Public Health Assessment

Final Release

BORIT ASBESTOS NATIONAL PRIORITIES LIST SITE

AMBLER, MONTGOMERY COUNTY, PENNSYLVANIA

Prepared by
Pennsylvania Department of Health

JANUARY 9, 2015

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

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR's Cooperative Agreement Partner pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 60-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by 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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Summary

Introduction

In response to the BoRit asbestos site ('the site') being listed on the Environmental Protection Agency (EPA) National Priorities List (NPL) and EPA's collection of environmental sampling data as part of the site Remedial Investigation/Feasibility Study (RI/FS), the Pennsylvania Department of Health (PADOH) prepared this Public Health Assessment (PHA) document. PADOH's primary goal is to evaluate whether a community is being exposed to levels of contaminants that may harm their health and make any necessary recommendations to prevent and mitigate exposures, as well as to ensure that the community has the best information possible to protect public health. PADOH worked under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR) to complete this PHA document.

PADOH evaluated air sampling and soil data for asbestos, collected at both on-site and off-site locations. As part of the removal activities and the RI/FS, EPA collected ambient air samples for asbestos, as well as activity-based sampling (ABS), to determine the potential exposure levels to asbestos in the air during vigorous activities such as lawn raking, children outdoors playing while lawn maintenance occurs, jogging, disturbing site soils and potential trespassing on the site itself. Using the air sampling data, PADOH assessed potential cancer risk for inhalation exposures to asbestos, on and off the BoRit site. PADOH also reviewed on-site soil and adjacent surface water data collected for asbestos. Lastly, PADOH compiled health outcome data, from the Pennsylvania Cancer Registry, for the Ambler community. The purpose of this PHA is to provide a summary of PADOH's review, answer community concerns, and provide relevant public health findings and recommendations. The public comment period for the PHA was from July 25, 2013 through September 30, 2013. After reviewing the comments and incorporating any changes or revisions, this version of the PHA now reflects PADOH's final conclusions and recommendations for the BoRit site, based on the information available about the site at this time.

Conclusions

After reviewing the EPA's asbestos sampling in ambient air, soil, sediment, surface water, and air samples collected during ABS both on-site and off-site, PADOH concludes the following for the BoRit site:

Conclusion 1 (Off-site)

Based on a review of the 2008-2011 ambient air sampling data, current exposures to the off-site airborne asbestos levels are not expected to harm people's health.

Basis for Conclusion

- The results of ambient air samples collected by EPA along the site perimeter and in the nearby community did not show levels of asbestos at levels exceeding EPA screening values for residential exposure. PADOH concludes that asbestos is not migrating off-site to the local community at levels that would harm their health.

Next Steps

- PADOH will continue to work with the local community, as well as EPA, to address potential community concerns related to the BoRit site. PADOH will consider reviewing additional data and issuing future public health documents, as needed.

Conclusion 2 (Off-site)

Based on an evaluation of ABS conducted off-site in residential areas and recreational walking trails, current exposures to the airborne asbestos levels (when off-site soils are being aggressively and vigorously disturbed) are not expected to harm people's health.

Basis for Conclusion

- The levels of airborne asbestos detected during personal air monitoring and area perimeter samples while off-site soils were aggressively disturbed by simulating raking, mowing, jogging, hiking and children playing outside during lawn maintenance activities were low and less than the EPA's screening level for residential exposures. ABS attempts to simulate activities to evaluate exposure to asbestos in soil, if disturbed.

Next Steps

- If additional sampling off-site data becomes available, PADOH will review this data and issue future public health documents, as needed.

Conclusion 3 (Off-site)

Based on a review of the surface water samples collected on-site and off-site, exposures to asbestos in surface water are not expected to harm people's health.

Basis for Conclusion

- EPA collected surface water samples from the on-site reservoir and the Wissahickon, Tannery Run, and Rose Valley Creeks, which are adjacent to the site. Several of the samples exceeded EPA's maximum contaminant level (MCL) for asbestos in drinking water. However, the public is currently not using the surface water as a drinking water source and therefore this is not a completed exposure pathway.
- For people living near the site, occasional recreational exposures to surface water are not expected to be a public health concern.

Next Steps

- PADOH recommends periodic stream surveys and, as needed, the removal of visible pieces of asbestos in the Wissahickon Creek downstream of the site.

Conclusion 4 (Off-site)

PADOH reviewed the ABS and ambient air data collected in the former Keasbey and Mattison/Nicolet buildings (K&M/Nicolet). Based on this review, PADOH does not expect past exposures (after manufacturing operations ceased) to have harmed people's health.

Basis for Conclusion

- Based on community concerns and the presence of asbestos containing material (ACM) in the buildings, EPA conducted ABS inside the former asbestos manufacturing buildings and in the community. EPA collected 1) personal air monitoring samples, 2) ambient air samples in the community while ABS occurred, and 3) ambient air samples in the community when no ABS activities occurred. The former K&M/Nicolet buildings are not part of the BoRit site remedial work, but were located close by. A few ABS samples collected inside the building, during scenarios that attempted to simulate trespasser and horseplay activities, exceeded EPA's risk-based residential screening value of 0.001 f/cc but were below the ABS screening value of 0.04 f/cc. No samples collected in the community exceeded the risk-based ambient air.
- Since the K&M/Nicolet sampling events, these buildings have been removed. However, there is still the potential for ACM in the soil near these buildings as well as additional former manufacturing properties, which may contain ACM, near the site.

Next Steps

- PADOH will continue to be engaged and available to evaluate sampling data or plans during the redevelopment and or mitigation of these buildings. At this time, to reduce the potential for exposures to ACM, PADOH recommends that the community not trespass on these former manufacturing properties. PADOH recommends that future developers carefully evaluate the risk for the release of ACM and take precautions to eliminate the release of asbestos.

Conclusion 5 (On-site)

PADOH reviewed the ABS sampling data collected on the BoRit site. PADOH concludes that on-site exposures to asbestos fibers when on-site soils and asbestos-containing material (ACM) are aggressively disturbed could harm people's health. Asbestos fibers show significant increases in on-site airborne levels when soils and ACM are disturbed through ABS while on the BoRit site.

Basis for Conclusion

- PADOH made this conclusion for several reasons; including (1) an estimated cancer risk for on-site exposures during ABS approaches or exceeds EPA lower level of target risk; (2) the quantity of buried asbestos and ACM at the site; (3) the current proximity of a residential community, and (4) the potential for re-development/re-use of this site in the future. During the on-site ABS events, EPA collected personal air monitoring and area perimeter samples for asbestos, for children and adult exposures during raking and shoveling scenarios. There was a significant increase in airborne asbestos levels when soils were aggressively disturbed through ABS at the BoRit site that resulting in air concentrations exceeding the EPA's ABS screening level for asbestos.
- At present, the site is restricted via a temporary fence, and on-site soil disturbing activities are not occurring on a regular basis. The data suggest that airborne asbestos could pose a threat to public health, should any of these

conditions change. Any direct soil activity should be avoided by visitors or trespassers at this site based on the on-site sampling results. Given that the site is undergoing removal and remedial work and there is a layer of clean soil on parts of the site, the potential for exposure to ACM is reduced. ABS samples were collected on-site prior to the installation of clean cover at the site.

Next Steps

- PADOH will continue to educate the local community to avoid disturbing asbestos in on-site soil, continue to work with EPA as they determine a remedial remedy for the BoRit site, and address any community public health concerns. At this time, PADOH recommends, until remedial work concludes, that access to the site continue to be restricted.

Conclusion 6 (Health Outcome Data)

PADOH reviewed the cancer registry data for all reportable cancers from 1990 to 2011 for Ambler. A statistically significant increase in the incidence of mesothelioma was observed in Ambler, compared to the expected number of cases in the Commonwealth of Pennsylvania as a whole.

Basis for Conclusion

- Mesothelioma and lung cancer have a long latency period. During the study period, Ambler had 32 cases of mesothelioma while 11.8 cases would be expected, based on Commonwealth rates.
- The overall cancer incidence rate (all cancers combined) for Ambler was lower than the overall rate for Pennsylvania as a whole.
- These cases of mesothelioma are likely due to past exposures when the asbestos manufacturing facilities were occurring and workers were exposed. Based on the ambient data discussed above, asbestos is not currently migrating off-site at levels that would harm people's health. The risk of malignant mesothelioma was greatest among residents in their mid-eighties, this is the cohort that included former employees and their household contacts. The majority of the mesothelioma cases were diagnosed in men. Of the 32 mesothelioma cases reported to the cancer registry for the Ambler zip code from 1990-2011, 23 of these cases were in males and 9 were in females.
- The rates of lung and bronchus cancers, which are linked to asbestos exposure but more strongly related to tobacco smoking, were lower than expected, compared to the statewide rates. Of the 419 lung and bronchus cases reported to the cancer registry for the Ambler zip code from 1990-2011, 211 of these cases were in males and 208 were in females.

Next Steps

- PADOH's Health Assessment Program will work with PADOH's Cancer Registry Program to obtain updated cancer statistics for the site area, and will review this information on a periodic basis. PADOH continues to remain interested in learning about any non-occupationally exposed individuals with mesothelioma in the community.

For More Information

If you have concerns about your health, you should contact your health care provider. For questions or concerns about the BoRit site, please contact the PADOH, Division of Environmental Health Epidemiology at (717) 346-3285.

Background and Statement of Issues

The BoRit Asbestos Site ('the site') is located in the Borough of Ambler, Montgomery County, Pennsylvania. The site was historically used to dispose of asbestos-containing materials (ACM) from the Keasbey & Mattison Company (K&M). K&M Company began manufacturing asbestos products in the Borough of Ambler in the late 1800s. Sometime during the 1930s, K&M began dumping waste materials containing ACM into a reservoir, which is the current location of the asbestos waste pile. In 1962, Nicolet Industries purchased K&M and continued to dispose of ACM at the location of the former reservoir until the 1970s, when Nicolet Industries ceased manufacturing of ACM. The asbestos waste pile property is currently vacant and not used for any purpose [EPA 2012a]. For this PHA, since asbestos is the contaminant of concern at the BoRit site, PADOH evaluated sampling data collected for asbestos, both on-site and in the community. A summary of the evaluation process used by PADOH is presented in Appendix A.

The site is bordered on the north by residential properties; on the northeast and east by Chestnut Avenue, West Maple Street, and commercial and residential areas; on the south by commercial properties (McDonalds, Classic Coachworks, and the Sons of Italy); on the southwest by Montgomery County and Pennsylvania Department of Transportation open space; and on the northwest by residential properties. A playground (Westside Tiny Tot Park) and basketball courts are located northeast and north of the property, respectively. The former Ambler Warehouse, Ambler Manor (an apartment complex), and a shopping plaza are located east of the property [EPA 2012a].

The site currently consists of three parcels; an asbestos waste pile ('the pile'), a reservoir ('the reservoir'), and the Whitpain Wissahickon Park ('the park') (Appendix B, Figure 1). The pile comprises 6 acres. The reservoir is a 15-acre reservoir with an asbestos berm constructed of asbestos shingles, millboard, and soil. Asbestos product waste, such as piping and tiles, is visible surrounding the reservoir and the nearby stream banks. The park is approximately 11 acres and was formally used as a park/playground for a number of years. In the mid-1980s, the park was closed and fenced due to asbestos contamination. Creeks running through the site include an intermittent tributary named Tannery Run, which is located south of the asbestos waste pile and Rose Valley Creek, located between the park and the reservoir. Both of these creeks eventually join the Wissahickon Creek, which is located along the western boundary of the site [EPA 2012a]. In 2013, The Army Corps of Engineers began a study of the reservoir, in part to determine if there are any seeps that drain to the Wissahickon Creek [U.S. Army Corps of Engineers 2013].

In the mid-1980s, the site was fenced (including the reservoir, park and pile) due to asbestos contamination. The asbestos waste pile is currently partially enclosed by a 12 foot high chain link fence that borders West Maple Street to the northeast and runs along Tannery Run to the south. Warning signs are posted along the fence line indicating that the enclosed area contains ACM. The asbestos waste pile is fenced along Wissahickon Creek to the west of the pile. The asbestos waste pile is currently about 20 to 30 feet above the ground. The BoRit site is located a few hundred yards northwest of the asbestos piles that became the Ambler Asbestos Piles NPL Site, which was remediated by EPA in 1993 [EPA 2012a].

