way, a trespasser who visited the wetlands twice a week for 10 months a year from age 6 to 21 years has an estimated excess cancer risks less than 3 in 1,000,000. We also interpret this as a low increased lifetime risk of developing cancer. The above estimated excess cancer risks were based on very conservative exposure parameters. For example, we assumed that trespassers were exposed to the PCBs concentration that are 4 times the detected level for extended periods of time. ATSDR concluded that the exposures to contaminated soil/sediment were not expected to harm people's health.

(2) PCBs exposures at the northern wetland area (sample location ERC–SED-11A)

As mentioned earlier, samples near this location had PCB concentrations ranging from 5.5 ppm to 805 ppm which was higher than the rest of the wetlands area. Although it is not likely that a trespasser visit this spot regularly for many years; however, it is plausible that a trespasser may visit the spot regularly for a short period (e.g., a year or two). ATSDR assumed these trespassing events occurred twice weekly for 10 months of the year, or 80 days per year at this location. See Appendix C, Figure 8, for the soil sample locations.

There were more than 60 soil samples (0-6") taken from this location. As discussed earlier, if all the contamination measure in these 0-6 inches samples was present in the top 3 inches and the contaminated soil was averaged with 3 additional inches of clean soil, the soil contamination might actually be 2 times as high as measured. Therefore, we multiplied the results of samples collected at 0 -6 inches by 2 to represent the exposure. To determine the appropriate EPC, ATSDR used EPA's ProUCL program to calculate the 95% Upper Confidence Level (95% UCL) of the mean. Using the multiplied soil results, the ProUCL estimated an EPC of 210 mg/kg in soil/sediment.

Estimated doses for most age groups are slightly higher than ATSDR's chronic MRL of 0.00002 mg/kg/day for PCBs. The highest dose is found for the age group of 6 to 11 year old and it is 0.000145 mg/kg/day. As mentioned earlier, the chronic oral MRL is based on a LOAEL of 0.005 mg/kg/day for immunological effects in adult monkeys and an uncertainty factor of 300 was applied. Therefore, ATSDR considers that non-cancerous effects would not be expected for this exposure because (1) conservative exposure assumptions were used for dose estimation, (2) the oral ingestion estimated doses are lower than the doses that resulted in adverse health effects in studies, and (3) the estimated highest oral ingestion dose of 0.000145 for the most sensitive age group is much lower than the LOAEL of 0.005 mg/kg/day.

(3) PCBs exposure at the NBHS campus

ATSDR calculated an exposure dose for persons likely exposed daily during the school year. ATSDR realized that parents with younger children may have visited the school intermittently, but those exposures were not as frequent as those of students that were attending the school daily. We assumed students, staff, and faculty were exposed to soil contaminants five days a week for 9 months of the year, or 180 days per year. A total of 106 soil samples collected from five exposure areas (HS-2, HS-4, HS-5, HS 8, and HS-10) were used for this evaluation. Concentrations of PCBs ranged from non-detect to 75.2 mg/kg. Since soil samples were collected at depths of 0 - 6 inches and 0-12 inches at the NBHS, we multiplied the results of samples collected at 0 -12 inches by 4 and the results of samples collected at 0-6 inches by 2 to represent the exposure. The appropriate EPCs of 5.0 mg/kg was calculated using EPA's ProUCL program. Using the above conservative exposure assumptions and EPA's default exposure parameters for different age groups, we calculated exposure doses and estimated potential cancer risks (see Appendix D for a detailed discussion of ATSDR's dose calculation).

For non-cancer effects, total doses for all age groups are lower than ATSDR's chronic MRL of 0.00002 mg/kg/day for PCBs. Therefore, ATSDR considers that non-cancer effects would not be expected in high school students and teachers.

The range of excess cancer risks for students, staff, and faculty exposed to the estimated EPC of PCBs is from 1.1E-06 for teachers (assume exposure duration of 25 years) to 1.7E-06 for students (assume exposure duration of 4 years). Stated another way, a teacher who worked at the school for 25 years has an estimated excess cancer risks between 1 in 1,000,000 and a student who attended the school 4 years has less than 2 in 1,000,000. We also interpret this as a low increased lifetime risk of developing cancer. Therefore, ATSDR concluded that the exposures to contaminated soil at NBHS were not expected to harm people's health.

As requested by the community, the MDPH conducted blood testing for PCBs on a sample of former teachers and students from both KMS and NBHS during 2009–2010. Blood testing is an easy and safe way to detect exposures to PCBs. Although blood testing can indicate PCB exposure, it cannot determine when and where exposure occurred, or whether harmful health effects will develop. The results of this study indicated that the participants had serum-PCB concentrations within the typical variation seen in the U.S. population [MDPH 2013]. The entire study is available at: http://www.mass.gov/dph/environmental_health (within the *Environmental Health Investigations* link, click on New Bedford).

Lead Evaluation Approach

Neither ATSDR nor EPA has developed a minimal risk level (MRL) or reference dose (RfD) for human exposure to lead. Therefore, the usual ATSDR approach of estimating a human exposure dose to an environmental contaminant and then comparing this dose to a health-based comparison value (such as an MRL or RfD) cannot be used [ATSDR 2005]. Instead, human exposure to lead is evaluated by using a biological model that predicts a blood lead concentration resulting from exposure to environmental lead contamination. Different biological models can estimate lead exposure of children and adults. The most widely used model to estimate lead exposure of children is the EPA's Integrated Exposure Uptake and Biokinetic (IEUBK) model. The IEUBK model is designed to integrate lead exposure from soil with lead exposures from other sources, such as air, water, dust, diet, and paint with pharmacokinetic modeling to predict blood lead concentrations in children 6 months to 7 years of age. The model estimates a distribution of blood lead concentrations centered on the geometric mean blood lead concentration [USEPA 2002]. For women of child-bearing age, the Adult Lead Methodology can be used to estimate blood lead levels in the developing fetus because the developing fetus is likely to be more sensitive to lead than adult women.

More information about U.S. EPA's adult lead methodology can be found at this U.S. EPA web address: http://www.epa.gov/superfund/lead/products.htm [USEPA 2009].

Lead was detected in soils in the sediment/soil at the KMS wetlands and at NBHS. The lead in the fill material at the KMS wetlands and NBHS could have come from a variety of sources (gasoline, ammunition manufacturing, or battery production). At NBHS, most of the lead was deeper than 1 foot. Several areas have detected higher levels of lead (>300 ppm) in the soil samples on the NBHS grounds.

Most of the lead in sediments and soil at the KMS wetlands was in the surface (top 6 inches). Surface-sediment sampling was conducted from 2004 through 2011 in the wetlands. ATSDR used the sample sets from 2004, 2005, and 2009 that analyzed for lead.

Because the IEUBK model suggested using the arithmetic mean (average) of lead concentrations, ATSDR calculated the average concentrations to determine the exposure point concentration a person likely encountered in the wetlands and on the NBHS campus. The average for lead in 53 surface samples analyzed from NBHS in 2008 was equal to 55 ppm, and from 114 surface samples in 2009 was equal to 136 ppm. In the KMS wetlands, the average for the 67 samples analyzed in 2004 was 144 ppm; for the 76 samples analyzed in 2005 it was 56 ppm; and for the 58 samples analyzed in 2009 it was 153 ppm. Because the model is not designed for intermittent trespassing exposures, ATSDR did not run the model. The model for children assumes a daily exposure (365 days a year) to lead, which ATSDR does not believe occurred in the past for students, faculty, or visitors at NBHS and trespassers at the wetlands. By comparing the default assumptions of the model with the site-specific exposures assumptions, ATSDR does not expect the lead contamination at the wetlands and NBHS to be accessed sufficiently to cause an increase in blood-lead levels.

ATSDR eliminated the current and future exposures pathways for the wetlands and NBHS because (1) the city and MDEP have taken preventive measures such as remove or cover the contaminated soil on the NBHS areas and install fences to restrict access to the wetlands. To date, more than 7,956 cubic-yards of impacted soil have been removed; and (2) an Activity and Use Limitation has been implemented to minimize potential exposures. Those preventive measures minimize and eliminate potential exposures.

Although ATSDR does not expect the lead contamination at the wetlands and NBHS to be accessed frequently enough to cause an increase in blood-lead levels, other sources of lead and many factors can influence lead exposure and uptake, and, therefore, the estimates of blood lead levels. Those factors include the lead bioavailability and individual nutritional status, model limitations, lead exposure risk factors, seasonality, exposure age, and multiple sources of lead exposure. See Appendix E for more information about other sources of lead. ATSDR recognizes that no level of lead in the blood is safe, therefore we recommend reducing lead exposure wherever possible. Practical ways to reduce exposure are provided in detail in Appendix E.

Conclusions

After evaluating the available data, ATSDR reached the following conclusions in this PHC.

1. ***Past Exposure to PCBs and lead in wetland soil/sediment, and surface water next to Keith Middle School:*** **ATSDR concludes that incidental ingestion of PCBs and lead contaminated soil/sediment by trespassers is not expected to harm people's health.**

For PCB exposures, conservative exposure dose calculations for trespassers revealed that PCBs levels were below levels known to result in non-cancer harmful health effects. The estimated cancer risk for trespassers (the most sensitive age group of age 6 to 21 years) exposed to the estimated exposure point concentrations (EPC) of PCBs is 2.7E-06. Stated another way, a trespasser who visited the wetlands twice a week for 10 months a year (age 6 to 21 years) has estimated excess cancer risks less than 3 in 1,000,000. We also interpret this as a low increased lifetime risk of developing cancer. For lead exposures, ATSDR calculated the arithmetic mean (average) lead concentrations in the wetlands and compared site-specific exposure scenarios with the default IEUBK model assumptions. ATSDR concluded that the exposures were unlikely to cause an increase in blood lead levels. Because there is no proven safe level of lead in the blood, ATSDR recommend reducing lead exposure wherever possible.

2. Past exposure to PCBs and lead in NBHS soil: **ATSDR concludes that incidental ingestion of soil by students and faculty in the NBHS campus is not expected to harm their health.**

For PCB exposures, using conservative exposure assumptions, all estimated exposure doses were below levels known to result in non-cancer harmful health effects. The range of excess cancer risks is from 1E-06 to 3E-06. Stated another way, out of 1,000,000 people exposed continuously for an entire lifetime, approximately one to three additional cases of cancer might occur due to the exposure. We also interpret this as a low increased lifetime risk of developing cancer. In addition, as requested by the community, the MDPH conducted blood testing for PCBs on a sample of former teachers and students from both KMS and NBHS during 2009–2010. The results of this study indicated that the participants in the study had serum-PCB concentrations within the typical variation seen in the U.S. population. For lead exposures, ATSDR calculated the arithmetic mean (average) lead concentrations in the NBHS areas and compared site-specific exposure scenarios with the default IEUBK model assumptions. ATSDR concluded that the exposures were unlikely to cause an increase in blood lead levels. However, since there is no proven safe level of lead in the blood, ATSDR recommends reducing lead exposure wherever possible.