In 2005, a developer was interested in constructing a multi-story housing complex on the waste pile. The local community has raised concerns about potential release of ACM. The zoning board ordinance was not passed. As a result of the initial potential development, interest in the site from the local community and elected officials increased [Rovira Jr 2006]. In April 2006, EPA's

Superfund site assessment program conducted an environmental sampling event at the BoRit Site. The results showed the presence of asbestos in the air, soil, surface water and sediments. In addition, asbestos and ACM were easily visible on the surface throughout the site area. In April 2009, the BoRit Asbestos site was listed on the EPA's NPL also known as the Superfund program EPA is currently conducting a short-term removal cleanup action and long-term remedial investigation at the site for the asbestos waste, which includes the asbestos pile, park and areas along the reservoir and stream banks. Additional information about the BoRit asbestos site can be found on the EPA's On-Scene Coordinator page at: http://www.epaosc.org/site/site_profile.aspx?site_id=2475 and on EPA's National Priorities List page for this site at: http://www.epa.gov/reg3hwmd/npl/PAD981034887.htm.

In 2010, EPA began long-term remedial investigation activities on the site. As part of the remedial investigation and feasibility study (RI/FS) process, EPA collected soil, sediment, groundwater, surface water, ambient air samples, and ABS sampling for asbestos. Data from the RI/FS will be used, in part, to determine a long-term remedial remedy for the site (EPA, 2012a). In the collection of data from the site, EPA determined that the average thickness of asbestos contamination on the park parcel is 13 feet below ground, with the highest thickness being 23 feet. The asbestos contamination appears to get thicker closer to the Wissahickon Creek. On the pile parcel, the average and maximum thickness of the asbestos contamination below ground is 17 feet and 40 feet, respectively. For the reservoir, the average thickness of asbestos contamination along the berm is 1 foot with a maximum of 3 feet [EPA 2010b].

Since 2008, significant site work has been performed by the EPA removal program. This site work will help ensure in the short-term that asbestos does not further migrate from the site and affect people's health. To summarize, the EPA's removal program efforts involve removal of waste, containment and stabilization of the stream bank, the placement of clean fill and erosion mats on the site, and hydroseeding. Beginning in 2008, EPA began major work on stream bank stabilization of the eastern bank of the Wissahickon Creek and the banks of Rose Valley Creek and Tannery Run. As part of the stream stabilization efforts, large pieces of ACM were removed, trees were removed, and geotextile fabric was installed on the banks of the creeks up to the 100-year flood plain. The stabilization of the eastern branch of the Wissahickon began in 2009 and included installing geocells on the creek slopes, which were filled in with rip rap stone. Next, geocells were filled in with soil and seeds, to increase the stream stabilization, covered with an erosion mat, and hydroseeded (which is a watery mix of seeds and mulch sprayed onto a location) [EPA 2008a].

In 2009, EPA performed work to stabilize the Rose Valley Creek stream bank. A 100-foot containment wall was constructed near the Rose Valley headwall that provided further support to the reservoir berm, while Rose Valley was being widened. The same stream bank stabilization and construction measures were used on the Rose Valley Creek as the Wissahickon Creek, as described above for the Wissahickon Creek, with the exception of concrete-cabled mats being used instead of geocells [EPA 2009a]. In 2010, EPA began work on stabilizing the banks of Tannery Run, to reduce the potential of ACM entering the stream through erosion. Geotextile fabric, concrete-cabled mats, and hydroseeding were used to stabilize the banks [EPA 2010b]. In 2011-2012, EPA placed geotextile material, erosion mats and 2 feet of clean fill on the Pile. The EPA removal program has used over 99,000 cubic yards of clean fill to cover the pile and other areas of the site. [Rovira Jr 2012] During the EPA removal process, exposed areas of the site were covered with clean fill. Since the site has a clean fill and vegetative cover, the current potential for the release of ACMs is reduced. Since removal work began, approximately 1850 tons of debris, which included both ACM and soil/organic material, has been removed from the BoRit site for off-site disposal [EPA 2011a].

Historical Sampling Data (Up to 2006)
A number of environmental investigations have been conducted over the years principally to address the nearby Ambler Asbestos NPL Site. However, due to the proximity of the two sites, the history of disposal operations in Ambler, and the selection of sampling points during these studies, air sampling data from these investigations may provide useful information regarding the past air quality status not only in the neighborhood surrounding the Ambler Asbestos Site but also the community near the BoRit Asbestos Site. Overall, the air sampling data collected prior to 2006 presents a complicated picture in terms of determining the health implications of asbestos exposure from the BoRit site. Much of these data are confounded by collection technique, analytical methods, and collection locations where other asbestos sources may have been prevalent. The extent of large piles of asbestos-contaminated material, combined with historical air data, indicates that under certain conditions local levels of air borne asbestos may have been a concern in the past.

Due to community concerns, in 1971, EPA collected air samples focused on either the active facility or the Ambler Asbestos pile. Air sampling at the BoRit site did not occur until after 2000. In total, from 1971 to 2006, EPA and/or PADEP performed 22 air sampling events in Ambler for asbestos. A summary of the historical air results is presented in Appendix B, Table 1.

Air samples were taken in the Ambler area from 1971 through 1987 (when Nicolet discontinued operations), but from 1987 until 2006, the air sampling data is more limited. The historic data showed ambient air levels as high as 2 fibers/cubic centimeter (f/cc), reported as TEM analysis. After Nicolet ceased operations in 1988, the asbestos air levels ranged from non-detect to 0.00049 f/cc (PCME method from TEM). The maximum on-site data do not appear to reflect or correlate with the maximum off site levels, since levels on-site levels would be much higher during processing. Information gaps in the historical record as well as the use of different counting methods make drawing any health conclusions regarding past exposures extremely difficult [ATSDR 2006].

In addition to historical air samples, EPA and/or Pennsylvania Department of Environmental Protection (PADEP), beginning in 1983 has collected soil samples on the BoRit site (park area) and water samples from the Wissahickon Creek and the downstream tributaries of Tannery Run and Rose Valley Creek. In 1983, four on-site park soil samples found asbestos levels up to 35%, although no sample depth is indicated. In 1984, EPA collected 24 surface samples on the BoRit site in the park. Asbestos in soil ranged from non-detect to 1% asbestos. In 1996, PADEP and EPA collected a total of 93 surface and subsurface samples. Overall, the levels ranged from trace to 15% asbestos, with the highest asbestos levels occurring at depths greater than five inches. EPA collected five surface water samples in the Wissahickon Creek in 1983 and 1986, the results were non-detect (for three samples), 59 millions of fibers per liter (MFL), and 310 MFL. In 1987, as part of the RI/FS for the Ambler Asbestos pile site, EPA collected samples in the Wissahickon (range was 59 MFL to 199 MFL), Tannery Run (8700 MFL) and Rose Valley Creek (4500 MFL). Lastly, in 2006, two samples collected by EPA from the Wissahickon were non-detect, and an on-site sample from the reservoir found asbestos at 110 MFL [Rovira Jr and Kelly 2010].

Public Health Involvement
The Pennsylvania Department of Health (PADOH), the Agency for Toxic Substances and Disease Registry (ATSDR) and the Centers for Disease Control and Prevention (CDC) have provided public health guidance, review of environmental sampling data, health education information and health outcome data reviews at various times for the Ambler Asbestos NPL and BoRit asbestos site. In 1975, PADOH conducted a review of mortality rates in Ambler from 1986 to 1973. Based on a

comparison of the mortality rates, no significant differences in mortality rates between Ambler and the rest of Pennsylvania were observed. In 1983, CDC issued a Public Health Advisory focusing on the Ambler Asbestos NPL Site area. In 1988, ATSDR and PADOH concluded the site was a potential public health concern because of the risk possible exposure to hazardous substances at concentrations that may result in adverse human health effects. The most significant potenital health concern from the site was considered the release of asbestos fibers into ambient air [CDC 1983; ATSDR 1988, 1989, 2006; ATSDR and PADOH 1993].

The following provides a historical summary of language specific to the park parcel. In an October 29, 1984 memorandum, CDC reviewed two asbestos samples collected by the EPA from Wissahickon Park. CDC recommended that (1) every effort should be made to prevent human exposure to the asbestos identified on site, and that it was particularly desirable to prevent the possible re-suspension of the fibers as a result of play activities at the park; (2) a series of samples for asbestos should be collected from the yards abutting the site; and (3) consideration should be given to providing temporary covering for the obvious asbestos outcroppings observed at the site [Georgi A. Jones, Centers for Disease Control, personal communication, 1984].

In a November 8, 1984 memorandum, CDC reviewed information for the BoRit asbestos pile and the Wissahickon Park/Whitpain Township Park. CDC concluded that the presence of exposed friable ACM was a public health risk and a potential chronic public health hazard to persons near the site. The memo notes that the suspension of asbestos fibers would be partially restricted by vegetative ground cover, but complete prevention could not be expected [Jeffrey A. Lybarger and Gailya Walter, Centers for Disease Control, personal communication, 1984].

In January 18, 1985 and February 5, 1985 memoranda, CDC reviewed bulk soil sampling results from the Wissahickon/Whitpain Township Park taken after the park was closed to the public. CDC stated that any sampling strategy also needed to include soil samples from adjacent residential yards, and that the site required sufficient containment of ACM to prevent re-suspension of fibers and to prevent offsite migration. CDC recommended that a plan be developed and implemented to ensure against further disturbance of the ground cover at this site [Gailya P. Walter and Jeffrey Lybarger, Centers for Disease Control, personal communication, 1985; Georgi Jones, Centers for Disease Control, personal communication, 1985]. A June 26, 1985 CDC memo reiterated the need to sufficiently contain waste materials at Wissahickon Park before reopening of the park could be reconsidered. CDC recommended that the fence be maintained and that the area remains closed to the public until adequate containment could be achieved [Georgi Jones, Centers for Disease Control, personal communication, 1985).

In December 2006, ATSDR Region 3 prepared an ATSDR Record of Activity (AROA) Health Consultation (HC) which detailed the extensive investigation and mitigation activities that have occurred on both the Ambler Asbestos and BoRit sites since the early 1970's. The AROA HC concluded, due to the large piles of on-site ACM and air sampling data, that under certain conditions local levels of airborne asbestos may be of concern and further investigation and examination is warranted [ATSDR 2006].

More recently, PADOH has produced three HCs for the BoRit site. The first HC was produced in 2009, including a public comment period, and evaluated 2006-2007 air sampling data collected at the site for asbestos [ATSDR and PADOH 2009a]. The second HC document reviewed health outcome data from the Pennsylvania Cancer Registry for the community [ATSDR and PADOH 2009b]. The third HC was published in 2012 and reviewed the groundwater sampling data at the BoRit site [ATSDR and PADOH 2012]. The following is a summary of the previous PADOH HCs for the BoRit site.

Previous Health Consultations for the BoRit Site

Air sampling HC (2009) – Initial and Public Comment
In 2009, based on the PADOH and ATSDR review of the 2006-2007 air sampling data, current exposures to the reported on-site and off-site airborne asbestos levels (when site soils are not being aggressively disturbed) from the 2006-2007 air sampling results were classified by PADOH and ATSDR as a no apparent public health hazard to the community for cancer effects and/or non-cancer effects. PADOH and ATSDR concluded that on-site exposures to asbestos fibers when on-site soils and asbestos-containing material are disturbed are a public health hazard to area residents [ATSDR and PADOH 2009a].

The current consensus in the scientific community, based on epidemiological and animal studies, is that exposures from short fibers (fibers with lengths less than 5 micrometers) do not contribute to lung cancer and mesothelioma. However, short fibers might play a role in asbestosis when exposure duration is long and fiber concentration high. At this site, the majority of the fibers detected during activity-based sampling were short fibers which, at the levels observed during the 2006-2007 sampling, would not be expected to increase asbestos-related disease. The general public and the Ambler community are not expected to be exposed to the levels of AHERA fibers detected during the ABS events at this site, since they were detected within the site boundary during aggressive soil manipulation. Seasonality appeared to have limited effect on airborne asbestos levels. However, under dryer conditions (e.g., September 2007), increases in airborne asbestos were seen and therefore, drought or severely dry conditions could exacerbate the problem of re-entrainment of airborne asbestos and migration from the site [ATSDR and PADOH 2009a].