3. Exposure to PCBs and lead in KMS soil, ground water, and indoor air volatile organic compounds (VOCs): **ATSDR concludes that exposures to soil, ground water, and indoor air at KMS are not expected to harm people's health because exposure controls are in place. As long as these controls are maintained, the exposure pathways are eliminated (i.e., no expose).**

KMS buildings were built on a 3-foot soil cap, and other areas were paved with a geotextile liner with a minimum 2-foot soil cap and an asphalt cover. For landscaped areas, a geotextile liner and a minimum 3-foot soil cap was used. Those measures prevented potential exposures to contaminated soil underground.

Passive ventilation was also installed to allow any sub-slab soil gases to move from beneath the vapor barrier to the vent stacks, which exit through the school's roof. Indoor air samples collected from 2006–2010 indicated that VOCs were detected at very low concentrations; however, they were below ATSDR's comparison values; and, therefore, not of health concern.

Ground water is not used for drinking water or other purposes at the KMS site. Drinking water sources for KMS and the city are from five ponds located outside of New Bedford, Massachusetts.

Recommendations

ATSDR recommends that the City of New Bedford continue the anticipated activities at the PSWS such as following the *Long-Term Monitoring and Maintenance Implementation Plan* (LTMMIP) and the Activity and Use Limitation (AUL) to ensure that contamination levels are below health concern.

Because there is no proven safe level of lead in the blood, ATSDR recommends reducing lead exposure from all sources wherever possible. Practical ways to reduce exposure are provided in detail in Appendix E.

Public Health Action Plan

Action taken:

- EPA developed a cleanup plan for the KMS site in 2005.
- ATSDR conducted a health consultation that concluded the EPA plan would be effective to protect public health in 2005.
- The city developed the Long-Term Monitoring and Maintenance Implementation Plan for KMS, which required regular inspection and sampling of the air, ground water, and soil.
- In 2006, the city hired a contractor to remove the top 6 inches of contaminated sediment in the wetlands and to restore the wetlands. In 2009 and 2012, fences were installed to the north and the entire wetland area to prevent exposures to occasional trespassers.
- In 2008, MDPH Bureau of Environmental Health completed an evaluation of indoor air quality conditions at the NBHS.
- The city acquired six properties that were impacted in 2010 and demolished the buildings and fenced the areas to prevent any exposures caused by remediation activities.
- EPA and MDEP worked together to define the boundaries of the PSWS site and conducted sampling events and cleanup activities.
- In February 2013, MDPH Bureau of Environmental Health completed two health consultations on the NBHS and the PSWS neighborhood in New Bedford.
- In January 2016, the City New Bedford released a draft partial permanent solution for the NBHS property. This report documented the completion of the remedial activities taken at the NBHS property and implemented an Activity and Use limitation to maintain risk level below health concern.

Action Planned:

- As needed, ATSDR will update this report, or prepare a new report, to reflect the most recent sampling results and site remediation activities in relation to any completed or potential exposure pathways identified in this health consultation.
- The city should continue the anticipated activities at the Parker Street Waste Site such as following the city's Long-Term Monitoring and Maintenance Implementation Plan (LTMMIP) and the Activity and Use Limitation to ensure that contamination levels remain below health concern.

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Appendix A. Explanation of Evaluation Process and Chemical Information

ATSDR's Evaluation Process

In evaluating environmental data for the KMS site, ATSDR followed the general evaluation process as described below:

Comparison Values and Screening Process

To evaluate environmental data for the KMS site, ATSDR used comparison values (CVs) to determine which chemicals should be examined more closely. CVs are contaminant concentrations found in a specific media (air, soil, or water) that are not likely to cause adverse effects to people exposed to it. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, and soil that a person might inhale or ingest each day. CVs are generated to be conservative. CVs are not intended as environmental clean-up levels, or to indicate that health effects occur at concentrations that exceed these values.

CVs are set at concentrations below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and non-cancer health effects. Non-cancer CV levels are based on valid toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children and adults are exposed every day. Cancer CV levels are based on a one-in-a-million excess cancer risk for an adult exposed to contaminated soil or contaminated drinking water every day for 70 years. Cancer-based CVs are calculated by using the U.S. Environmental Protection Agency's (EPA's) oral cancer slope factor (CSF) or inhalation risk unit. For chemicals for which both cancer and non-cancer CVs exist, we use the lower level to be protective. If a contaminant level exceeds a CV, it does not mean that health effects will occur, just that more evaluation is needed.

The following CVs were used in preparing this document.

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations that are expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime. CREGs are calculated from EPA's CSFs.

Environmental Media Evaluation Guides (EMEGs) are concentrations of contaminants in water, soil, or air that are unlikely to produce any appreciable risk of adverse, non-cancer effects over a specified duration of exposure. EMEGs are derived from ATSDR minimal risk levels by factoring in default body weights and ingestion rates. ATSDR computes separate EMEGs for acute (≤14 days), intermediate (15–364 days), and chronic (>365 days) exposures.

Maximum Contamination Levels (MCLs) are enforceable standards set by EPA for the highest level of a contaminant allowed in drinking water. MCLs are set as close to MCL goals (MCLGs, the level of a contaminant in drinking water below which no known or expected health risk) as feasible using the best available treatment technology and considering cost.

Reference Media Evaluation Guides (RMEGs) are estimated contaminant concentrations in a medium where non-cancer health effects are unlikely. RMEGs are derived from EPA's reference dose (RfD); RfDs can be found at http://www.epa.gov/iris.

Regional Screen Levels (RSLs) are concentrations of chemical contaminants used by EPA as risk-based screening levels at hazardous waste sites. RSLs are calculated using the latest toxicity values, default exposure assumptions, and physical and chemical properties.

Determining Exposure Pathways

ATSDR identifies human exposure pathways by examining environmental and human components that might cause exposure to contaminants. A pathway analysis considers of five principal elements: a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and an exposed population. Completed exposure pathways are those for which the five principal elements exist, and exposure to a contaminant has occurred in the past, is now occurring, or will occur in the future. Potential exposure pathways are those for which exposure is possible, but one or more of the elements is not clearly defined, and exposure to a contaminant could have occurred in the past, could be occurring now, or could occur in the future. The identification of an exposure pathway does not imply that health effects will occur, and exposures might or might not be substantive. Therefore, even if exposure has occurred, is now occurring, or likely will occur in the future, human health might not be affected.

ATSDR reviewed site history, information on site activities, and the available sampling data. Based on this review, completed exposure pathways at the site include incidental ingestion of contaminated soil, surface water, and sediment by occasional trespassers and nearby residents. ATSDR eliminated drinking water, air, and subsoil exposure pathways for the site.

Evaluating Public Health Implications

The next step of the process is to evaluate further those contaminants present at levels above the CVs to determine whether they may be a health hazard, given the specific exposure situations at this site. We calculate children and adult exposure doses for the site-specific exposure scenario using our assumptions of who goes on the site and how often they are exposed to the site contaminants. The amount of chemical that is swallowed or gets absorbed through the skin is called a dose. A detailed explanation of the calculation of estimated exposure doses is presented in Appendix D. Exposure doses are calculated in units of milligrams per kilograms per day (mg/kg/day). We conducted separate calculations to account for non-cancer and cancer health effects, if applicable, for each chemical based on the health effects reported for that chemical. Some chemical exposures are associated with non-cancer health effects, but are not associated with cancer-related health effects.

<u>How non-cancer health effects are evaluated</u>

The exposure doses calculated for each individual chemical are compared to an established health guideline, such as a MRL (Minimal Risk Level) or RfD (Reference Dose), to assess whether adverse health effects are expected. These health guidelines, developed by ATSDR and EPA, respectively, are chemical-specific values that are based on the available scientific literature and are considered protective of human health. Non-cancer effects, unlike cancer-related effects, are believed to have a threshold, that is, a dose below which adverse health effects will not occur. Because of these circumstances, the current practice for deriving health guidelines is to identify, usually from animal toxicology experiments, a No Observed Adverse Effect Level (NOAEL) or a lowest-observed-adverse-effect level (LOAEL). NOAEL is the experimental exposure level in animals (and sometimes humans) at which no adverse effect is observed. LOAEL is the lowest concentration or amount of a substance found by experiment or observation that causes an adverse health effect. The NOAEL and LOAEL are then modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the general human population. The design of the uncertainty factor incorporates various factors such as sensitive subpopulations (for example, children, pregnant women, and the elderly), extrapolation from animals to humans, and the completeness of available data. Exposure doses at or below the established health guideline are not expected to cause adverse health effects because these values are much lower (and more protective of human health) than doses that do not cause adverse health effects in laboratory animal studies. For non-cancer health effects, the health guidelines are described in more detail in below. The methods used to develop these health guidelines do not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate evaluation is necessary to determine the potential risks from cancer-causing chemicals detected at this site.

Minimal Risk Levels (MRLs) – developed by ATSDR

ATSDR has developed MRLs for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. MRLs are developed for different routes of exposure such as inhalation and ingestion, and for lengths of exposure such as acute (less than 14 days), intermediate (15–364 days), and chronic (365 days or more). A complete list of the available MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

References Doses (RfDs) – developed by EPA

A reference dose (RfD) is an estimate of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause non-cancerous health effects. The design of the RfD considers exposures to sensitive sub-populations, such as the elderly, children, and the developing fetus. EPA has developed their RfDs using information from the available scientific literature and has calculated them for oral and inhalation exposures. A complete list of EPA's available RfDs can be found at http://www.epa.gov/iris.

If the estimated exposure dose for a chemical is less than the health guideline value, the exposure likely will not cause non-cancer health effects. If the calculated exposure dose is greater than the health guideline, the exposure dose is compared to known toxicological values for the particular chemical; this circumstance is discussed in more detail in the text of the PHC. The known toxicological values are doses derived from human and animal studies that are presented in the ATSDR Toxicological Profiles and EPA's IRIS. A direct comparison of site-specific exposure doses to study-derived exposures and doses that cause adverse health effects is the basis for deciding whether health effects likely will occur. This in-depth evaluation is performed by comparing calculated exposure doses with known toxicological values, such as the NOAEL and the LOAEL from studies used to derive the MRL or RfD for a chemical.

How cancer risk is evaluated

1. Information about the increased risk for cancer from exposure to these chemicals is also provided in each exposure scenario. Cancer is a complex subject, and some background information is provided before discussing cancer evaluations of specific chemicals. The probability that U.S. residents will develop cancer at some point in their lifetime is 1 in 2 for men (44.9 %) and 1 in 3 (38.5%) for women. This is considered the background risk of developing cancer. Stated another way, half of all men and one-third of all women will develop some type of cancer in their lifetime. This is based on medical data collected on all types of cancer, regardless of whether the cause was identified, the case was successfully treated, or the patient died (directly or indirectly) of the cancer. Another study indicated that, the lifetime risk for cancer in the general population is about 1 in 2.5, or about 4,000 out of every 10,000 people [National Cancer Institute. SEER cancer statistics review 1975-2006, Table 1.14, lifetime risk of being diagnosed with cancer by site and race/ethnicity, 2004-2006.]

Factors that play major roles in cancer development include:

- lifestyle (what we eat, drink, smoke; where we live);
- exposures to natural light (sunlight) and medical radiation;
- workplace exposures;
- drug use;
- socioeconomic factors; and
- chemicals in our air, water, soil, or food.

Infectious diseases, aging, and individual susceptibilities such as genetic predisposition are also important factors in cancer development.

We rarely know the environmental factors or conditions responsible for cancer onset and development. We have some understanding of cancer development for some occupational exposures or for the use of specific drugs. Overall cancer risks can be reduced by eating a balanced diet, getting regular exercise, having regular medical exams, and avoiding high-risk behaviors such as tobacco use and excessive alcohol consumption. Using proper safety procedures, appropriate personal protective equipment, and medical monitoring programs can decrease workplace cancer risks.

To calculate a population's cancer estimate, ATSDR uses a quantitative risk assessment method. Using this method, site-specific doses and concentrations of cancer-causing contaminants are multiplied by EPA's CSF. Some cancer slope factors are derived from human studies; others are derived from laboratory animal studies involving contaminant doses much higher than people encounter in the environment. Using animal data requires extrapolation of the cancer potency obtained from these studies of high-dose exposures most people might not experience, which involves much uncertainty. The resulting risk of cancer is called an estimated excess cancer risk because it is the risk of cancer greater than the background risk of cancer that already exists (as mentioned above). This additional estimated cancer risk from chemical exposures is often stated as 1E-04 (the same as 1 x 10^{-4}), 1E-05, or 1E-06. Therefore, the excess cancer risk is between 0 and some number for every 10,000, 100,000, or 1,000,000 exposed people. For example, an estimated cancer risk of 2E-06 represents the possibility of 2 excess cancer cases in a population of 1 million. Put another way, 2 x 10^{-6} means that in a population of 1 million people exposed to a specific dose of a cancer-causing substance over a lifetime, 2 additional cases of cancer may occur because of the exposure. The "one-in-a-million" risk level is generally regarded as a very low increased risk. In a small exposed population, proving that cancer cases in a community are caused by chemical exposures is difficult, especially given that large number of people can get the same type of cancer from other causes.

An estimated additional cancer risk of 1×10^{-4} means that in a population of 10,000 people exposed for a lifetime to a certain chemical dose, between zero and one additional cancer case may occur. Although a "one-in-ten thousand" risk level may be viewed as an increased level of risk, understanding the exposure assumptions for that calculation provides a more realistic view of the actual risk. In general, ATSDR uses very conservative exposure assumptions when site-specific exposure parameters are unavailable. For example, for sediment exposures, ATSDR assumed that adults and children would be exposed for 80 days (10 months and two days per week) per year for 33 years. Because some sediment samples were collected from 0-12" and we consider that people are usually only exposed to the top 3 inches of sediment, we multiplied the results by 4 to represent the exposure. For samples collected from 0-6", we multiplied the results by 2 to represent the exposure. In addition, ATSDR used the 95% upper confidence level (UCL) concentration of the maximum likelihood mean (MLE) of the environmental data as the EPCs for dose calculation. Those assumptions are very conservative and are likely to overestimate exposures.

Chemical Information

Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are a group of synthetic organic chemicals that are present as either oily liquids or solids, range from colorless to light yellow, and have no smell or taste. PCBs are complex mixtures of chlorinated biphenyls that vary in the degree of chlorination. No known natural sources of PCBs exist. In the United States, many commercial PCB mixtures go by the trade name Aroclor. PCBs detected at the site were reported as total PCBs (the sum of Anoclor 1248, Anoclor 1254, and Anoclor 1260).

Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures, and electrical devices and appliances such as television sets and refrigerators. PCBs were also widely used as coolants and lubricants in transformers, capacitors, and other electrical equipment because of their insulating and nonflammable properties [ATSDR 2000]. The United States stopped manufacturing PCBs in August 1977 because evidence showed that PCBs build up in the environment and may cause adverse health effects.

Once in the environment, PCBs do not readily break down and may remain for very long periods. PCBs bond strongly to soil and usually do not seep deep into the soil with rainwater. Once our bodies take in PCBs, we may change them into other related chemicals called metabolites. Some of the metabolites may leave our body in the feces in a few days, but others may remain in our body fat for months. Unchanged PCBs may also remain in our body and be stored for years, mainly in the fat and liver [ATSDR 2000]. Many studies have examined how PCBs can affect human health. Skin conditions, such as acne and rashes, may occur in people that are occupationally exposed to high levels of PCBs. Exposures in the general population likely do not cause these well-documented effects on the skin. Most of the human studies have many shortcomings, which makes it difficult for scientists to establish a clear association between PCB-exposure levels and health effects [ATSDR 2000].

ATSDR has derived a chronic MRL of 0.00002 mg/kg/day for PCBs. The chronic oral MRL is based on a LOAEL of 0.005 mg/kg/day for immunological effects in adult monkeys that were evaluated after 23 and 55 months of exposure to Aroclor 1254 [Tryphonas et al. 1989, 1991]. An uncertainty factor of 300 was applied (10 for extrapolating from a LOAEL to a NOAEL, 3 for extrapolating from monkeys to humans, and 10 for human variability). EPA has established an oral RfD of 0.00002 mg/kg/day for Aroclor 1254 [IRIS 2000] based on dermal, ocular, and immunological effects in monkeys, and an oral RfD of 0.00007 mg/kg/day for Aroclor 1016 based on reduced birth weight in monkeys [IRIS 2000]. It should be noted that using MRL of Aroclor 1254 for total PCBs would over estimates concentrations and doses.

Lead

Lead is a naturally occurring bluish-gray metal found in the earth's crust and it has many different uses. It is used in the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays. Because of health concerns, lead from paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years. The use of lead as an additive to gasoline was banned in 1996 in the United States. Today, lead can be found in all parts of our environment because of human activities including burning fossil fuels, mining, manufacturing, and past uses. [ATSDR 2007].

Although lead can affect almost every organ and system in the body, especially young children and unborn fetus. The main target for lead toxicity is the nervous system. In general, the level of lead in a person's blood gives a good indication of recent exposure to lead and also correlates well with adverse health effects [ATSDR 2007].

Blood Lead Levels and Health Effects

- Blood Lead Reference Level now 5 µg/dL - Until recently, children were identified as having a blood lead level of concern if the test result was 10 µg/dL or more of lead in blood. CDC recommends a reference level of 5 µg/dL to identify children as having lead exposures. This new level is based on the U.S. population of children ages 1 to 5 years who are in the highest 2.5% of children when tested for lead in their blood [CDC 2012].

- Shift of Focus from Exposure to Prevention - In May 2012, CDC updated its recommendations on children’s blood lead levels. By shifting the focus to primary prevention of lead exposure, CDC wants to reduce or eliminate dangerous lead sources in children’s environments before they are exposed.

- No Change in Blood Lead Levels Requiring Medical Treatment - What has not changed is the recommendation for when to use medical treatment for children. Experts recommend chelation therapy when a child is found with a test result of greater than or equal to 45 µg/dL [CDC 2012].

- Health Effects in Children With Blood Lead Levels less than 10 µg/dL - Chronic exposure to lead resulting in blood lead levels below 10 µg/dL has shown sufficient evidence of neurological, behavioral, and developmental effects in young children. Specifically, lead causes or is associated with the following [CDC 2012a; CDC 2012b; CDC 2012c]:

  - decreases in intelligence quotient (IQ);
  - attention-related behaviors problems;
  - deficits in reaction time;
  - problems with visual-motor integration and fine motor skills;
  - withdrawn behavior;
  - lack of concentration; issues with sociability;
  - decreased height; and
  - delays in puberty, such as breast and pubic hair development and delays in the first menstrual cycle.

- Health Effects in Children With Blood Lead Levels less than 5 µg/dL - In children, sufficient evidence shows that blood lead levels less than 5 µg/dL are associated with increased diagnosis of attention-related behavioral problems, greater incidence of problem behaviors, and decreased cognitive performance as indicated by (1) lower academic achievement, (2) decreased intelligence quotient (IQ), and (3) reductions in specific cognitive measures [NTP 2012].

- Health Effects of Lead on Unborn Babies: Lead crosses the placenta; consequently it can pass from a mother to her unborn baby. Too much lead in a pregnant women’s body can:

  - Put her at risk for miscarriage;
  - Cause the baby to be born too early or too small;
  - Hurt the baby’s brain, kidneys, and nervous system; and
  - Cause the child to have learning or behavior problems [CDC 2010].

Follow-up testing, increased patient education, and environmental, nutritional and behavioral interventions are indicated for all pregnant women with blood lead levels greater than or equal to 5 µg/dL to prevent undue exposure to the fetus and newborn [CDC 2010].

• Blood Test - Children can be given a blood test to measure the level of lead in their blood.

Because there is no proven safe level of lead in the blood, ATSDR and CDC recommend reducing lead exposure wherever possible. Practical ways on how to reduce lead exposure are provided in Appendix E.

Others Sources of Lead

Lead can be found in many products and locations. Lead-based paint and contaminated dust are the most widespread and dangerous high-dose sources of lead exposure for young children [CDC2009].

Because no level of lead in the blood is safe, ATSDR recommends reducing lead exposure wherever possible. More information on practical ways to reduce lead exposure is provided in Appendix E of this document.

Lead exposure can occur from one or more of the following:

Indoor

Paint – Ingesting paint chips primarily found in homes built before 1978 and on older toys and furniture

Dust – Ingesting dust (from hand-to-mouth activity) found in older homes (built before 1978) or tracked in from contaminated soil

Water – Drinking water containing lead that comes from corrosion of older fixtures, from the solder that connects pipes, or from wells where lead contamination has affected the ground water

Tableware – Eating foods from imported, old, handmade, or poorly glazed ceramic dishes and pottery that contains lead. Lead may also be found in leaded crystal, pewter, and brass dishware

Candy – Eating consumer candies imported from Mexico. Certain candy ingredients such as chili powder and tamarind may be a source of lead exposure. Candy wrappers have also been shown to contain some lead

Toy Jewelry – Swallowing or putting in the mouth toy jewelry that contains lead. This inexpensive children's jewelry is generally sold in vending machines and large volume discount stores across the country

Traditional (folk) Medicines –Ingesting some traditional (folk) medicines used by India, Middle Eastern, West Asian, and Hispanic cultures. Lead and other heavy metals are put into certain folk medicines on purpose because these metals are thought to be useful in treating some ailments. Sometimes lead accidentally gets into the folk medicine during grinding, coloring, or other methods of preparation

Outdoor

Outdoor Air – Breathing lead particles in outdoor air that comes from the residues of leaded gasoline or industrial operations

Soil – Ingesting dirt contaminated with lead that comes from the residues of leaded gasoline, industrial operations, or lead-based paint

Other

Hobbies – Ingesting lead from hobbies using lead such as welding, auto or boat repair, the making of ceramics, stained glass, bullets, and fishing weights. Other hobbies that might involve lead include furniture refinishing, home remodeling, painting and target shooting at firing ranges

Workplace – Ingesting lead found at the workplace. Jobs with the potential for lead exposure include building demolition, painting, remodeling/renovation, construction, battery recycling, radiator repair, and bridge construction. People who work in a lead environment may bring lead dust into their car or home on their clothes and bodies exposing family members

References:

U.S. Centers for Disease Control and Prevention (CDC 2009). Lead (web page). Last Updated June 1, 2009. Available online@ http://www.cdc.gov/nceh/lead/tips/sources.htm

Appendix B. Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency based in Atlanta, Georgia, with 10 regional offices in the United States. ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases from toxic substances. ATSDR is not a regulatory agency, in contrast to the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces laws to protect the environment and human health. This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. For additional questions or comments, call 1-800-CDC-INFO.