Health Outcome Data HC (2009)
In 2009, in response to community concerns, historical site activities, and air sampling data, the PADOH analyzed and summarized available health outcome data for malignant mesothelioma and lung cancer in the Ambler, Blue Bell and Fort Washington communities for 1996-2005. The health outcome data analysis evaluated the entire ZIP code of Ambler because it includes the BoRit site. In addition, the Blue Bell and Fort Washington ZIP code areas were also selected because they are adjacent to the BoRit site, and since mesothelioma is a relatively rare cancer, a large enough population base is required to reliably calculate a potential statistical difference in cancer incidence rates [ATSDR and PADOH 2009b].

For the Ambler ZIP code, a non-statistically significant increase in the incidence of mesothelioma was observed, particularly more in the male population, compared to the expected number of cases in the Commonwealth of Pennsylvania as a whole. For the Blue Bell and Fort Washington ZIP codes respectively, observed mesothelioma incidence rates were not elevated above expected levels. Rates of bronchus and lung cancer in all three study ZIP code areas respectively were lower than expected Commonwealth rates and statistically significantly lower than expected. No statistically significant excess or increase in incidence rates for the cancers of interest were observed in the study ZIP codes when compared to the overall expected Commonwealth rates [ATSDR and PADOH 2009b]. PADOH updated the cancer incidence review for the Ambler community in this PHA, which included additional reporting years.

PADOH also reviewed a Montgomery County Health Department (MCHD) report of a separate health outcome data analysis. The MCHD evaluation showed that residents living within a 2-mile radius from six historic asbestos manufacturing and waste disposal sites in Montgomery County had a statistically significant higher mesothelioma incidence rate than those living outside these 2-mile zones. Both male and female mesothelioma incidence rates were elevated within the 2-mile radii, but were only statistically significant for the male population. Since mesothelioma has a long latency period (i.e., 30 years), elevated incidence rates detected by the MCHD provide information on historical exposures potentially related to the site and other exposure sources (i.e. occupational exposure) but do not reflect current site conditions or exposure levels. This study provides data on the overall trend of mesothelioma cases in Montgomery County adjacent to those six asbestos sites. However, since aggregate data from the six asbestos sites were used in the MCHD analysis, it is difficult for PADOH to draw conclusions regarding the BoRit site based on these data [ATSDR and PADOH 2009b].

Groundwater HC (2012)
Some community members had expressed concern that asbestos or other chemicals could be present in residential drinking water from site contaminants. PADOH produced a HC in 2012 for the groundwater pathway at the site. PADOH reviewed data collected as part of the RI/FS for the site. Based on an evaluation of the groundwater sampling data for volatile organic compounds (VOCs), semi-volatile compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, inorganic/metals, and asbestos, exposure to groundwater beneath the site is not expected to harm people's health. The community near the site is on public drinking water. PADOH also reviewed the public water supply sampling data for the Ambler area and concluded that exposure to asbestos and other contaminants in public drinking water is not expected to harm people's health. It appears that private well water use near the site is very limited. However, PADOH does not have much information on private well use or sampling of private wells in the site area. Therefore, PADOH cannot currently make a conclusion regarding public health and private wells in the area. Due to the lack of information and data on private wells, PADOH suggested that EPA conduct a private well survey near the site to establish if any private well users could be impacted by site-related contamination [ATSDR and PADOH 2012].

Demographics
As part of the PHA, PADOH reviewed the population demographics within a 1-mile radius of the BoRit site (Appendix B, Figure 2). The population density immediately surrounding the site (>2,000 people per square mile) is higher than other areas within 1-mile of the site. The review was based on 2010 U.S. Census data and encompassed part of Ambler and parts of Fort Washington and Blue Bell. The total population within 1 mile of the site is 9,570 with 78.8% white, 12.3% black, and American Indian, Asian and other races making up the remainder. There are 1,400 residents 65 years or older and 779 children ages 6 or less. There are a total of 4,121 households.

Asbestos Overview
Asbestos minerals fall into two classes: serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers and includes chrysotile. Amphibole asbestos minerals are brittle and have a rod- or needle-like shape. Amphibole minerals regulated as asbestos by OSHA include five classes: fibrous tremolite, actinolite, anthophyllite, crocidolite, and amosite. However, other amphibole minerals, including winchite, richterite, and others, can exhibit fibrous asbestiform properties [ATSDR 2001].

Chrysotile, also known as white asbestos, is the predominant commercial form of asbestos; amphiboles are of minor commercial importance. Asbestos minerals have separable long fibers that are strong and flexible enough to be spun and woven and are heat resistant. Because of these characteristics, asbestos has been long used (mainly chrysotile) for a wide range of manufactured goods, mostly in building materials, heat-resistant fabrics, packaging, brakes, building materials, and coatings. Currently only the long fibers are considered a health threat (>5µm) Asbestos fibers may break into shorter pieces or separate into a larger number of individual fibers as a result of physical processes [ATSDR 2001].

ACM is considered "friable" when it can be easily crushed by hand. Friable asbestos can release fibers into the air, creating a potential health hazard. When asbestos fibers are intact, such as in an asbestos-containing cement pipe, they are considered "non-friable." This means that the individual fibers are contained and are not readily released into the surrounding air. From a public health and regulatory standpoint, "friable" asbestos is the greatest health concern [ATSDR 2001].

People can be exposed to asbestos by breathing fibers in the air or swallowing contaminated water containing asbestos fibers. Asbestos fibers are poorly absorbed through the skin [ATSDR 2001]. Exposure to asbestos usually occurs by breathing contaminated air in workplaces that make or use asbestos. Asbestos exposure can cause serious lung problems and cancer. Low level concentrations of asbestos are present in the ambient air. These levels range from 0.00001 to 0.0001 f/cc of air and are usually highest in cities and industrial areas. People working in industries that make or use asbestos products or who are involved in asbestos mining may be exposed to high levels of asbestos [EPA 1993].

Asbestos fibers can enter the air or water from the breakdown of natural deposits and manufactured asbestos products. Asbestos fibers are generally not broken down to other compounds and will remain virtually unchanged over long periods. People living near these industries may be exposed to asbestos in air. Asbestos fibers may be released into the air by the disturbance of ACM during product use, demolition work, building or home maintenance, repair, and remodeling. In general, exposure may occur only when the ACM is disturbed in some way to release particles and fibers into the air. Asbestos fibers do not have any detectable odor or taste. They do not dissolve in water or evaporate and are resistant to heat, fire, and chemical and biological degradation [ASTDR 2001].

Current Standards and Regulations for Asbestos

Friable asbestos is listed as a Hazardous Air Pollutant under Section 112 of the Clean Air Act in the National Emissions Standards for Hazardous Air Pollutants (NESHAP) [EPA 2014a]. Under NESHAP, work practices for asbestos to be followed during demolitions and renovations of all facilities, including, but not limited to, structures, installations, and buildings (excluding residential buildings that have four or fewer dwelling units). The regulations require a thorough inspection where the demolition or renovation operation will occur. The regulations require the owner or the operator of the renovation or demolition operation to notify the appropriate delegated entity (often a state agency) before any demolition, or before any renovations of buildings that contain a certain threshold amount of regulated asbestos-containing material. The rule requires work practice standards that control asbestos emissions [Rovira Jr 2012]. Companies releasing friable asbestos at concentrations greater than a 0.1% *de minimus* limit are required to report the release under Section 313 of the Emergency Planning and Community Right-to Know Act [EPA 2005a]. In industrial applications, ACM is defined as any material >1% bulk concentration of asbestos. However, this concentration is not health based, but represents a regulatory limit established in the 1970's under Occupational Safety and Health Administration (OSHA) [ATSDR 2012b].

In 1986, under the Toxic Substances Control Act, the Asbestos Hazard Emergency Response Act (AHERA) was signed into law [US Code 2009]. AHERA requires public and private non-profit primary and secondary schools to inspect their buildings for ACM. Therefore, experience demonstrated that removal of asbestos from school buildings was often not the best course of action as the release of previously unavailable fibers by remediation activities could create a dangerous situation. EPA only requires removal of asbestos to prevent significant public exposure during demolition or renovation. EPA does, however, require an in-place, pro-active asbestos management program to ensure ACM remains in good condition and is left undisturbed.

In 1989, EPA banned all new uses of asbestos; uses established before this date are still allowed. EPA regulates the release of asbestos from factories and during building demolition or renovation to limit and prevent asbestos from being released into the environment. OSHA has set a permissible exposure limit (PEL) of 0.1 f/cc for asbestos fibers greater than 5 µm in length and with an aspect ratio (length: width) greater than 3:1, as determined by PCM. This value represents a time-weighted average (TWA) exposure level based on 8 hours a day for a 40-hour work week. In addition, OSHA has defined an excursion limit in which no worker should be exposed in excess of 1 f/cc as averaged over a sampling period of 30 minutes [ATSDR 2001].

The National Institute of Occupational Safety and Health (NIOSH) set a Recommended Exposure Limit (REL) of 0.1 f/cc for asbestos fibers greater than 5 µm in length. This REL is a TWA for up to a 10-hour workday in a 40-hour work week. The American Conference of Government Industrial Hygienists (ACGIH) has also adopted a TWA of 0.1 f/cc as its threshold limit value (ATSDR 2001). Nationwide studies have shown that background rural air levels of asbestos are about 0.00001 f/cc. Background levels of asbestos found in cities are typically 10-fold higher, at 0.0001 f/cc [ATSDR 2001].

In response to the World Trade Center disaster in 2001 and concerns about asbestos in homes, an asbestos workgroup, made up of representatives from EPA, U.S. Department of Health and Human Services (DHHS), the U.S. Department of Labor, and state and local governments was established. The workgroup set a short-term reoccupation level for asbestos of 0.01 f/cc, after clean-up. In 2002, a multi-agency task force was developed to examine the long-term health risk from residential exposures to asbestos in lower Manhattan. The task force developed a health-based benchmark of 0.0009 f/cc, based on PCMe fibers and represents a 10^{-4} cancer risk levels for residential exposures of 30 years. This benchmark was developed to be protective under long-term exposure scenarios, and was based on conservative exposure assumptions and EPA's cancer slope factor [ATSDR 2003].

Fiber Size and Evaluation of Risk

Many researchers, risk assessors, and health professionals in the asbestos field agree that asbestos toxicity is a function of both fiber length and mineralogy, with fibers that are longer being the most carcinogenic and fibers from the amphibole class of minerals being the more toxic of the two asbestos mineral classes. Health assessors currently evaluate asbestos health effects by examining the risk of lung cancer and mesothelioma. Although asbestos is associated with other cancers, these other types of cancer are thought to occur at exposures higher than lung cancer and mesothelioma. Therefore, protecting the public from the most sensitive cancer health effects (lung cancer and mesothelioma) will protect them from other asbestos- related cancers [ATSDR 2001; ATSDR 2003].

The scientific community generally accepts the correlations of asbestos toxicity with fiber length as well as fiber mineralogy. Short fibers are those with lengths less than 5 micrometers. Only fibers greater than 5 µm in length and having an aspect ratio (i.e., length: diameter) of at least 3:1 are counted, as these sizes are the greatest health concern. EPA's IRIS considers potent fibers as those having greater than 5 micrometers in length. Long and thin fibers are expected to reach the lower airways and alveolar regions of the lung, to be retained in the lung longer, and to be more toxic than short and wide fibers or particles. Wide particles are expected to be deposited in the upper respiratory tract and not to reach the lung and pleura, the sites of asbestos-induced toxicity. Short, thin fibers, however, may also play a role in asbestosis pathogenesis. Fibers of amphibole asbestos such as tremolite asbestos, actinolite asbestos, and crocidolite asbestos are retained longer in the lower respiratory tract than chrysotile fibers of similar dimension. Various factors determine how exposure to asbestos affects an individual. These factors include the following [ATSDR 2005]:

- Exposure concentration - what was the concentration of asbestos fibers?
- Exposure duration (i.e., years) - how long did the exposure time period last?
- Exposure frequency (i.e., hours, days) - how often during that time period was the person exposed?
- Size, shape and chemical makeup of asbestos fibers.

Asbestos exposure and cigarette smoking act synergistically to produce dramatic increases in lung cancer (not mesothelioma) compared with those from exposure to either agent alone [ATSDR 2001]. Therefore, if you have been exposed to asbestos you should stop smoking. Smoking cessation will, over time, reduce the increased risk of lung cancer from asbestos in former smokers. For example, a recent study of those occupationally exposed to asbestos combined with smoking, showed that quitting smoking can reduce lung cancer mortality by half in 10 years after smoking cessation and converged with that of never-smokers 30 years after smoking cessation [Markowitz et al. 2013]. Quitting smoking may be the most important action that you can take to improve your health and decrease your risk of cancer [ATSDR 2012a].

In 2002, ATSDR held an expert panel meeting to review fiber size and toxicity in response to asbestos concerns from the World Trade Center disaster [ATSDR 2003]. The panel concluded that fiber length plays an important role in toxicity. Fibers with lengths less than 5 micrometers (<5 μm) are unlikely to cause cancer in humans. However, fibers of this size *might* play a role in asbestosis when exposure duration is long and fiber concentration high. Cleavage fragments, or short fibers, of respirable dimensions have generally proven nonpathogenic in animal studies, and are less cytotoxic and bioreactive in animal studies [Mossman 2007]. The short fibers can be cleared from the lung by various mechanisms, depending on where the fibers deposit. Fibers depositing on the surface of the tracheobronchial region are efficiently cleared generally within 24 hours. Many of the short fibers that reach the gas exchange region of the lung are cleared by alveolar macrophages, and the rate of clearance by phagocytosis has been found to vary with fiber length and to differ across mammalian species. Deposition and retention patterns may differ in people with impaired capacities to clear foreign material from their lungs. The extent to which short fibers preferentially translocate from the gas exchange region to the pleura is not well known [ATSDR 2003]. The following is a summary of the asbestos expert panel made the on the cancer and non-cancerous effects of short fibers:

> **Cancer effects of short fibers -** Results from epidemiologic studies, laboratory animal studies, and *in vitro* genotoxicity studies, combined with the lung's ability to clear short fibers, the Expert Panel agrees that there is a strong weight of evidence that asbestos fibers shorter than 5 μm are unlikely to cause cancer in humans.
>
> **Non-cancerous effects of short fibers –** Findings from the laboratory animal, epidemiologic, and *in vitro* studies suggest that short fibers, less than 5*um* may be pathogenic for pulmonary fibrosis. Fibers of this size *might* play a role in asbestosis when exposure duration is long and fiber concentration high. However, further scientific research is needed in this area to draw a definitive conclusion.

Overall, there is limited evidence of non-cancer toxicity being associated with fibers less than 5 μm in length, with two exceptions. First, very high doses to short fibers, especially those that are durable in intracellular fluids, may have the propensity to cause interstitial fibrosis. Second, exposure to short, thin durable fibers may play a role in development of pleural plaques or diffuse pleural fibrosis if the dose is high enough. For asbestos fibers, no studies have examined the effects of exposures exclusively to short fibers. Given data collected in Libby, Montana, however, some scientists questioned whether short fibers might play a role in the observed cases of pleural plaques and diffuse pleural fibrosis; but others cautioned against inferring that the risk results from exposure to short fibers, given that the Libby samples contained significant numbers of long fibers as well [Mohr et al, 2005]. In 2003, EPA reviewed the current research and methodologies related to risk associated with asbestos-related diseases, and complied a technical document. According to the EPA review [2003; hereafter 'Berman-Crump' method], the current base of scientific research shows short structures do not contribute to overall cancer risk. However, the role of short fibers in the development of asbestosis is not conclusive.

IRIS Inhalation Unit Risk

The EPA IRIS is a human health assessment program that evaluates information on health effects that may result from exposure to environmental contaminants. As part of that program, EPA establishes an Inhalation Unit Risk (IUR), based on laboratory animal data and epidemiology data, and EPA's Cancer Slope Factor (CSF), and represents the estimated excess lifetime cancer risk from continuous exposure to an agent. For asbestos the EPA IUR was developed for risk calculations based on PCM fibers and should not be applied to other counting methods. This value represents a combined risk for both lung cancer and mesothelioma. IRIS also states that the use of PCM alone in environmental samples that might contain other fibers might not be adequate. [EPA 2008a] EPA recognized there is some uncertainty with PCME counting fibers to determine risk, but the amount of uncertainty is thought to be rather small. The EPA IRIS model was developed based upon epidemiology studies of primarily chrysotile exposures but also included studies involving some mixed asbestos types and amosite exposures. The model has been shown to reasonably predict chrysotile and amphibole risk at a number of waste sites. The unit risk value is based on risks calculated using U.S. general population cancer rates and mortality patterns without consideration of smoking habits [EPA 1993].

The IUR value estimates additive risk of lung cancer and mesothelioma using a relative risk model for lung cancer and an absolute risk model for mesothelioma, based on PCME fibers. Using the IUR value, one can calculate average lifetime asbestos fiber air concentrations corresponding to specified risk levels. EPA's asbestos IUR is 0.23 per f/cc of asbestos, or $2.3 \times 10\text{-}1\ (\text{fibers/cc})^{-1}$. The concentration that would result in an increased excess risk of 1 in 10,000 is 0.0004 f/cc. The concentration resulting in an increased excess risk of 1 in 100,000 and 1 in 1,000,000 is 0.0004 f/cc and 0.000004 f/cc, respectively. Or, looking at this in another way, the unit risk estimates that there is a 23 in 100 risk of developing cancer if you are exposed to 1 f/cc for 24 hours, 365 days a year for a lifetime. [EPA 1993] Based on guidance in EPA's Asbestos Framework document, an adjusted IUR is recommended for less than lifetime exposures.

For exposures that are likely to be less than lifetime, EPA uses an adjusted IUR. The default EPA IUR (0.23 f/cc) is based on continuous exposures from birth over 70 years to PCME fibers. To account for less than this timeframe and to determine a site-specific risk based on likely activities and exposure scenarios, the EPA framework document adjusts the IUR to reflect the exposure duration [EPA 2008a]. A discussion on cancer risk and less than lifetime IUR can be found in the Cancer Risk Section.

EPA's Asbestos Framework

In 2008, EPA's Office of Solid Waste and Emergency Response published an Asbestos Framework Documents which provide recommendations for investigating and characterizing the potential for human exposure from asbestos contamination in outdoor soil and indoor dust at Superfund removal and remedial sites. The framework recommends a risk-based and site-specific approach for site evaluation based on current asbestos science. This recommended framework is needed because there are a number of unique scientific and technical issues associated with the investigation of human exposure and risk from asbestos.

Asbestos fibers in outdoor soil, indoor dust, surface waters, and/or other source materials that may be ingested are typically not inherently hazardous, unless the asbestos is released from the source material into air where it can be inhaled. If inhaled, asbestos fibers can increase the risk of developing lung cancer, mesothelioma, pleural fibrosis, and asbestosis. The relationship between the concentration of asbestos in a source material, such as soil, and the concentration of fibers in air that results when that source is disturbed is very complex and dependent on a wide range of variables. The framework document recommends a combination of soil and air samples be collected to characterize risk and that ABS, via personal air monitors, be performed while actively disturbing soil, to evaluate potential human exposures to airborne asbestos at a site. The document emphasized that asbestos materials are not hazardous unless asbestos fibers are released to the air and inhaled. Analysis of asbestos in aqueous media is not address in this document because ingestion of asbestos via drinking water has not historically been considered an important exposure route when compared to inhalation [ATSDR 2001; EPA 2008b].

Methods for Measuring Asbestos

Since the toxicity of asbestos appears to be related to fiber size, analytical methods focus on providing information on these parameters, as well as total number of fibers and mineral type. The number and size distribution of fibers is determined via direct microscopic examination. Binning is a term used by microscopists and health assessors to describe dividing the sample according to certain criteria, such as size and width. Measuring asbestos content in air samples and in bulk materials that could become airborne involves both quantification of fibers and determination of mineral content of the fibers to identify whether they are asbestiform. However, counting fibers by regulatory standards alone does not adequately describe potential health risks. The following table is a summary of the asbestos size ranges described in this PHA:

	Asbestos Hazard Emergency Response Act (AHERA)	**Transmission Electron Microscope (TEM)**	**Phase Contrast Microscopy Equivalents (PCME)**	**Berman-Crump (Protocol Structures)**
Length	≥0.5 µm	≥0.5 µm	>5 µm	>10 µm
Width	Any width	Any visible width	≥0.25 µm	≤ 0.4 µm
Aspect ratio (length to width)	>5 to 1	>3 to 1	>3 to 1	Upper width cutoff

For analysis of air samples, fiber quantification was historically done through phase contrast microscopy (PCM) via light microscopy, by counting fibers longer than 5 µm (>5 µm) and with an aspect ratio (length: width) greater than 3:1. This was the standard method by which regulatory limits were developed. However, PCM cannot differentiate asbestos and non-asbestos fibers or fibers thinner than 0.25 µm. Currently the standard method for determining asbestos fibers in the workplace is NIOSH Method 7400, asbestos by PCM. This method is mostly useful when the samples are comprised of mainly asbestos. Disadvantages of this method include the inability to detect fibers smaller than 0.25 µm in diameter and the inability to distinguish between asbestos and non-asbestos fibers.

If samples contain non-asbestos fibers (such as particulate matter such as dust) in air sampling, the transmission electron microscope (TEM) is used for identification. The TEM method can detect smaller fibers than PCM. The AHERA, PCMe, and Berman-Crump rely on using the TEM for analysis. TEM can detect long fibers but the counts are less accurate, but the accuracy of detecting longer fibers is more limited due to the size of the filter. This information can be used to determine the elemental composition of the visualized fibers. Two different procedures are used for the preparation of samples under TEM. Direct transfer methods retain particles in the same relative position on the filter. The indirect method involves dispersing the particulate matter from the filter into a liquid and then capturing the particles on a second filter for analysis via TEM. The indirect method allows for the removal of unwanted particulate matter and may allow filters overloaded with particulate matter to be analyzed [ATSDR 2001].

In environmental samples many of the fibers are non-asbestos fibers, thus TEM is most often used so that mineralogy can be determined and so that only asbestos fibers are counted. TEM, however, can see fibers that are much shorter and thinner than PCM fibers. Therefore, TEM , based on a specified size count, is used to derive PCM equivalent (PCME) fibers. With PCME, as with PCM method, only fibers with lengths greater than 5 µm and with an aspect ratio (length: width) greater than 3:1 are counted as asbestos fibers. The primary difference between PCM and PCME is that fibers are only counted if they are positively identified as asbestos. The advantage to PCME is more accurate in predicting risk in the environmental setting. However, again, only fibers greater than 5 µm are counted, and the different asbestos fibers are given equal consideration in terms of human health risk. It is vital that 'apples be compared to apples' and all risks calculated using PCME counts. At the BoRit site, the category of primary interest is PCME, since toxicity and cancer risk data is based on fibers of the PCM size. These fibers most match those measured in the past for epidemiological studies to determine human cancer risk from asbestos exposure [EPA 2004].

In response to the AHERA legislation, a counting method for asbestos in air, referred to as AHERA, was developed. The rule is a statistical method for determining if indoor air (in schools) has significantly higher levels of asbestos than the corresponding outdoor air. This method used TEM and counts as an asbestos structure any structure that has at least one verified asbestos fiber, using electron diffraction and energy dispersive X-ray analysis, an aspect ratio of 5:1 or greater, and a length greater than 0.5 µm. AHERA uses the TEM method. However, the major disadvantage to the AHERA method is the results cannot be used to predict the health risk at a particular asbestos concentration [EPA 2004]. AHERA does not provide a method for determining asbestos risk, but rather only is able to indicate if there are elevated asbestos levels. PADOH present this data for qualitative purposes in this review and cannot estimate on risk levels using this binning method, since the accepted health risk method is based on the PCME method.

The Berman-Crump method [EPA 2003a] also allows for differences in mineralogy. Several researchers and asbestos experts suspect that long fibers are the primary structures responsible for disease. The Berman-Crump model accounts for greater toxicity of amphibole fibers and greater potency of longer fibers. Although the Berman-Crump method is not currently adopted by regulatory agencies, it has been used as an alternative risk assessment method in several instances. . The premise of the model is that fibers greater than 10µm and less 0.4µm pose the greatest risk, based on animal studies and epidemiological data. Berman-Crump allows for the contribution of amphibole and chrysotile-specific potency factors analyzed through TEM analysis. This method uses the same lung cancer and mesothelioma risk model as the EPA Integrated Risk Information System (IRIS) model. Although the Berman-Crump method takes into account longer fiber toxicity, it is not used in this PHA to calculate a cancer risk [EPA 2003a].