Acute

Occurring over a short time [compare with chronic]

Acute exposure

Contact with a substance that occurs only once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure]

Adverse health effect

A change in body function or cell structure that might cause disease or health problems

Cancer

Any of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control

Cancer risk

A theoretical risk for cancer development if exposure to a substance occurs every day for 70 years (a lifetime exposure). The true risk might be lower or higher.

Carcinogen

A substance that causes cancer

Chronic

Occurring over a long time [compare with acute]

Chronic exposure

Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Comparison value (CV)

The calculated concentration of a substance in air, water, food, or soil that likely will not cause harmful (adverse) health effects in people exposed the substance. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be evaluated further in the public health assessment process.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

CERCLA, also known as Superfund, is the federal law on the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. The Superfund Amendments and Reauthorization Act later amended this law [see SARA further in Glossary].

Concentration

The amount of a substance that is in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other medium

Contaminant

A substance that is either in an environment where it does not belong or is at levels that might cause harmful (adverse) health effects

Dose

The amount of a substance to which a person is exposed over a period. Dose is a measurement of exposure and is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) that a person is exposed to contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is the amount of a substance encountered in the environment. An "absorbed dose" is the amount of a substance that the body absorbs through the eyes, skin, stomach, intestines, or lungs.

Environmental media

Soil, water, air, biota (plants and animals), or any other parts of the environment that a substance can contaminate

Epidemiologic study

A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses

Epidemiology

The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and cause of health effects in humans

Exposure

Contact with a substance by swallowing, breathing, or touching it; exposure can occur if the substance touches your skin or gets in your eyes. Exposure may be short-term [acute], intermediate, or long-term [chronic].

Exposure pathway

The route of a substance from its source (where it began) to its end point (where it ends), and how people are 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 ground water); 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.

Exposure point concentration (EPC)

The concentration of a contaminant within an exposed area under acute, intermediate, or chronic scenarios during past, current, and future period of the exposure duration. The estimated EPC represents the contaminant concentration that is used to evaluate exposure.

Ground water

Water beneath the earth's surface in the spaces between soil particles and rock surfaces [compare with surface water]

Health outcome data

Information from private and public institutions on the health status of populations. Health outcome data can include disease or illness (morbidity) and death (mortality) statistics, birth statistics, tumor and disease registries, or public health surveillance data.

Ingestion

Eating or drinking a substance, or simply putting a substance in the mouth, as young children often do. A hazardous substance can enter the body this way [see route of exposure].

Inhalation

Breathing; a hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure

Contact with a substance that occurs for more than 14 days but less than 1 year [compare with acute exposure and chronic exposure]

Minimal risk level (MRL)

An estimate of daily human exposure to a hazardous substance at or below which that substance likely will not pose a measurable risk of harmful (adverse), non-cancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Point of exposure

The place where someone is exposed to a substance in the environment [see exposure pathway]

Population

A group of people living within a specified area or sharing similar characteristics (such as occupation or age)

Prevention

Actions that reduce exposures or other risks, keep people from getting sick, or keep diseases from getting worse

Reference dose (RfD)

An estimate determined by EPA of the daily lifetime dose of a substance, with uncertainty or safety factors built in, that is unlikely to cause harm in humans

Risk

The probability that something will cause injury or harm

Route of exposure

How people are exposed to a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal].

Sample

A portion or piece of a whole. A selected subset of what is being studied. In a study of people, the sample is the number of people chosen to be a part of the study from a larger population [see population]. In an environmental study, a sample (e.g., a small amount of soil or water) would be collected to measure contamination in the environment at a specific location.

Source of contamination

Where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum; the first part of an exposure pathway

Toxicological profile

A synopsis ATSDR issues after examining, interpreting, and summarizing information about a specific hazardous substance to determine harmful exposure levels and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Volatile organic compounds (VOCs)

Organic compounds that evaporate readily into the air; VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:

Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)

National Library of Medicine (NIH) (http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

Appendix C. Figures and Tables

Figure 1. Keith Middle School Air Sampling Locations

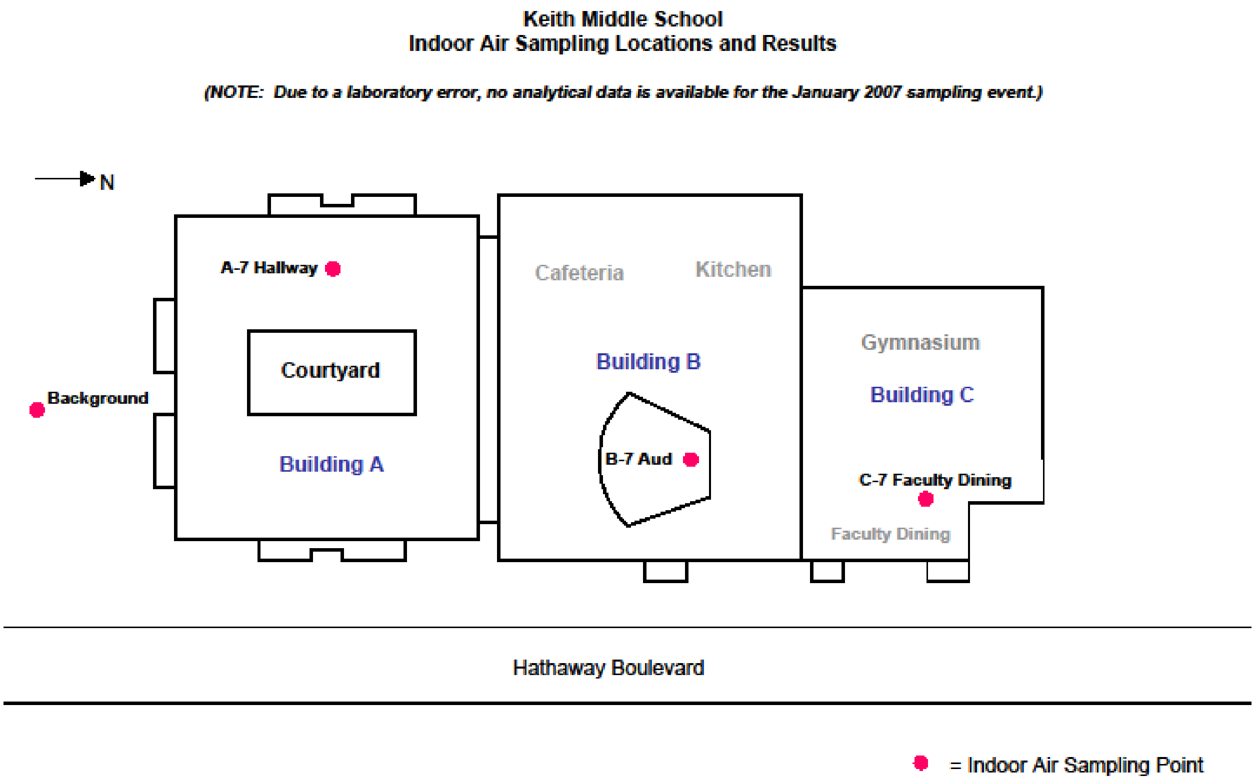

Figure 2. Keith Middle School Northern & Southern Wetland

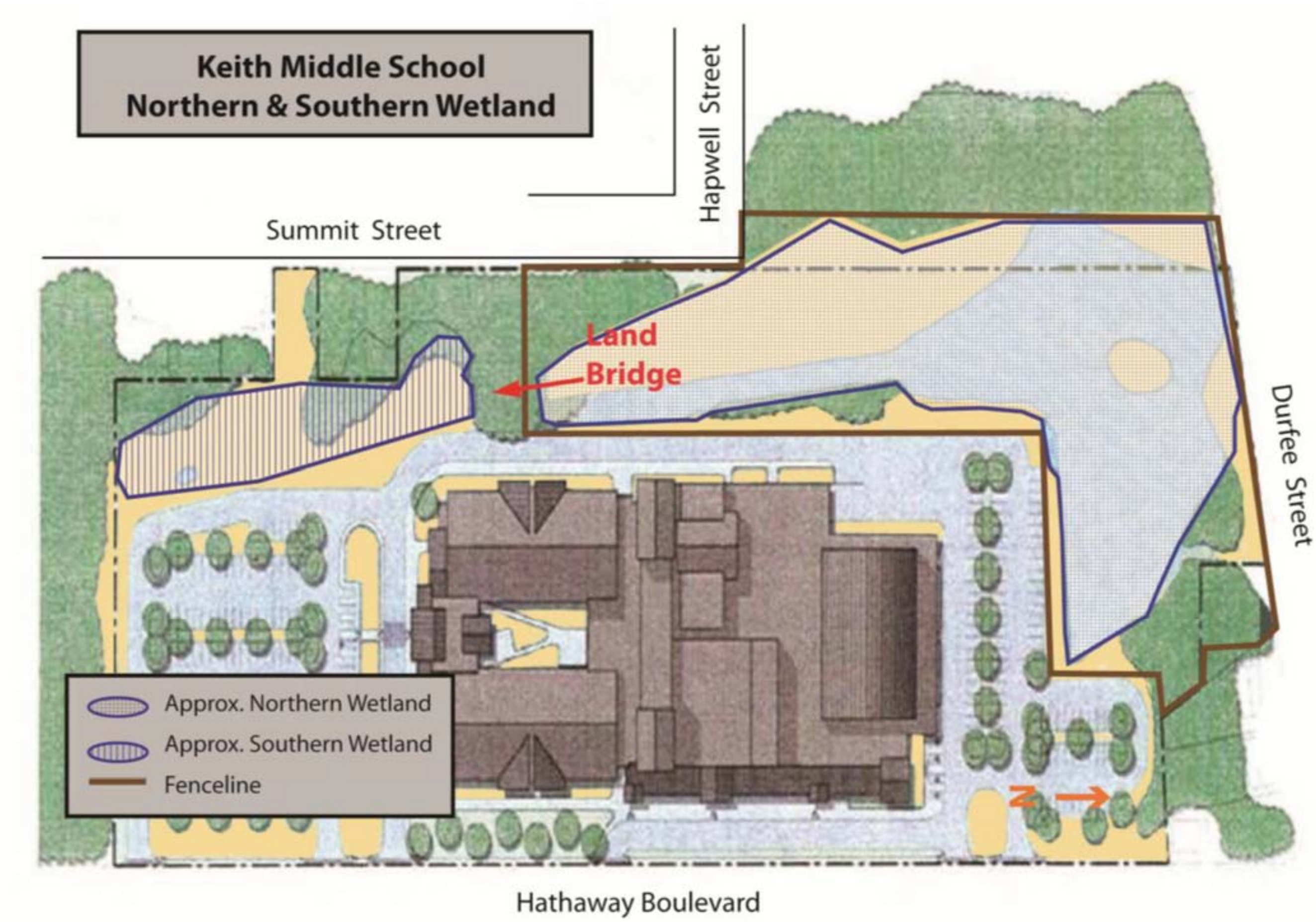

Figure 3. Stabilized slope along northwestern slope looking north

Figure 4. Wetlands Sampling Locations

Please see the following page.