Asbestos in soil is analyzed by light microscopic analysis.   For asbestos in surface soils at the site, EPA used the Polarized Light Microscopy (PLM), California Air Resource Board (CARB) 435 method with point counting. PLM relies on optical microscopy and can distinguish between asbestos and non-asbestos fibers as well as determine mineralogy [EPA 2005a]. However; it is not currently possible to determine what level of asbestos in soil poses a health risk, because it is difficult to predict what portion of asbestos fibers in soil will become airborne following disturbance.

Exposure Pathway

An exposure pathway is the way chemicals may enter a person's body. Both environmental and human components can contribute to potential human exposure to site contaminants. An exposure pathway includes the following five elements [ATSDR 2005]:

- A contaminant source
- Environmental medium (or media) and transport mechanisms
- A point of exposure
- A route of exposure
- A receptor population

Exposure pathways are categorized as completed, potential or eliminated. A completed exposure pathway is one in which all five elements are present, indicating that an exposure has occurred, is occurring or will occur in the future. In a potential exposure pathway, at least one of the pathways elements are missing and are uncertain, indicating that exposure to a contaminant could have occurred in the past, may be occurring or could occur in the future. A pathway is eliminated when one or more elements are missing and are very unlikely to be present. It is important to note, that having contact with a chemical does not necessarily result in adverse (harmful) health effects. A chemical's ability to produce adverse health effects is influenced by a number of factors in the exposure situation, including [ATSDR 2005]:

- how much of the chemical a person is exposed to (the dose)
- how long a time period a person is exposed to the chemical (the duration)
- how often the person is exposed (the frequency)
- the amount and type of damage the chemical can cause in the body (the toxicity of the chemical)

PADOH considers the air pathway or inhalation route of exposure to be the most significant in the current evaluation of this site. PADOH considers the air exposure pathway complete at this site. Groundwater near the site is eliminated as an exposure pathway. The public is currently not using the groundwater as a drinking water supply. We acknowledge that soil, surface water and sediment at the site contains asbestos but unless that asbestos becomes airborne we do not expect dermal or ingestion exposures to result in adverse effects.

PADOH also considers the inhalation route of exposure from ACM materials from the site possibly present in residential yards a completed pathway. However, the site is covered with a layer of clean fill and the public does not have access to the site, reducing the potential for exposures. Persons in the past could have been exposed to ACM via inhalation while trespassing in the former Keasbey and Mattison/Nicolet (K&M/Nicolet) Buildings and on the BoRit site. Since the buildings have been demolished, this is not a current exposure pathway but is a past exposure pathway. However, there is still the potential for ACM in the soil near these buildings as well as additional former manufacturing properties, which may contain ACM, near the site.

Completed exposure pathways

Source	**Medium**	**Exposure Point**	**Route of Exposure**	**Exposed Population**
Air dispersion of on-site soil	Ambient Air	Residential and trespasser inhalation	Inhalation of airborne asbestos from soil, outside or tracked into the home	Persons in the past, present and future from air dispersal of on-site soils to residential or recreational areas and trespassers
Contaminated surface soil from site activities	Soil	Residential or recreational/ public use or	Ingestion of contaminated soil or ACM, outside near homes or recreational areas or tracked into the home	Persons in the past, present and future with contaminated residential and recreational soil
ACM in former K&M/Nicolet Buildings	ACM	Trespasser inhalation	Inhalation of ACM disturbed in the buildings	Persons in the past from inhalation of ACM while trespassing. Since the buildings have been cleaned-up, this is not a
Soil near the former K&M/Nicolet and other manufacturing Buildings	Soil	Trespasser inhalation and ingestion	Inhalation or ingestion of ACM in soils near these buildings	Persons in the past, current and future from inhalation of ACM while trespassing near buildings not cleaned up yet.

Screening Values

EPA has developed several screening values for the BoRit site. The first is asbestos in soil screening value of 1%. The soil screening value is not risk or health based and is used for EPA's remedial action. Next, EPA developed asbestos in air screening values for asbestos in ambient air and asbestos in air during ABS. The following is a summary of the screening values, discussed further in the following sections, used at the BoRit site:

Media/Exposure	Screening Value
Asbestos in soil (not risk or health based) – used for EPA's remedial screening	>1% asbestos
Residential exposures to ambient asbestos	0.001 f/cc
Adult and childhood exposures to airborne asbestos during soil disturbing activities (lawn maintenance, trespassing on the site and children playing outdoors while soil is disturbed)	0.04 f/cc

Ambient Screening Value (for Residential and Perimeter Air Sample)

To estimate potential residential exposure risk, EPA has established site-specific screening values for the BoRit site, based on EPA's Asbestos Framework guidance for investigating asbestos-contaminated superfund sites. The document recommends using a risk-based action level. The risk-based action levels is based on a target cancer risk 1E-4 cancer risk (or 1 excess cancer is 10,000 exposed), the EPA's IUR of 0.17 f/cc, and a time-weighted factor (or exposure duration). For the BoRit site, EPA applied a target risk level of 1E-4 cancer risk (or 1 excess cancer is 10,000 exposed) and a TWF of 0.96 (or an exposure frequency of 350 days out of 365 days per year) to screen for potential cancer exposures in the community. Based on these factors, the residential ambient air screening value for asbestos was calculated to be 0.0006 f/cc and was rounded up to 0.001 f/cc. This value (0.001 f/cc) has been an historical benchmark at BoRit and other sites; additionally, EPA's Asbestos Framework identifies 0.001 f/cc as a common baseline residential action level [EPA 2008a]. The following table is a summary of information used to derive the baseline residential screening value:

Input Parameter	Value	Explanation
Cancer Risk Level	1.00E-04	upper bound of U.S. EPA's target cancer risk range
Inhalation Unit Risk for asbestos	0.17 (risk per f/cc)	24-year exposure, beginning at age 6
Exposure Frequency	350 days/year	350 days out of year
Exposure Time	24 hours/day	estimated duration, assumes worst case scenario
Time Weighted Frequency	0.96	24 hours/24 hours x 350 days/365 days

Screening value for residential ambient exposures (f/cc)

= Target Risk ÷ (IUR (f/cc) x TWF)

= 1x10E-4 ÷ (0.17 f/cc x 0.96)

=0.0006 f/cc PCME (Rounded up to 0.001 f/cc)

Adult Raking/Lawn Maintenance and children playing (during ABS scenario)
In the EPA's Asbestos Framework document, personal air monitors are generally preferred over stationary monitors since personal air monitors generally reflect the concentration of asbestos in the breathing zone to an exposed person. Activity based sampling (ABS), which is a procedure used in industrial hygiene to provide workplace exposure for risk assessment, recommended in the Framework document. Research has shown that airborne exposures associated with soil disturbance depend on a number of factors including environmental conditions, soil compositional, friability of ACM, and concentration of asbestos in the soil.

For the purpose of evaluating analytical results for asbestos in air at the BoRit site, EPA derived site-specific screening values for exposure scenarios involving aggressive soil disturbance, as detailed in the sections below. Specifically, screening values for airborne asbestos were developed for child and adult residents under conditions of raking/ lawn maintenance. This task is considered to be a vigorous form of ABS and attempts to temporarily move asbestos fibers from soil into air in order to capture worst-case exposure conditions (inhalation of friable asbestos). Adults were assumed to perform lawn maintenance activities, while children were assumed to play outdoors during aggressive lawn work. The calculated screening levels for adults (0.04 f/cc) is more stringent than for children (0.08 f/cc), primarily due to exposure duration. Therefore, PADOH used the adult screening value of 0.04 f/cc, for both children and adult exposures, to evaluate the ABS sampling results. The following tables summarize the calculated risk values for adults and children:

Adults Outdoors during Raking/Lawn Maintenance (During ABS scenario)

Input Parameter	**Value**	**Explanation**
Screening Risk Level	1E-04	upper bound of U.S. EPA's acceptable cancer risk range
Inhalation Unit Risk for asbestos	0.12 (risk per f/cc)	24-year exposure, beginning at age 6
Exposure Frequency	50 days/year	roughly 1 day/week
Exposure Time	4 hours/day	estimated duration of lawn work per event
Time Weighted Frequency	0.023	4 hours/24 hours x 50 days/365 days

Screening value for adults exposures during ABS (f/cc)

= Target Risk ÷ (IUR (f/cc) x TWF)
= 1x10E-4 ÷ (0.12 f/cc x 0.023)
= 0.04 f/cc

Child Playing Outdoors during Raking/Lawn Maintenance (During ABS scenario)

Input Parameter	Value	Explanation
Screening Risk Level	1E-04	upper bound of U.S. EPA's target cancer risk range
Inhalation Unit Risk for asbestos	0.055 (risk per f/cc)	6-year exposure, beginning at age 0
Exposure Frequency	50 days/year	roughly 1 day/week
Exposure Time	4 hours/day	estimated duration of lawn work per event
Time Weighted Frequency	0.023	4 hours/24 hours x 50 days/365 days

Screening value for children exposures during ABS (f/cc)

=Target Risk ÷ (IUR (f/cc) x TWF)

= 1x10E-4 ÷ (0.055 f/cc x 0.023 f/cc)

= 0.08 f/cc PCME (However, since the adult value is more conservative, PADOH used 0.04 f/cc for residential ABS scenarios).

Environmental Sampling Data

In 2009 to 2011, as part of the RI/FS, EPA collected on-site and off-site sampling data during a Phase I and Phase II investigation. On-site data for asbestos consisted of soil samples, reservoir surface water and sediment data, air sampling during activity-based sampling (ABS), personal monitoring samples, and groundwater sampling data. Off-site data consisted of soil and sediment data, surface water, ambient air data, and residential air sampling during ABS activities. As discussed above, the groundwater sampling data were reviewed in a previous HC [EPA 2012a]. In addition to the RI/FS data, EPA also collected off-site ambient data for asbestos in 2008 -2009 for the EPA removal program [EPA 2009a, 2009b]. ABS samples were also collected from the former buildings, to evaluate potential trespasser exposures, and along the Green River trail, to evaluate recreational exposures to airborne asbestos [EPA 2012b; EMSL Analytical, Inc. 2010].

For this PHA, PADOH concludes that the inhalation of asbestos is the most critical exposure pathway, since asbestos inhalation toxicity is a concern. A discussion of potential risk for the air exposure is included in Cancer Risk section. The following is a summary of the results from environmental sampling data and ABS events:

Soil for asbestos

Pile - 5 of 14 surface samples for asbestos were above the screening level. Soil cover/waste layer asbestos was detected in 1 of 3 samples. 3 of 8 surface soil samples collected in conjunction with the ABS activities contained asbestos that exceeded screening values.

Park - No surface soil samples exceeded the screening level. Three of the six soil cover/waste interface layer samples were above the 1% remedial soil screening value. Three soil samples collected for ABS exceed the screening value.

Reservoir - A surface soil collected from run –off contained 1.8% asbestos. No other samples exceeded the soil screening level.

Kids Park –no asbestos detected in surface soil.

Walking Trails - no samples had asbestos results exceeding the screening level.

Sediment and Surface Water Sampling for asbestos

Reservoir sediment – 5 samples exceeded the EPA MCL for asbestos of 7 million fibers per liter (MFL). The results ranged from non-detect to 160 MFL.

Creek surface water - 4 surface water samples exceeded the MCL for asbestos in drinking water. Results ranged from non-detect to 30 MFL.

Creek Sediment –No samples exceeded soil screening levels.

Floodplain Sediment -No samples exceeded soil screening levels.

Off-site Ambient Air Sampling

Perimeter Air Samples (2008-2009) - The results range from <0.0006 to 0.0006 f/cc via TEM

Community Air samples (2010-2011) - no ambient results exceeded the screening value of 0.001 f/cc, based on PCME from TEM analysis

On-site ABS

Pile ABS data- personal monitors range from 0.04 (for child monitor) to 0.096 f/cc (adult exposures) based on PCME, with all 6 samples exceeding the screening level of 0.04 f/cc. Area perimeter monitors were non-detect to 0.041, with 1 of 9 samples exceeding the screening level.

Park ABS data – personal monitors range from 0.0012 for adult monitors to 0.2 f/cc (child exposures) based on PCME, with 8 of 12 ABS samples exceeding the screening level. Area perimeter monitors were non-detect to 0.17 f/cc with 6 of 18 samples exceeding the screening level

Reservoir ABS data – no asbestos fibers were detected.

Personal Air Sampling w/ Perimeter Sampling during intrusive site work- one 8-hour time weighted average (TWA) PCME concentration of 0.15 f/cc in the Pile area exceeded the OSHA standard (greater than 0.1 fibers/cc). Only one area perimeter sample had detectable asbestos (concentration of 0.009 f/cc at the pile). For worker exposure scenarios, air samples were compared with OSHA limits and not EPA risk-based levels.

Off-site ABS

Former K&M/Nicolet Buildings - 9 of 13 ambient air samples collected during ABS contained asbestos fibers but no ambient samples exceeded the 0.04 f/cc screening level. Ambient air samples were collected when ABS was not occurring. Two samples contained asbestos, but were below the 0.04 f/cc screening level.

Green River and Walking Trails – One ABS sample and one sample collected from perimeter area during ABS contained asbestos fibers at 0.0008 f/cc and 0.005 f/cc, but below the 0.04 f/cc screening level.

Residential Properties – No ABS samples exceeded the screening level. Results during ABS were non-detect to 0.0094 f/cc and the area perimeter were non-detect to 0.039 f/cc.

Pile, Park, and Reservoir Soil Data
In 2009 to 2011, as part of the remedial investigations of the site, EPA collected a variety of soil and waste samples at the pile, park and reservoir (Appendix B, Figure 3). Grab samples were collected for surface soil samples (0 to 3"), subsurface soil samples, the soil cover/waste interface layer (approximately between 0 to 2'), and the native soil. In addition to these sampling events, EPA collected surface soil samples prior to conducting ABS activities on the pile, park and reservoir parcels. ABS surface soil sample were collected using a 30-point soil composite from 0 to 3 inches. The surface soil, and to a lesser extent the soil and waste interface, are the most the relevant for potential public health exposures and therefore PADOH reviewed the present the results from these two areas. Soil data were screened against EPA's asbestos framework guidance of 1% asbestos in soil. EPA uses the 1% soil screening value for remedial action at site. However, this value is not a health-based value and cannot be used to determine risk at a site. Asbestos levels present in soil cannot accurately be used to predict potential airborne asbestos levels, which is the pathway of greatest concern [EPA 2008b].

EPA collected nine grab surface samples on the pile parcel and three samples in the cover/waste interface layer (Appendix 3, Table 2). One of the grab samples was collected in a location where surface runoff leaves the site. Asbestos was not detected in this sample. Overall, the results showed 5 surface soil samples containing asbestos above the 1% screening levels, with a range of non-detect to 15%. For the soil cover/waste layer (samples from between 0 to 2'), asbestos was detected in one of the three samples at 15%. EPA also collected eight surface soil boring and surface soil samples prior to ABS activities (Appendix B, Table 3). Of these samples, three contained asbestos (1.3%, 2.2%, and 3.5%) exceeding the soil screening values.

Nine surface soil and six cover/waste interface layers samples were collected in the park (Appendix C, Table 2). Surface soil samples consisted of two locations where surface soil was believed to exit the site. No surface soil samples exceeded the screening level. Three of the six soil cover/waste interface layer samples collected from 0 to 1.7 feet, exceeded the 1% screening value. The results ranged from non-detect to 12% chrysotile with an average of 4.2%. EPA also collected 13 surface soil samples in the park prior to ABS activities and surface samples from soil borings (Appendix 3, Table 4). Three of these soil samples contained asbestos (1.1%, 1.2%, and 3.5%) exceeding the soil screening value.

EPA performed surface soil sampling adjacent to the reservoir, from soil borings and surface grab samples, to determine potential ABS locations (Appendix C, Table 5). EPA collected a surface grab soil sample for asbestos near the reservoir, to determine surface runoff. The surface soil sample collected for surface runoff contained 1.8% asbestos. EPA collected a composite surface soil sampling as a location for future ABS sampling activities and the results showed less than 1% asbestos. It is important to point out that since the site is covered with a layer of clean fill and access is restricted to the site, public would not be exposed to asbestos, currently, in on-site soil.

Surface Water Sampling Data
In 2009 to 2011, as part of the remedial investigations of the site, EPA collected surface water samples from the Reservoir on-site and the adjacent Wissahickon Creek (Appendix B, Figure 6). EPA collected 16 surface water samples from the reservoir; five of the samples exceeded the EPA MCL for asbestos of 7 MFL (Appendix 3, Table 6). The results ranged from non-detect to 160 MFL, with an average of 58 MFL. A total of 14 surface water samples were collected in the adjacent creeks. Asbestos results ranged from non-detect to 30 MFL and an average concentration

of 6.2 MFL, below the EPA MCL for asbestos in drinking water. Of these samples, 4 surface water samples exceeded the MCL for asbestos in drinking water [EPA 2013, 2010c]. However, since the public does not use the surface water as a drinking water source, it is not an exposure pathway. Therefore, the concentrations of asbestos detected in the surface water are not expected to harm people's health. As discussed in the Previous Health Consultations Section, PADOH prepared a HC on the groundwater and drinking water pathways near the site.

Reservoir and Creek Sediment and Floodplain Soil
EPA collected sediment samples from the reservoir (Appendix C, Table 7) [EPA 2012a, 2010c]. EPA collected 15 surface sediment samples in the reservoir. Samples were below EPA's remedial (not health-based) soil screening level for asbestos. EPA performed sampling of surface sediment in the Wissahickon Creek (Appendix 2, Figure 6). Twelve grab sediment samples in the creek were collected to delineate the amount the amount of asbestos, if any in these areas. Sediment in the creek spanned non-detect to 0.8% [EPA 2012c, 2010c]. Eight surface soil grab samples were also collected in the creek flood plain. Surface soil in the flood plain of the creek ranged from non-detect to 0.5%.

Walking Trails Soil
EPA conducted two sampling events along the Green River Trail in 2010 and Wissahickon Creek in 2011 (Appendix B, Figure 7-8). A visual investigation for ACM was carried out along the banks of the Wissahickon Creek and the nearby walking trails. Surface soils from two locations associated with ABS were collected at the walking trail on the west side of the Wissahickon Creek adjacent to the park parcel and along the Green Ribbon Preserve. These samples were used to help determine potential sampling locations for ABS events. Surface soil samples were collected at a depth of 0-3 inches and analyzed for asbestos [EPA 2012c].

Three surface grab samples, from soil borings and prior to ABS, were collected along the southwest part of the Wissahickon creek. Surface soil near the Wissahickon creek and walking trail ranged from non-detect to 0.3% (Appendix C, Table 8). This indicates that asbestos is present in some locations along the trail. Therefore, trail users should avoid picking up these materials when they encounter them, and practice safe hygiene practices. The soil moisture results from this sampling event were ~4-6%. These soil moisture results are important, because they demonstrate that conditions on the trail during this sampling event were relatively dry. Obtaining dry conditions was a goal of the sampling event, because this would represent more of a "worst" case scenario for any fibers to become airborne. Asbestos fibers were not detected in the Green Ribbon Trail sampling event (Appendix C, Table 9).

Residential Soil Sampling
Prior to conducting ABS activities, EPA collected composite surface soil samples from 8 residential properties (Appendix B, Figure 9). Five of the properties were along Maple Street, directly across the street from the Park parcel and three properties were along Mercer Drive and Betsy Lane, which is located on the other side of the Wissahickon creek from the site. The residential properties were selected to obtain a good distribution of the possible extent of asbestos contamination. A vacant lot was also included in this selection because portions of it have been used as a community garden and makeshift playground for the neighborhood children. Access permission was granted to EPA by each property owner before sampling was conducted surface soil. A 30-point surface soil composite sample was collected at a depth of 0-3 inches at each location [EPA 2012c].

No residential soil samples exceeded the EPA's remedial (not health-based) asbestos screening level (Appendix 3, Table 10). One residential location (residential #4) had detectable levels of asbestos in the surface soil. The results were 0.6% asbestos in surface soil, below the soil screening level. EPA considers asbestos in residential soil may be a result of the use of non-native soil as top soil. The homeowner at this location noted that 17 yards of screened topsoil had been placed in the lower level of the backyard in 2007 and an additional 4 yards of fill were added in 2010. The screened topsoil was purchased from a nursery in Montgomeryville, Pennsylvania, but the source is unknown.

Kid's Park Soil Sampling Data
The Kid's Park is adjacent to the BoRit site, at the corner of Maple Street and Oak Street (Appendix C, Table 11). Surface soil sampling was performed beneath both swing sets at the Kid's Park, to determine if asbestos has migrated offsite. Two samples were collected, in addition to a visual inspection for the depth of wood chips and the presence of visible ACM. Two surface soil grab samples were collected at a depth of 0-3 inches below the natural grade (i.e., no wood chips were collected) beneath the swing sets and analyzed for asbestos. Woodchips were observed to a depth of 8 inches, and soil samples were collected from the surface (beneath the wood chips) to a depth of 3 inches. No ACM was visually observed in the wood chips or in the soil below and no asbestos fibers were detected in either sample [EPA 2012c].

Off-site Ambient Air Samples (2008-2009)
EPA collected air samples from July 2008 to November 2008 and July 2009 to September 2009, during site removal activities (Appendix B, Figure 10). A total of 51 off-site samples were collected over a 24-hour time period (Appendix C, Table 1). Off-site locations (# 6, 8, 9, 14, 19 and 25) were located west of the site boundary along the Wissahickon Creek and one location (#5) was located east of the site boundary along Maple Street. Air sampling for asbestos was conducted following NIOSH Method 7400 for PCM at all locations where particulate monitoring was being conducted. Sampling was conducted for the first three days during operations in areas suspected of containing asbestos and then once a week while work was continuing in that area. The sampling locations were dependent on the work activities for the day. No air monitoring was performed on rainy days. If fibers were detected during this analysis, samples were subsequently analyzed for TEM [EPA 2009b, 2010a].

The results range from < 0.0003 to 0.0006 f/cc via TEM method. Only one sample contained detectable fibers. The maximum PCM concentration was 0.012 f/cc (at location #5), and when analyzed via TEM was 0.0006 f/cc. Since PCM is a nonspecific technique, it will detect other fibrous material that is not asbestos fibers [EPA 1993]. This is the case in the PCM sample collected at location # 5 (0.012 f/cc). During the reanalysis, with the TEM method to determine if asbestos fibers are present, the fiber concentration was 0.0006 f/cc. Since the IRIS risk model is based on PCME data and with confirmed fibers by TEM analysis, PADOH cannot use the one detection from 2008-2009 ambient air results for a cancer risk analysis. However, overall, the ambient air sampling results, are similar and consistent with the air sampling results observed during the 2006-2007 air sampling events. In an evaluation of that air sampling event, PADOH concluded asbestos levels pose no apparent public health hazard to the community for cancer effects. Based on a review of the 2008-2009 air sampling data collected off-site, PADOH does not feel asbestos is migrating off-site at levels that would harm people's health.

Off-site Ambient Air samples (2010-2011)
Ambient air monitoring was conducted from November 2010 to October 2011, as part of the remedial investigation (Appendix B, Figure 11). Sampling was conducted at seven locations in the residential/commercial area surrounding the Site. One background location was used in Oreland, situated 3 miles southeast of the site, for each sampling event. In total, 14 sampling events were performed, with at least one event per month with a total of 98 samples. Each sampling event was

24 hours in duration and was analyzed via TEM and fiber sizes corresponding to PCM, AHERA, and Berman-Crump protocol fibers were documented. PCME, TEM, AHERA and Berman-Crump. Ambient air samples were not collected during a rain event. If rainfall exceeded 0.25 inches, EPA waited at least 24 hours to collect ambient air samples. If rainfall exceeded 0.5 inches, EPA waited at least 48 hours to collect ambient samples. This was done in an effort to capture a 'worst case scenario' based on dry conditions that could cause release or disturb asbestos in soil [EPA 2012c].

PADOH evaluated the off-site air sampling data against a risk-based screening value of 0.001 f/cc. A summary of detections is presented in Appendix 4, Table 3. During the sampling event, asbestos PCME concentrations ranged from non-detect to 0.001 f/cc (Appendix C, Table 2). Asbestos fibers, via PCME analysis were detected in 3 samples (out of the 98 collected). These detections occurred at monitoring location 1 in September 2011 (0.001 f/cc), monitoring location 7B in August 2011 (0.00079 f/cc), and monitoring location 3 in August 2011 (0.00079 f/cc). No ambient results exceeded the screening value of 0.001 f/cc. Asbestos fibers were not detected at the background monitoring location.