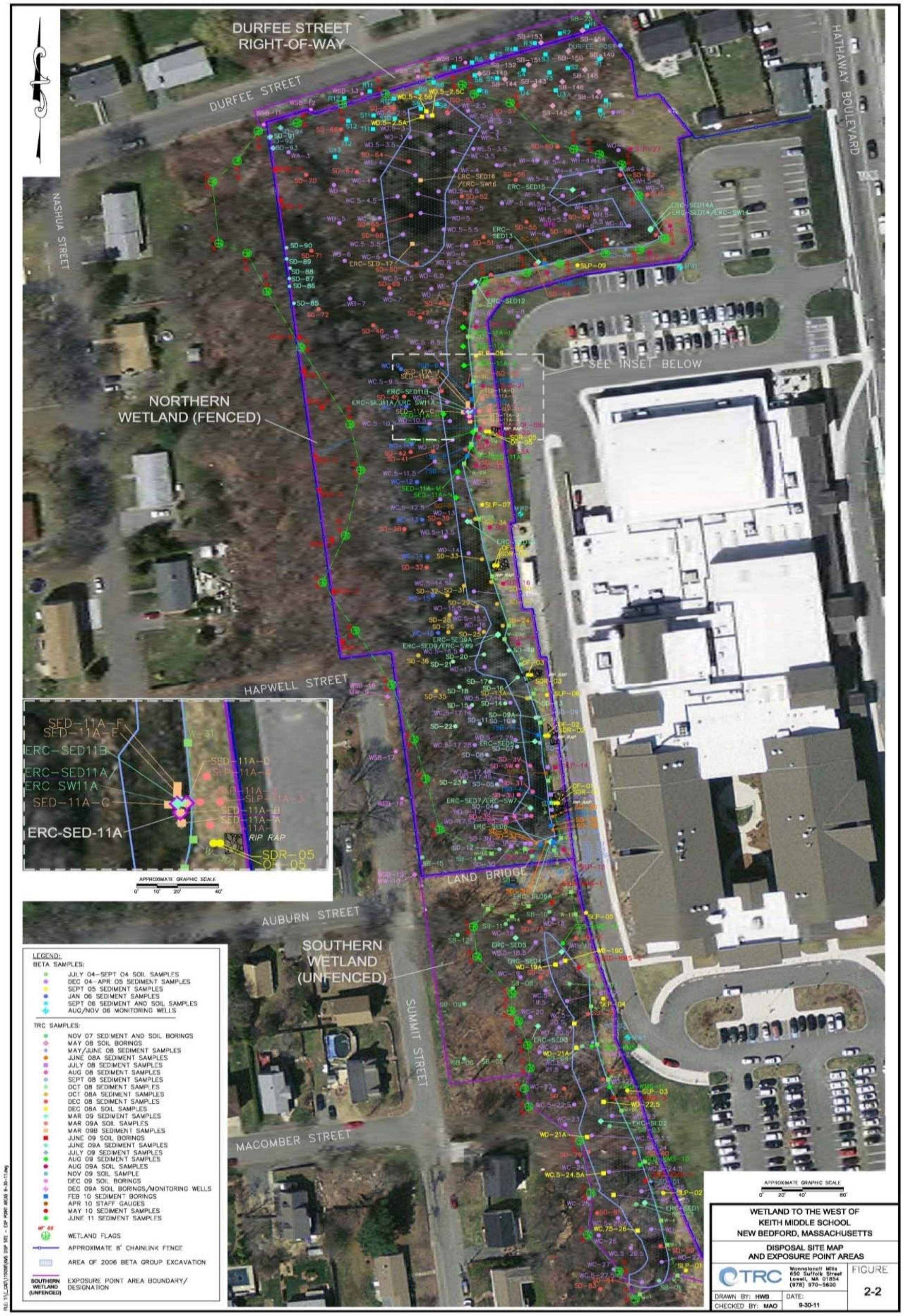
DURFEE STREET RIGHT-OF-WAY
DURFEE STREET
HATHAWAY BOULEVARD
NASHUA STREET
SEE INSET BELOW
NORTHERN WETLAND (FENCED)
HAPWELL STREET
LAND BRIDGE
AUBURN STREET
SOUTHERN WETLAND (UNFENCED)
SUMMIT STREET
MACOMBER STREET
SED-11A-F
SED-11A-E
ERC-SED11B
ERC-SED11A
ERC SW11A
SED-11A-C
ERC-SED-11A
SED-11A-D
SED-11A-B
SED-11A-A
RIP RAP
SDR-05
OF-05
APPROXIMATE GRAPHIC SCALE
0' 10' 20' 40'
LEGEND:
BETA SAMPLES:
JULY 04–SEPT 04 SOIL SAMPLES
DEC 04–APR 05 SEDIMENT SAMPLES
SEPT 05 SEDIMENT SAMPLES
JAN 06 SEDIMENT SAMPLES
SEPT 06 SEDIMENT AND SOIL SAMPLES
AUG/NOV 06 MONITORING WELLS
TRC SAMPLES:
NOV 07 SEDIMENT AND SOIL BORINGS
MAY 08 SOIL BORINGS
MAY/JUNE 08 SEDIMENT SAMPLES
JUNE 08A SEDIMENT SAMPLES
JULY 08 SEDIMENT SAMPLES
AUG 08 SEDIMENT SAMPLES
SEPT 08 SEDIMENT SAMPLES
OCT 08 SEDIMENT SAMPLES
OCT 08A SEDIMENT SAMPLES
DEC 08 SEDIMENT SAMPLES
DEC 08A SOIL SAMPLES
MAR 09 SEDIMENT SAMPLES
MAR 09A SOIL SAMPLES
MAR 09B SEDIMENT SAMPLES
JUNE 09 SOIL BORINGS
JUNE 09A SEDIMENT SAMPLES
JULY 09 SEDIMENT SAMPLES
AUG 09 SEDIMENT SAMPLES
AUG 09A SOIL SAMPLES
NOV 09 SOIL SAMPLE
DEC 09 SOIL BORINGS
DEC 09A SOIL BORINGS/MONITORING WELLS
FEB 10 SEDIMENT BORINGS
APR 10 STAFF GAUGES
MAY 10 SEDIMENT SAMPLES
JUNE 11 SEDIMENT SAMPLES
WETLAND FLAGS
APPROXIMATE 8' CHAINLINK FENCE
AREA OF 2006 BETA GROUP EXCAVATION
SOUTHERN WETLAND (UNFENCED)
EXPOSURE POINT AREA BOUNDARY/ DESIGNATION
APPROXIMATE GRAPHIC SCALE
0' 20' 40' 80'
WETLAND TO THE WEST OF
KEITH MIDDLE SCHOOL
NEW BEDFORD, MASSACHUSETTS
DISPOSAL SITE MAP
AND EXPOSURE POINT AREAS
TRC
Wannalancit Mills
650 Suffolk Street
Lowell, MA 01854
(978) 970-5600
FIGURE
2-2
DRAWN BY: HWB
CHECKED BY: MAO
DATE:
9-30-11

Figure 5. New Bedford High School Soil Sample Locations

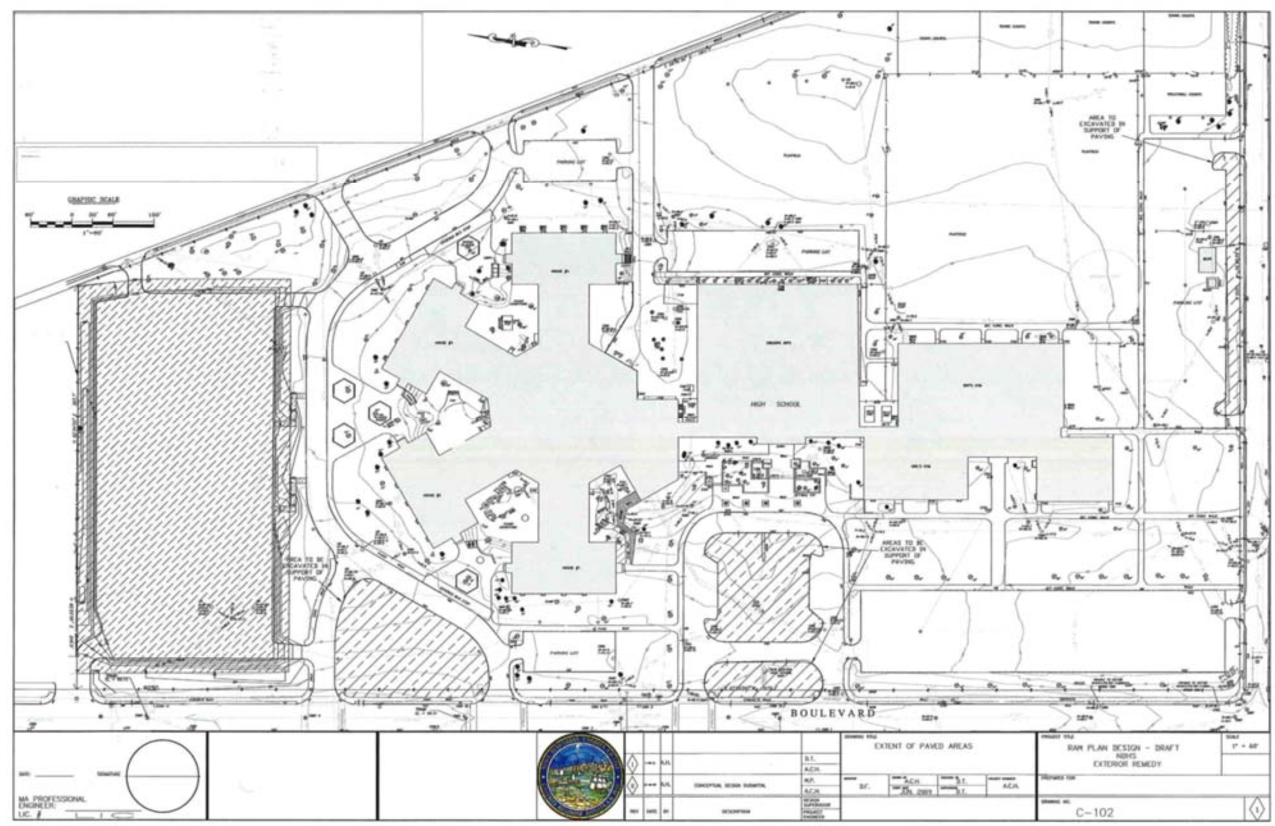

Figure 6. NBHS Campus Soil Remediation

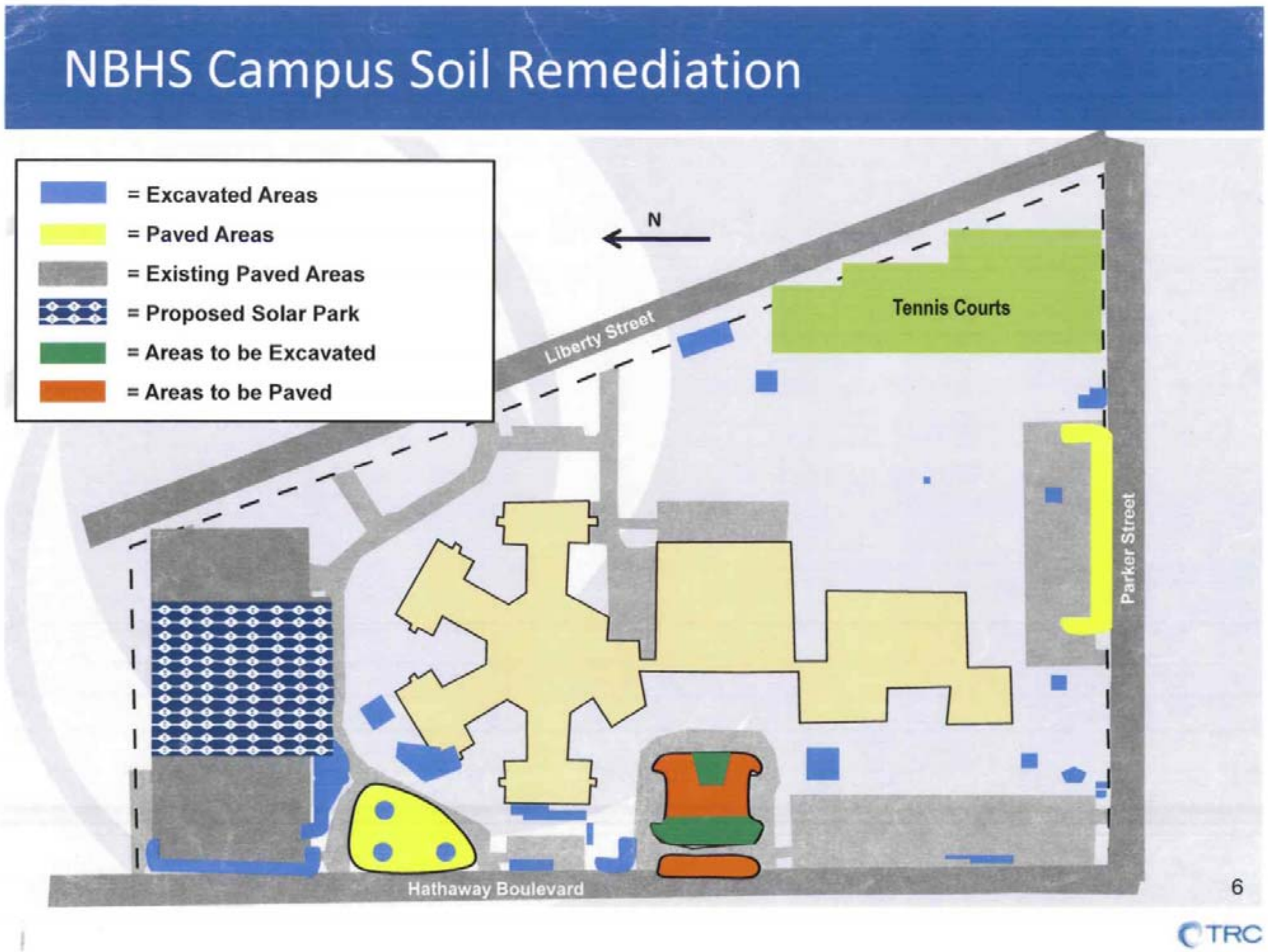

Figure 7. Exposure Point Areas at NBHS

Please see the following page.

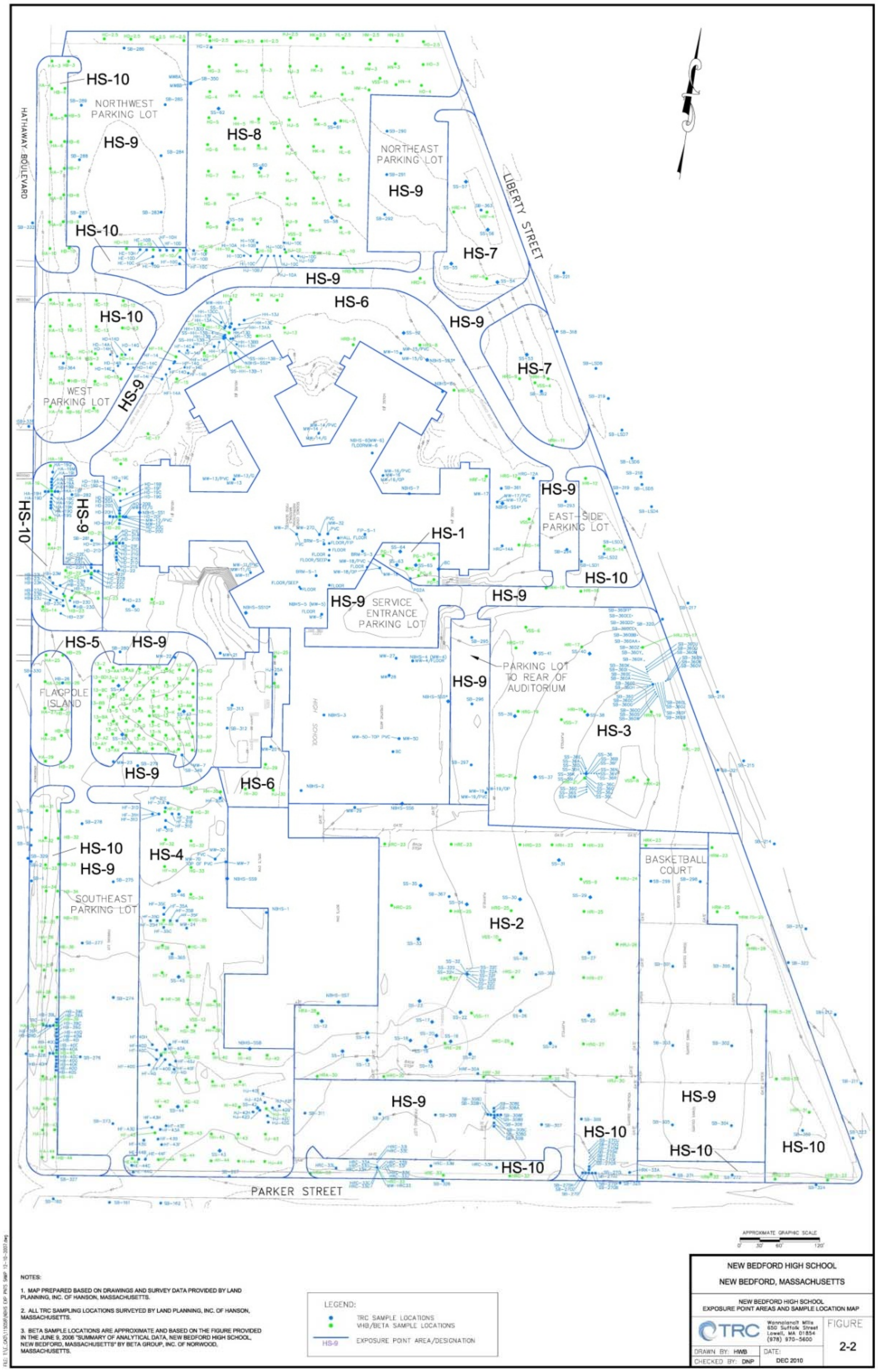
HATHAWAY BOULEVARD
LIBERTY STREET
PARKER STREET
NORTHWEST PARKING LOT
NORTHEAST PARKING LOT
WEST PARKING LOT
EAST-SIDE PARKING LOT
SERVICE ENTRANCE PARKING LOT
PARKING LOT TO REAR OF AUDITORIUM
FLAGPOLE ISLAND
SOUTHEAST PARKING LOT
BASKETBALL COURT
HS-1
HS-2
HS-3
HS-4
HS-5
HS-6
HS-7
HS-8
HS-9
HS-10
APPROXIMATE GRAPHIC SCALE
0' 30' 60' 120'
NOTES:
1. MAP PREPARED BASED ON DRAWINGS AND SURVEY DATA PROVIDED BY LAND PLANNING, INC. OF HANSON, MASSACHUSETTS.
2. ALL TRC SAMPLING LOCATIONS SURVEYED BY LAND PLANNING, INC. OF HANSON, MASSACHUSETTS.
3. BETA SAMPLE LOCATIONS ARE APPROXIMATE AND BASED ON THE FIGURE PROVIDED IN THE JUNE 9, 2006 "SUMMARY OF ANALYTICAL DATA, NEW BEDFORD HIGH SCHOOL, NEW BEDFORD, MASSACHUSETTS" BY BETA GROUP, INC. OF NORWOOD, MASSACHUSETTS.
LEGEND:
TRC SAMPLE LOCATIONS
VHB/BETA SAMPLE LOCATIONS
HS-9 EXPOSURE POINT AREA/DESIGNATION
NEW BEDFORD HIGH SCHOOL
NEW BEDFORD, MASSACHUSETTS
NEW BEDFORD HIGH SCHOOL
EXPOSURE POINT AREAS AND SAMPLE LOCATION MAP
TRC
Wannalancit Mills
650 Suffolk Street
Lowell, MA 01854
(978) 970-5600
FIGURE
2-2
DRAWN BY: HWB
CHECKED BY: DNP
DATE:
DEC 2010