Some off-site ambient air monitors did detect fibers, via the AHERA, TEM and Berman-Crump methods as well. For example, the maximum concentrations of asbestos fibers were 0.0022 f/cc (location # 7B) for AHERA, 0.023 f/cc (location #7) for TEM, and 0.011 f/cc (location #7B) for Berman-Crump method. In total, asbestos fibers were detected in 17 samples analyzed for AHERA and TEM and in 3 samples analyzed via Berman-Crump. As stated previously, these counting methods are not currently used by EPA IRIS data, and cannot calculate a health risk. Based on the sampling data, PADOH concludes asbestos is not migrating off-site to the local community at levels that would harm their health. PADOH used the air sampling data to compute an estimated cancer risk for the community, as described further in the Public Health Implications Section.

PADOH plotted the maximum fiber concentration against the amount of rainfall in Ambler in the days and week prior to sampling (Appendix B, Figure). A summary of the rainfall data collected during the sampling event is presented in Appendix 3, Table 4. The PCME and AHERA counting methods were used, as this would show both the concentrations of asbestos for cancer risk and the potential presence of shorter fibers. Based on the sampling and precipitation data, the asbestos airborne levels do not appear to vary as a function of rainfall.

Activity Based Sampling

ABS attempts to estimate potential airborne exposures to asbestos contaminated soil by mimicking typical activities people may do. It has the advantage of showing levels of exposure under conditions similar to real world environments [EPA 2008a]. Since asbestos is an inhalation hazard if material is disturbed, EPA has developed sampling plans for ABS at sites contaminated with asbestos. These procedures are outlined in the EPA Framework for Investigating Asbestos-Contaminated Superfund Site. ABS is a well-established method adopted from the industrial hygiene field in which personal monitors are placed on employees as they perform their physical job functions. Similar samplings during various activities have been used at many sites including Illinois Beach Park State Park Site where asbestos piping and building materials were discovered in a public state park [ATSDR 2009].

The goals of the ABS activities at the BoRit site were to: (1) determine if asbestos has migrated from the BoRit site, and (2) determine if day-to-day activities would expose people to unhealthy levels of asbestos [EPA 2011b]. At the BoRit site, EPA collected two types of ABS samples. The first type is from personal air monitors, worn by individuals performing such activities as raking. Personal exposure is influenced by the activities performed, the duration of the activity, and the site-specific soils. Personal monitoring can be conducted for a number of activities including digging, raking, shoveling, children playing in the dirt, lawn mowing, bicycling, and jogging. The second type of sampling during ABS is area perimeter samples. Area perimeter samples are collected at the perimeter of an ABS location and help to determine the levels of asbestos in proximity to activities that disturb soil such as raking. For all ABS events, asbestos samples are collected from the breathing zones of the subject at an appropriate flow rate [EPA 2007, 2011b].

To determine potential on-site exposures, EPA conducted ABS sampling at the pile, park and reservoir properties as well as personal monitoring during site intrusive work (i.e. drilling of groundwater monitoring wells). To determine potential off-site exposures, EPA conducted ABS along recreational walking trails, at residential homes, and in and around the former K&M/Nicolet Buildings. Two types of air samples were collected during the ABS activities at both on-site and off-site locations: (1). Personal air monitors or air cassettes worn by an adult actor; (2). and area perimeter samples, where air cassettes were placed in the vicinity of ABS location. Personal air monitors while ABS included high both volume and low volume collections. Sampling was performed during a two-hour ABS raking scenarios for the Pile and Park and shoveling scenario for the Reservoir location. Area perimeter air samples were located with one pump upwind and two pumps located downwind. Pumps were positioned at the edge of each sampling location grid. Sampling location grids were delineated at 10 feet x 10 feet. ABS personal air samples were analyzed for asbestos based on two heights, with one at shoulder height (4 to 6 feet) to simulate the breathing zone of an adult, and one at waist height (2.5 to 3.5 feet) to simulate the breathing zone of a child. Flow rates were set at 5.0 liters per minute (L/min) for the high volume samples and 2.5 L/min for the low volume samples. Flow rates of personal and perimeter pumps were checked at 30 minute intervals and recalibrated as necessary. All air samples collected via ABS activity were analyzed via PCME [EPA 2012c].

Soil moisture content was measured at 10 locations in a 10-foot by 10-foot area before sampling. The scenario was started after it was confirmed that soil moisture criteria were met. There were two soil moisture criteria that had to be met before sampling proceeded: (1) any single measurement could not exceed 50 percent soil moisture, and (2) the average of all measurements must not exceed 30 percent soil moisture. These criteria were used to ensure that data were not biased low. A portable meteorological (MET) station was also set up in proximity to the ABS sampling area and collected wind speed, wind direction, relative humidity, temperature and barometric pressure [EPA 2012c]. Appendix 3, Table 5 presents a summary of the ABS results, by location and counting method.

On-site ABS

The data described in this section represent potential air exposures, when on-site soil is actively and vigorously disturbed. Overall, the on-site ABS results show:

- When soils and asbestos-containing material were actively disturbed through ABS on-site, there was a significant increase in on-site fibers observed in the personal air monitors and area perimeter samples.
- Any direct soil disrupting activity should be avoided by visitors or trespassers. At present the community has restricted access to the site, via a temporary fence, and on-site soil disturbing activities are not occurring on a regular basis.
- At this time, PADOH recommends, until remedial work concludes, that access to the site continue to be restricted.

Asbestos Pile ABS
ABS raking activities were conducted at the asbestos pile parcel at three locations (Appendix D, Table 6). Two high volume and two low volume air samples were collected during each two-hour ABS raking scenario at the pile. Three high volume and three low volume area perimeter samples were collected during the ABS activities. Personal air sample results via PCME analysis ranged from 0.04 f/cc to 0.096 f/cc and area perimeter levels were 0 to 0.13 f/cc. Fibers were detected via the AHERA, TEM and Berman-Crump counting methods, with maximum personal air monitor results of 5 f/cc with AHER, 5.9 f/cc with TEM, and 0.087 f/cc with Berman-Crump [EPA 2012a]. Although these concentrations are all listed as f/cc, they are not comparable because they are based on different fiber sizes and can't be used to determine risk using PCME methods. The sample data show that when the on-site soil on the pile parcel is vigorously disturbed, there is a significant rise in airborne asbestos levels, especially of short fibers.

Park ABS
ABS raking activities were conducted in the park parcel at six locations selected based on results from prior soil samples (Appendix 4, Table 7). Two high and two low volume air personal samples were collected during each two-hour ABS raking scenarios at the Pile. Three high volume and three low volume area perimeter samples were collected during the ABS activities. Sample results ranged from 0 f/cc to 0.072 f/cc. During the ABS events at the Park, fibers were also detected via the AHERA, TEM and Berman-Crump counting methods in personal air monitors. AHERA detections in the personal air monitors during ABS ranged from 0.0052 f/cc to 13 f/cc. Asbestos fibers measured via TEM analysis ranged from 0.12 f/cc to 16 f/cc and using Berman-Crump counting method from 0 to 0.043 f/cc [EPA 2012c]. These concentrations are all listed as f/cc, however, they are not comparable because they are based on different fiber sizes and can't be used to determine risk using PCME methods. The sampling data collected in the Park during ABS shows that when the on-site soil on the Park parcel is vigorously disturbed, there is a significant rise in airborne asbestos levels.

Reservoir ABS
An ABS shoveling activity was conducted at one reservoir parcel location for asbestos (Appendix 4, Table 8). Two high volume and two low volume air samples were collected during the two-hour ABS shoveling scenario at the reservoir ABS location. Asbestos was not detected in any of the samples. Three high volume and three low volume perimeter air samples were collected during the ABS shoveling activity, with one pump upwind and two pumps downwind [EPA 2012c]. Asbestos was not detected in any of the samples.

Personal Air Sampling with Perimeter Sampling during intrusive site work
During intrusive site work (subsurface drilling) at the park, asbestos pile and reservoir parcels air samples were collected from personal air sampling pumps and at the perimeter of the Site and screened against the OSHA standard 29 CFR 1926.1101 for asbestos. (Note that these data were not used to determine the need for personal protective equipment requirements for site workers because all personnel working within the intrusive work zones were required to wear respirators in accordance with the health and safety plan for the site).

Personal air samples were analyzed using PCM. Personal air limits are set based on OSHA standard 29 CFR 1926.1101. If more than 2 asbestos fibers were detected in perimeter air samples, engineering controls were to be used during subsequent intrusive activities. Samples collected the first two days of intrusive activities at each parcel were submitted for analysis, and samples collected on subsequent days were archived. In total, eight days of perimeter air samples were submitted for analysis including two extra samples collected while drilling at the top of the asbestos pile where ACM was visible [EPA 2012c].

No personal air samples exceeded the 30 minute PCME of 1.0 f/cc (Appendix D, Table 9). The 8-hour time TWA PCME concentration from one sample exceeded the standard (greater than 0.1 f/cc). That sample was collected during the second day of drilling at the Asbestos Pile and had a concentration of at 0.15 f/cc. No perimeter air samples exceeded the 2 asbestos fibers "trigger" for engineering controls and only one perimeter sample had detectable asbestos. This sample occurred near the Asbestos Pile at a concentration 0.009 f/cc.

Off-site ABS
ABS data was collected in the residential areas and recreational walking trails. Overall PADOH concludes the following for the off-site ABS data:

- The ABS sampling results in the residential areas were low and below the EPA risk-based screening levels and therefore there is no unacceptable risk to child or adult residents from aggressive soil disturbance activities (disturbed by raking, mowing, jogging, hiking and children playing outside during lawn maintenance activities) at these properties.

Walking Trails ABS
Prior manufacturing and disposal activities have left ACM both in the Wissahickon Creek, on the stream banks, and along adjacent trails. EPA conducted two ABS sampling events in 2010 and 2011, along the Green River Trail and the Wissahickon Creek, respectively. The air sampling include ABS while people engaged in activities on the trails (walking with a walking stick, vigorous stamping on the materials, sitting by the water, etc.) and passive air sampling via area perimeter monitors. These sampling events were conducted to determine potential exposures to asbestos, during recreational activities on the trails adjacent to the BoRit site. Two high volume and two low volume personal air samples were collected during each two-hour ABS scenario. In addition, three high volume and three low volume perimeter air samples were also collected during the ABS scenarios at each location, with one pump located upwind and two pumps located downwind. Pumps were positioned at the edge of the sampling location grids [EMSL Analytical, Inc 2010; EPA 2012c].

ACM has been seen along the Green River trail, and these materials appear concentrated in the washout area near the Wissahickon Valley Watershed Association (WVWA) office. To address the potential for airborne exposures in this area, EPA performing ABS air sampling in this area of the trails on June 18, 2010. Four ABS sampling locations were used, with two types of activities at each location. These actives included walking/jogging and raking, shoveling and banging rocks. In addition, on June 21st, 2010, EPA collective passive air sampling at the same locations, while no ABS was occurring. All air samples were non-detect for PCME.

All but one of the air samples from EPA's ABS sampling even on the Green River trails came back without any detection of asbestos fibers (Appendix D, Table 10). The single air sample with a detection (crocidolite fiber type) was collected from a personal air monitor during the walking and jogging scenario near the WVWA office. The concentration at that location was 0.00098 f/cc (crocidolite fibers), based on analysis via TEM and AHERA analysis. No fibers were detected in the PCME or Berman-Crump analysis. No asbestos fibers were detected in area perimeter sampling during ABS or passive sampling.

A second ABS sampling event for potential recreational exposures was conducted along the Wissahickon and nearby walking trail between July 13 and 15, 2011 (Appendix D, Table 11). ABS activities included a mowing scenario on the other side of the Wissahickon Creek and a hiking scenario along the nearby walking trail. Two high volume and two low volume air samples (one each for children and adult heights) were collected during each two-hour ABS scenario. For area perimeter sampling, the sampling location associated with the mowing along the Wissahickon was contained within a 10 feet by 30 feet grid on a grassy patch of the trail. The area perimeter sampling location for the walking trail was contained within a quarter-mile radius on the trail [EPA 2012c].