Figure 8. North Wetland Hot Spot Soil Samples

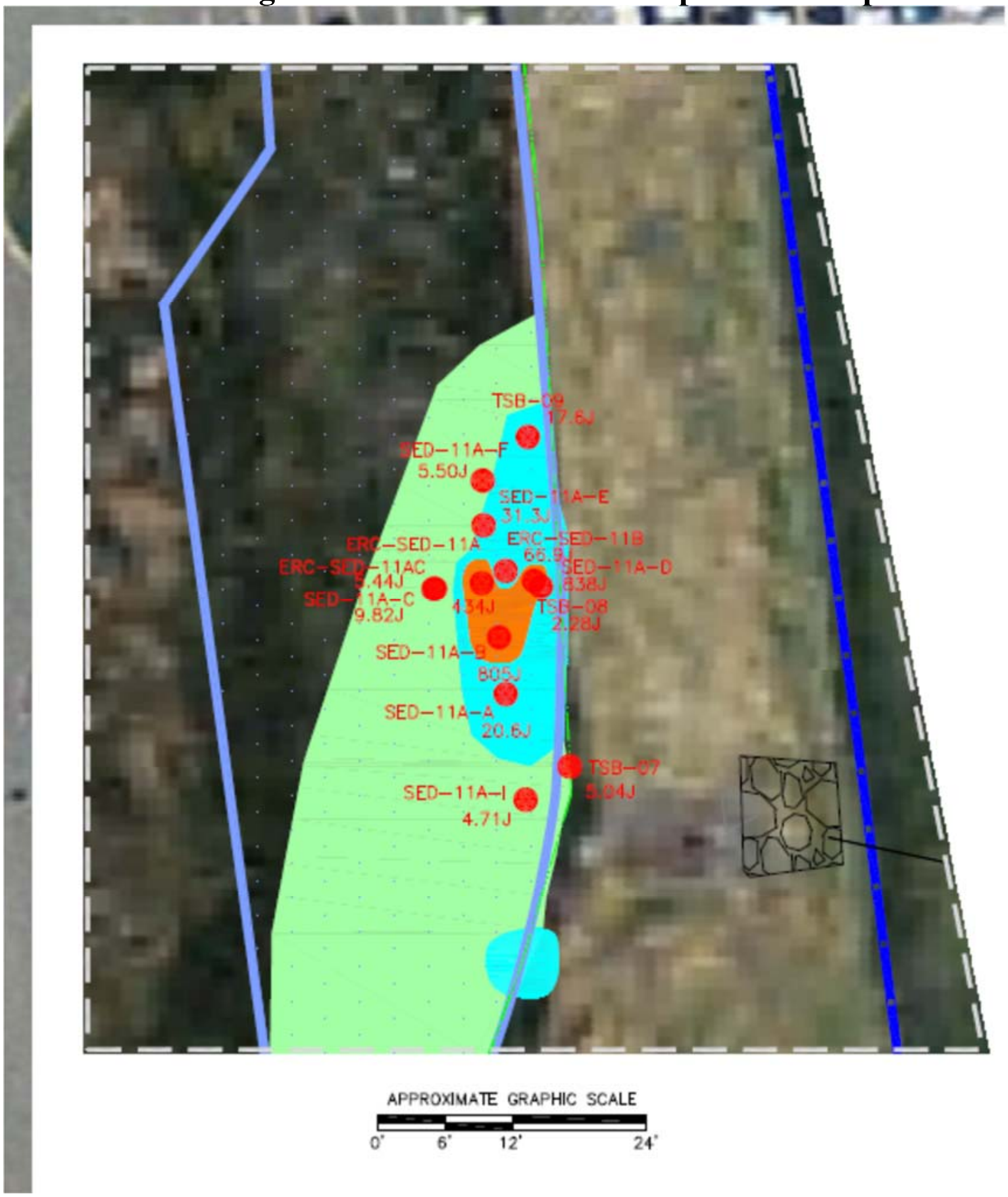

Table 4. Wetland Soil/Sediment – Occasional Trespasser

Polychlorinated Biphenyls (PCBs) * Dose Estimation

Age Group (year)	Mean Body Weight (kg)	Soil Intake (mg/day)	Estimated EPC (mg/kg)	CTE Doses (mg/kg/day)	MRE Doses (mg/kg/day)	MRL (mg/kg/day)
6 to < 11	31.8	100	15.2	1.0E-05	2.1E-05	2.0E-05
11 to <16	56.8	100	15.2	6.0E-06	1.2E-05	2.0E-05
16 to <21	71.6	100	15.2	5.0E-06	9.0E-06	2.0E-05
≥21	80	50	15.2	2.0E-06	4.0E-06	2.0E-05

EPC = exposure point concentration. Soil results of samples collected at 0 -12 inches were multiplied by 4 and soil results of samples collected at 0 - 6 inches were multiplied by 2 to represent the exposure.

**Total PCBs (sum of Arcolor1248, Arcolor1254, and Arcolor1260) was used for the dose calculation.*

CTE: Central Tendency Exposure

MRE: Reasonable Maximum Exposure

MRL: Minimal Risk Level

NA = not applicable

Table 5 Wetland Soil/Sediment – Occasional Trespasser

Polychlorinated biphenyls (PCBs) * Cancer Risk Estimation**

Age Group (year)	Mean Body Weight (kg)	Soil Intake (mg/day)	Estimated EPC (mg/kg)	Estimated Excess Cancer Risk (CTE)	Estimated Excess Cancer Risk (RME)
6 to < 11	31.8	100	15.2	1.3E-06	2.7E-06
11 to <16	56.8	100	15.2	7.5E-07	1.5E-06
16 to <21	71.6	100	15.2	6.0E-07	1.2E-06
Combined child	NA	NA	15.2	2.7E-06	5.4E-06
≥21	80	50	15.2	6.4E-07	1.6E-06
Combined child+adult	NA	NA	NA	3.3E-06	3.4E-06

EPC = exposure point concentration. Soil/sediment results of samples collected at 0 -12 inches were multiplied by 4 and soil/sediment results of samples collected at 0 - 6 inches were multiplied by 2 to represent the exposure.

**Total PCBs (sum of Arcolor1248, Arcolor1254, and Arcolor1260) was used for the dose calculation.*

*** EPA considers that the estimated excess cancer risks between 1.0E-04 and 1.0E-06 are acceptable.*

NA = not applicable

CTE: Central Tendency Exposure

MRE: Reasonable Maximum Exposure

Combined child = the risk for the total of children of all ages

Combined child +adult = the total of all children and adults

Appendix D. Estimated Exposure-Dose Calculations

ATSDR calculate children and adult exposure doses for the site-specific exposure scenario. Exposure doses are calculated in units of milligrams per kilogram per day (mg/kg/day). We conducted separate calculations to account for non-cancer and cancer health effects for PCBs.

Following is a brief explanation of how we calculated the estimated exposure doses for the site.

Exposure Dose Formulas

(1) The exposure dose formula for accidental ingestion of chemicals in soil or sediment is:

$$\textit{Ingestion Dose (ID)} = \frac{\boldsymbol{C \times IR \times EF \times ED \times CF}}{\boldsymbol{BW \times AT}}$$

Where:

ID *= ingestion dose in milligrams per kilogram per day (mg/kg/day)*

C *= concentration of contaminant in soil in milligrams per kilogram (mg/kg or ppm)*

IR *= ingestion rate in milligrams per day (mg/day)*

EF *= exposure frequency (days/year)*

ED *= exposure duration (years)*

CF *= conversion factor (10^{-6} kg/mg)*

BW *= body weight (kg)*

AT *= averaging time, days (ED x 365 days/year)*

For example, if a child (between 6 to 11 years old) was exposed to total PCBs in the wetlands from soil/sediment ingestion, using an EPC of 15.2 mg/kg (using the multiplied soil results for PCE calculation), trespasser's ingestion rate of 100 mg/day, EF of 80/365 days/year, exposure duration of 5 years, conversion factor of 10^{-6} kg/mg, body weight of 31.8 kg, we calculated a ingestion dose of 0.00001 mg/kg/day.

The following equation is the calculation for excess cancer risk:

Excess Cancer Risk = (C x CSF x IR x ED)/BW x AT where

C = contaminant concentration in mg/kg or µg/L/

CSF (mg/kg/day) = cancer slope factor

IR = ingestion rate in mg/day or L/day

ED (years) = exposure duration

BW (kg) = body weight

AT (lifetime in years) = 78 years

EPA CSFs can be found at: http://www.epa.gov/iris.

For example, for children 6-11 years old exposed to total PCBs in the wetlands from soil/sediment ingestion, using a EPC of 15.2 mg/kg, CSF of 2.0E+00 $(mg/kg/day)^{-1}$ for total PCBs, ingestion rate of 100 mg/day, exposure duration of 5 years, body weight of 31.8 kg, and averaging time of 78 years, we calculated an estimated excess cancer risk of 1.3E-06 for CTE and 2.7E-06 for RME.

Exposure parameter assumptions

Table D-1. ATSDR-recommended soil and sediment ingestion rates

Age Range in Years	Mean mg/day	Upper Percentile mg/day	Mean Body Weight kg
6 weeks to <1	60	100	7.8
1 to <2	100	200	11.4
2 to <6	100	200	17.4
6 to <11	100	200	31.8
11 to <16	100	200	56.8
16 to <21	100	200	71.6
≥21	50	100	80

Wetland soil/sediment – Occasional Trespassers

Conservatively, ATSDR made the following assumptions for our dose calculations.

The exposure assessment assumes that hypothetically a person trespasses on the site over time, beginning in childhood (aged ≥6 years) and continuing into adulthood (aged ≥21 years). The trespasser scenario assumes that these trespassing events occurred twice weekly for 10 moths per year, or 80 days/year assuming exposure stopped because of the installation of fences. ATSDR used 15.2 as estimated EPCs for total PCBs.

See Table 4 and 5 in Appendix C for the summary results of the dose calculations.

NBHS soil exposures

ATSDR calculated an exposure dose for persons likely exposed daily during the school year. ATSDR realized that parents with younger children may have visited the school intermittently, but those exposures were not as frequent as those of students who attended the school daily. We assumed students and faculty were exposed to soil contaminants 5 days a week for 9 months of the year, or 180 days per year. A total of 106 soil samples collected from the five areas were available for this evaluation. Concentrations of PCBs ranged from non-detect to 75.2 mg/kg. Because soil samples were collected at depths of 0- 6 inches and 0-12 inches at the NBHS, we multiplied the results of samples collected at 0 -12 inches by 4 to represent the exposure. The appropriate EPCs of 5.0 mg/kg was calculated using EPA's ProUCL program. Using the above conservative exposure assumptions and EPA's default exposure parameters for different age groups, we calculated exposure doses and estimated potential cancer risks. Appendix C Table 4 and 5 are summaries of the dose and cancer risk calculation results.

Appendix E. Resources for Lead Education

1. Lead Exposure Sources
2. Information on Reducing Lead Exposure
3. Recommendation for Clinicians

1. Lead Exposure Sources

Lead is found in many products and locations. Lead-based paint and contaminated dust are the most well-known and dangerous high-dose sources of lead exposure for young children. Here are ways that you can be exposed to lead.

Indoor

Paint – Swallowing small pieces of peeling leaded paint found in homes built before 1978 and on older toys and furniture.

Dust – Swallowing dust (from hand-to-mouth behavior in children) found in older homes (built before 1978) or tracked inside the home from contaminated soil.

Water – Drinking water having lead from wearing away of older fixtures, from the solder that connects pipes, or from wells where lead contamination has affected the ground water

Tableware – Eating foods from old Mexican-made clay dishes that contain lead and drinking from leaded crystal, pewter, and brass cups.

Candy – Eating candies brought in from Mexico. Certain candy ingredients such as chili powder and tamarind may be a source of lead exposure. Candy wrappers have also been shown to contain lead.

Toy Jewelry – Swallowing or putting in the mouth toy jewelry that contains lead. This inexpensive children's jewelry is generally sold in vending machines and large volume discount stores across the country.

Traditional Medicines –Swallowing some traditional home medicines from India, the Middle East, Asia, and Mexico. Lead and other heavy metals are mixed with some home medicines and are believed to help treat illness. Sometimes lead accidentally gets into the home medicine during grinding, coloring, or other methods of preparation.

Outdoor

Outdoor Air – Breathing lead dust in outdoor air that comes from the residues of leaded gasoline or industrial operations.

Soil – Ingesting dirt contaminated with lead from old smelters and other industries.

Other

Hobbies – Ingesting lead from hobbies that include welding, auto or boat repair, the making of clay pottery, stained glass, bullets, and fishing weights. Other pastimes that might involve lead include furniture refinishing, home remodeling, painting, and target shooting at firing ranges.

Workplace – Swallowing lead found at the workplace. Jobs with the potential for lead exposure include building demolition, painting, remodeling/renovation, construction, battery recycling, radiator repair, and bridge construction. People who work in a lead environment may bring lead dust into their car or home on their clothes, shoes, and bodies exposing family members.[i]

[1] References for Sources:
U.S. Centers for Disease Control and Prevention (CDC 2009). Lead (web page). Last Updated June 1, 2009. Available online@ http://www.cdc.gov/nceh/lead/tips/sources.htm
Oregon Department of Human Services (DHS) Undated. Available online at http://www.doh.state.fl.us/environment/medicine/lead/pdfs/OregonLeadSources.pdf

New York Department of Health (NYDOH 2010). Sources of Lead. Last updated April 2010. Available online at http://www.health.ny.gov/environmental/lead/sources.htm

2. Information on Reducing Lead Exposure

http://www.cdc.gov/nceh/lead/ACCLPP/Lead_Levels_in_Children_Fact_Sheet.pdf

Parents can take simple steps to make their homes more lead-safe.

- Talk to your local health department about testing paint and dust in your home for lead if you live in a home built before 1978.
- Common home renovation activities like sanding, cutting, and demolition can create hazardous lead dust and chips by disturbing lead-based paint. These can be harmful to adults and children.
- Renovation activities should be performed by certified renovators who are trained by EPA-approved training providers to follow lead-safe work practices.
- Learn more at EPA's Renovation, Repair, and Painting rule Web page: http://www.epa.gov/lead/pubs/renovation.htm.
- If you see paint chips or dust in windowsills or on floors because of peeling paint, clean these areas regularly with a wet mop.
- Wipe your feet on mats before entering the home, especially if you work in occupations where lead is used. Removing your shoes when you are entering the home is a good practice to control lead.
- Remove recalled toys and toy jewelry from children. Stay up-to-date on current recalls by visiting the Consumer Product Safety Commission's Web site: http://www.cpsc.gov/.

Lead can be found in a variety of sources.

These include:

- paint in homes built before 1978
- water pumped through leaded pipes
- imported items, including clay pots.
- certain consumer products such as candies, make-up and jewelry
- certain imported home remedies

Protect your Children from Lead Exposure

It is important to determine the construction year of the house or the dwelling where your child may spend a large amount of time (e.g., grandparents or daycare). In housing built before 1978, assume that the paint has lead unless tests show otherwise.

- ***Have your children tested for lead beginning at 9 months to one year of life.***
- ***Provide a healthy diet for your child that is rich in iron, calcium and vitamin C, and with appropriate levels of fat based on age.***
- ***Regularly wash children's hands, especially before eating.*** Always wash their pacifiers, drinking bottles, and toys before they use them.
- ***Regularly wet-mop floors and wet-wipe window components.*** Because household dust is a major source of lead, parents should wet-mop floors and wet-wipe horizontal surfaces every 2-3 weeks. Windowsills and wells can contain high levels of leaded dust. They should be kept clean. If feasible, windows should be shut to prevent abrasion of painted surfaces or opened from the top sash.
- ***Make sure your child does not have access to peeling paint or chewable surfaces painted with lead-based paint.*** Do not try to remove peeling paint yourself! If there is peeling paint in your home, call the health department for help on how to remedy this. If you rent, report peeling paint to your landlord. Your landlord is responsible for properly taking care of this problem.
- ***Ensure that pregnant women and children are not present in housing built before 1978 that is undergoing renovation.*** They should not participate in activities that disturb old paint or in cleaning up paint debris after work is completed.
- ***Create barriers between living/play areas and lead sources.*** Until environmental clean-up is completed, parents should clean and isolate all sources of lead. They should close and lock doors to keep children away from chipping or peeling paint on walls. You can also apply temporary barriers such as contact paper or duct tape, to cover holes in walls or to block children's access to other sources of lead.
- ***Remove shoes before entering your home and ask others to do the same.***
- ***Prevent children from playing in bare soil; if possible, provide them with sandboxes.*** Parents should plant grass on areas of bare soil or cover the soil with grass seed, mulch, or wood chips, if possible. Until the bare soil is covered, parents should move play areas away from bare soil and away from the sides of the house. If using a sandbox, parents should also cover the box when not in use to prevent cats from using it as a litter box. That will help protect children from exposure to animal waste.

Let tap water run for one minute before you start using it.

http://www.cdc.gov/nceh/lead/tips.htm

3. Information for Clinicians on Blood Lead Testing, Exposure History, and Follow-up

PEHSU Pediatric Environmental Health Specialty Units

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Recommendations on Medical Management of Childhood Lead Exposure and Poisoning

No level of lead in the blood is safe. In 2012, the CDC established a new "reference value" for blood lead levels (5 mcg/dL), thereby lowering the level at which evaluation and intervention are recommended (CDC).

Lead level	Recommendation
< 5 mcg/dL	1. Review lab results with family. For reference, the geometric mean blood lead level for children 1-5 years old is less than 2 mcg/dL . 2. Repeat the blood lead level in 6-12 months if the child is at high risk or risk changes during the timeframe. Ensure levels are done at 1 and 2 years of age. 3. For children screened at age < 12 months, consider retesting in 3-6 months as lead exposure may increase as mobility increases. 4. Perform routine health maintenance including assessment of nutrition, physical and mental development, as well as iron deficiency risk factors. 5. Provide anticipatory guidance on common sources of environmental lead exposure: paint in homes built prior to 1978, soil near roadways or other sources of lead, take-home exposures related to adult occupations, imported spices, cosmetics, folk remedies, and cookware.
5-14 mcg/dL	1. Perform steps as described above for levels < 5 mcg/dL. 2. Re-test venous blood lead level within 1-3 months to ensure the lead level is not rising. If it is stable or decreasing, retest the blood lead level in 3 months. Refer patient to local health authorities if such resources are available. Most states require elevated blood lead levels be reported to the state health department. Contact the CDC at 800-CDC-INFO (800-232-4636) or the National Lead Information Center at 800-424-LEAD (5323) for resources regarding lead poisoning prevention and local childhood lead poisoning prevention programs. 3. Take a careful environmental history to identify potential sources of exposures (see #5 above) and provide preliminary advice about reducing/eliminating exposures. Take care to consider other children who may be exposed. 4. Provide nutritional counseling related to calcium and iron. In addition, recommend having a fruit at every meal as iron absorption quadruples when taken with Vitamin C-containing foods. Encourage the consumption of iron-enriched foods (e.g., cereals, meats). Some children may be eligible for Special Supplemental Nutrition Program for Women, Infants and Child (WIC) or other nutritional counseling. 5. Ensure iron sufficiency with adequate laboratory testing (CBC, Ferritin, CRP) and treatment per AAP guidelines. Consider starting a multivitamin with iron. 6. Perform structured developmental screening evaluations at child health maintenance visits, as lead's effect on development may manifest over years.
15-44 mcg/dL	1. Perform steps as described above for levels 5-14 mcg/dL. 2. Confirm the blood lead level with repeat venous sample within 1 to 4 weeks. 3. Additional, specific evaluation of the child, such as abdominal x-ray should be considered based on the environmental investigation and history (e.g., pica for paint chips, mouthing behaviors). Gut decontamination may be considered if leaded foreign bodies are visualized on x-ray. Any treatment for blood lead levels in this range should be done in consultation with an expert. Contact local PEHSU or PCC for guidance; see resources on back for contact information.
>44 mcg/dL	1. Follow guidance for BLL 15-44 mcg/dL as listed above. 2. Confirm the blood lead level with repeat venous lead level within 48 hours. 3. Consider hospitalization and/or chelation therapy (managed with the assistance of an experienced provider). Safety of the home with respect to lead hazards, isolation of the lead source, family social situation, and chronicity of the exposure are factors that may influence management. Contact your regional PEHSU or PCC for assistance; see resources on back for contact information.

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Recommendations on Medical Management of Childhood Lead Exposure and Poisoning

Principles of Lead Exposure in Children
• A child's blood lead concentration depends on their environment, habits, and nutritional status. Each of these can influence lead absorption. Children with differing habits or nutritional status but who live in the same environment can vary on blood lead concentration. Further, as children age or change residences, habits or environments change creating or reducing lead exposure potential.
• While clinically evident effects such as anemia, abdominal pain, nephropathy, and encephalopathy are seen at levels >40 μg/dL, even levels below 10 μg/dL are associated with subclinical effects such inattention and hyperactivity, and decreased cognitive function. Levels above 100 μg/dL may result in fatal cerebral edema.
• Lead exposure can be viewed as a lifelong exposure, even after blood lead levels decline. Bone acts as a reservoir for lead over an individual's lifetime. Childhood lead exposure has potential consequences for adult health and is linked to hypertension, renal insufficiency, and increased cardiovascular-related mortality.
• Since lead shares common absorptive mechanisms with iron, calcium, and zinc, nutritional deficiencies in these minerals promotes lead absorption. Acting synergistically with lead, deficiencies in these minerals can also worsen lead-related neurotoxicity.

Principles of Lead Screening
• Lead screening is typically performed with a capillary specimen obtained by a finger prick with blood blotted onto a testing paper. Testing in this manner requires that the skin surface be clean; false positives are common. Therefore, elevated capillary blood lead levels should be followed by venipuncture testing to confirm the blood lead level. In cases where the capillary specimen demonstrates an elevated lead level but the follow-up venipuncture does not, it is important to recognize that the child may live in a lead-contaminated environment that resulted in contamination of the finger tip. Efforts should be made to identify and eliminate the source of lead in these cases. Where feasible, lead screening should be performed by venipuncture.

Principles of Iron Deficiency Screening
• The iron deficiency state enhances absorption of ingested lead.
• Hemoglobin is a lagging indicator of iron deficiency and only 40% of children with anemia are iron deficient.
• Lead exposed children (≥ 5 mcg/dL) are at risk for iron deficiency and should be screened using CBC, Ferritin, and CRP. Alternatively, reticulocyte hemoglobin can be used, if available.
• Children with iron deficiency, with or without anemia, should be treated with iron supplementation.

Resources	
• Pediatric Environmental Health Specialty Unit (PEHSU)Network	• www.pehsu.net or 888-347-2632
• Poison Control Center (PCC)	• www.aapcc.org/ or 800-222-1222
• Centers for Disease Control and Prevention	• www.cdc.gov/nceh/lead/ or 800-232-4636
• U.S. Environmental Protection Agency	• www.epa.gov/lead/ or 800-424-5323

Suggested Reading and References:

Pediatric Environmental Health, 3rd edition. American Academy of Pediatrics, 2012.

Woolf A, Goldman R, Bellinger D. *Pediatric Clinics of North America* 2007;54(2):271-294.

Levin R, et al. *Environmental Health Perspectives* 2008; 116(10):1285-1293.

Baker RD, Greer FR. *Pediatrics* 2010;126(5):1040-50.

Guidelines for the Identification and Management of Lead Exposure in Pregnant and Lactating Women. CDC, 2010.

CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention" June 7, 2012

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(June 2013 update)

[i] References for Sources:

U.S. Centers for Disease Control and Prevention (CDC 2009). Lead (web page). Last Updated June 1, 2009. Available online@ http://www.cdc.gov/nceh/lead/tips/sources.htm

Oregon Department of Human Services (DHS) Undated. Available online at http://www.doh.state.fl.us/environment/medicine/lead/pdfs/OregonLeadSources.pdf

New York Department of Health (NYDOH 2010). Sources of Lead. Last updated April 2010. Available online at http://www.health.ny.gov/environmental/lead/sources.htm