During the mowing scenario, asbestos fibers were detected in personal air monitors at 0.0008 f/cc (at the children's height only) in all counting methods (PCME, AHERA, TEM, and Berman-Crump). Area perimeter monitors near this ABS locations during the mowing scenario detected asbestos only in the AHERA and TEM counting methods at a concentration of 0.0014 f/cc. During the trail hiking scenario, asbestos fibers were detected (at the children's sampling height only) in the personal air monitors at 0.0036 f/cc from the AHERA method and 0.0048 f/cc in the TEM methods. Area perimeter sampling during the trail hiking scenario included one detection with 0.005 f/cc (PCME), 0.13 f/cc (AHERA) and 0.14 f/cc (TEM). No sample collected during the ABS event exceeded the PCME adult residential screening level of 0.04 f/cc.

Residential Properties ABS

ABS raking activities were conducted at the same eight residential properties where surface soil samples were collected (Appendix D, Table 11). Samples collected and analyzed from the activities include two high and two low volume personal and area perimeter, air samples. The air samples were collected from two heights: the breathing height for a child and the breathing height for an adult, while vigorously raking the yards during each two-hour ABS raking scenario at the Residential locations. Soil moisture at all residential sampling locations were within the soil moisture threshold.

High volume air samples and several corresponding low volume air samples collected were not analyzed due to overload. This is indicative of a large amount of dust particles. Sample results ranged from non-detect to 0.0094 f/cc PCME asbestos fibers. No sample results for the adult and child exposure scenarios exceeded the PCME PRG level of 0.040 f/cc. Sample results ranged from 0 f/cc to 0.039 f/cc (located at residential property #3 for the adult exposure height). Residential property #8 was the only location without detectable fibers during ABS activities. AHERA and TEM fibers were also detected in the personal air monitors during ABS at low levels, with the exception of residential property #3. At residential property #3, asbestos fibers via AHERA and TEM analysis showed concentrations of 3.7 f/cc and 4 f/cc, respectively. Only one residence (#7), contained detectable levels of Berman-Crump fibers (0.0004 f/cc).

Air samples were collected at the edge of the sampling area to determine if there are levels of asbestos detected in close proximity to the sampling. The area perimeter data ranged from non-detect to 0.0039 f/cc, via PCME. Residential property #8 was the only location without detectable fibers in area perimeter samples. The highest perimeter data, observed at residential #3, did not exceed the site-specific screening value for a raking/lawn maintenance scenario (0.04 f/cc). However, the maximum values during the perimeter air sampling in the residential scenario are greater than the ambient air screening value established for long-term residential exposure (0.001 f/cc). Asbestos fibers via AHERA (maximum value of 0.05 f/cc) and TEM (maximum value of 0.51 f/cc) were detected in some of the area perimeter samples. Berman-Crump fibers were only detected in one residential property (#3). As indicated earlier, the other counting methods are not currently used for risk analysis but provide an idea of the relative quantity of various sized fibers.

Former Keasbey and Mattison/Nicolet Buildings
In response to concerns by some local residents about residual contamination inside these buildings formerly used for manufacturing, EPA conducted an assessment of former K&M/Nicolet buildings. Although the former K&M/Nicolet buildings are not part of the BoRit site remedial work, PADOH included information and sampling data about the buildings due to their proximity to the BoRit site and community concerns. The Boiler House for the former K&M/Nicolet facilities is located at 201 South Maple Way and the Processing Buildings are on South Chestnut Street. The former K&M warehouse building was located on North Maple Street across from the BoRit site and was the former site of shingle, slate and sheathing manufacturing facility [EPA 2012b; PADEP 2011]. In 2011, a clean-up of the Boiler House building was conducted under The Montgomery County's Brownfield's Revolving Loan Fund. The space will be used as a Leadership in Energy and Environmental Design certified office space. The former K&M manufacturing builds underwent demolition and abatement by the property owner, under the NESHP regulations and overseen by PADEP [EPA 2010b].

In June 2011, PADEP received notification for the asbestos abatement and demolition of the former K& M manufacturing building and Ambler Borough subsequently issued the demolition permit. PADEP has oversight responsibilities for asbestos abatement under the NESHAP. Approximately 18,000 square feet of transite siding were removed from the building and was transported to BFI Imperial Landfill in, Imperial, PA. The contractor removed non-friable siding on the walls of the building prior to demolition and demolished the non-friable sheathing that was also on the roof, following a roof collapse. PADEP informed the contractors about the fugitive emission regulations and the prevention of prevent fugitive emissions during demolition. A letter from the PADEP to the BoRit CAG states that under NESHAP, there are no requirements to conduct air sampling during on-site abatement, and demolition only requires procedures to prevent visible emissions [Jullian Gallagher, Pennsylvania Department of Environmental Protection, personal communication, 2011]. The K&M warehouse building was demolished in August 2011, which is after the EPA sampling event [Celona 2011]. However, there is still the potential for ACM in the soil near these buildings as well as additional former manufacturing properties, which may contain ACM, near the site. At this time, to reduce the potential for exposures to ACM, PADOH recommends that the community not trespass on the properties. Any future redevelopment options should carefully consider the potential for ACM and actions should be taken to mitigate any potential asbestos releases.

In 2009, EPA conducted an assessment of the buildings, which included a visual inspection of the properties. During the inspections, EPA observed evidence of trespassers, which included graffiti especially in the former processing buildings, and visible material that was suspected to be ACM. EPA assessment report recommended that: (1) the waste drums at the former Boiler House be addressed, (2) any disturbance of asbestos-containing soils or waste not occur or is carefully controlled and monitored, and (3) the property owners implement and maintain access restrictions to the property in an attempt to prevent community exposure to hazardous substances [EPA 2012b]. Based on community concerns, the presence of ACM, and observance of trespasser activity, EPA, in June 2010, performed a sampling event which included the collection of ABS samples. Ambient exterior air samples at varying distances from the former K&M/Nicolet Processing and Boiler House buildings were also collected (Appendix C, Table 13). The air samples collected during ABS activity inside the buildings were done to evaluate potential trespasser exposure. The activities performed during ABS simulated those perceived to be occurring by building trespassers based on obvious visual cues. The activities included walking, running, paint spraying and general "horseplay" (dust spray cans were used to simulate paint spraying). Two individuals conducted the

ABS activities in each of the two buildings. The activities were performed for 120 minutes and the samples were collected over the same duration. The analytical sensitivity was set at 0.001 f/cc.

On both June 15 and June 18, 2010 EPA collected 8 hour ambient air samples, both inside and outside the buildings. Two down-wind ambient air monitors were located on the western side of the Ambler Piles site, which would capture potential community exposures if the asbestos materials were being disturbed in the buildings by trespassers. The analytical sensitivity limit for the ambient samples was 0.0004 f/cc. Samples were analyzed by TEM and PCME. In addition, several bulk samples were collected from materials located in the buildings of noticeable quantity and questionable composition. The bulks samples were analyzed by CARB 435 with 400-point count.

Ambient air samples collected on June 15, 2010 took place when ABS was collected inside the buildings (Appendix B, Figure 13). Four air samples were collected from personal sampling pumps placed in the breathing zone. EPA collected 13 ambient air samples, with nine samples collected inside the buildings and four samples outside the building, two of which were located down-wind and across the street. The ambient data for PCME analysis ranged from non-detect to 0.0066 f/cc, which was detected inside the buildings. Levels of ambient asbestos in the two down-wind off-site monitors during ABS were 0.0004 and 0.00039 f/cc. Of the 13 ambient air samples collected during ABS activities, 9 contained asbestos chrysotile fibers. Tremolite fibers were also detected in one sample. Ambient air sampling on June 18, 2010 took place when no ABS sampling occurred. Ambient air sampling results when no ABS occurred showed two detections of PCME chrysotile fibers (Appendix D, Table 14). Asbestos in ambient air was detected at 0.00037 f/cc inside the building and 0.00044 f/cc at one of the downwind monitoring location on the opposite side of the Ambler Piles site.

Asbestos fibers were detected in all four ABS samples. (Appendix D, Table 15). These samples were collected inside the building, from personal air monitors. ABS results ranged from 0.0055 f/cc to 0.033 f/cc. EPA's site specific level established at the BoRit site for target risk to trespassers is 0.001 f/cc. This means that the asbestos results from the ambient outdoor air near these buildings were below levels of concern for long term cancer risk for people who might visit or travel near these buildings on an occasional basis over many years. For people who might trespass and disturb the ACM inside the buildings (which have since been demolished), EPA's results indicate that these kinds of activities can result in elevated exposures to asbestos fibers. The highest asbestos sampling results were found inside the buildings, which have since been demolished, during the times that trespasser disturbing activities were being simulated.

Bulk analysis samples for asbestos were collected in the former manufacturing and processing buildings (Appendix B, Figure 16). The results of the bulk analysis indicated chrysotile and amosite asbestos waste were present in the manufacturing and processing K&M/Nicolet buildings. Bulk asbestos results showed 39.5% chrysotile asbestos in slurry material found in the manufacturing building and 4.75 % (chrysotile) and 50.25% (amosite) in pipe wrap material in the processing building [EPA 2012b].

Public Health Implications

The following section describes the potential health effects from breathing airborne asbestos on and near the BoRit site. For a public health hazard to occur, people must contact hazardous materials at high enough levels and for a long enough time to harm their health. Based on a review of all of the PCME air sampling, asbestos fibers are not migrating off the site at levels that could harm people’s health. Based on the sampling data evaluated, PADOH finds that exposures to the asbestos levels, via ambient and off-site exposures, are not a current public health hazard.

Overall, based on the air sampling and ABS results, PADOH concluded the following (on-site):

- On-site airborne asbestos, when soil is vigorously disturbed, could pose a threat to public health. An estimated cancer risk for on-site exposures during ABS approaches or exceeds the EPA lower level of acceptable risk.
- When soils and ACM were actively disturbed through ABS, there was a significant increase in on-site fibers observed in the personal air monitors and area perimeter samples.
- Any direct soil disrupting activity should be avoided by visitors or trespassers. At present the community has restricted access to the site, via a temporary fence, and on-site soil disturbing activities are not occurring on a regular basis.

PADOH concludes the following, based on ambient air sampling and ABS results (off-site):

- PADOH conclude that current exposures to the airborne asbestos levels (when off-site soils are being aggressively and vigorously disturbed) are not expected to harm people's health.
- The results of the ambient off-site sampling along the site perimeter and in the community did not show levels of asbestos at levels exceeding EPA screening values for residential exposure.
- The ABS sampling results in the residential areas were low and below the EPA risk-based screening levels and therefore there is no unacceptable risk to child or adult residents from aggressive soil disturbance activities at these properties.
- PADOH does not expect past exposures to asbestos detected during ABS and ambient air sampling of the former Keasbey and Mattison/Nicolet buildings to harm people's health. A few ABS samples collected inside the building, during scenarios that attempted to simulate trespasser and horseplay activities, exceeded EPA's risk-based residential screening value but were below the ABS screening value. No samples collected in the community exceeded the risk-based screening value for ambient air.

Health Effects Related to Asbestos Exposure

The mammalian lung responds to exposures from inert materials whether fibrous or particulate. Once an inert material deposits in the lung beyond the conductive airways, it will either dissolve or be engulfed and cleared by alveolar macrophages; if the dose exceeds the lungs' capacity to clear the material, natural defense mechanisms may act, leading to fibrosis [ATSDR 2003]. In studies, long chrysotile fibers were observed to break apart into small particles and smaller fibers in the lung. [Bernstein and Hoskins 2006].

People can be exposed to asbestos by swallowing contaminated water, swallowing asbestos fibers, or by breathing fibers in the air. Asbestos fibers are poorly absorbed through the skin. The greatest concern about asbestos is inhalation of fibers. The toxicity of asbestos is related to the fiber size. Smaller fibers are more easily cleared from the lung. They are less likely to remain in the lung and cause health effects. EPA classifies asbestos as a human carcinogen. However, asbestos is commonly found at very low levels in urban air, and no evidence has shown an increased cancer risk in people exposed to those very low levels.

Asbestos fibers mainly affect the lungs and the membrane that surrounds the lungs, known as the mesothelioma. Breathing asbestos fibers increases the risk of developing the following cancer and non-cancer health effects:

Malignant mesothelioma

Cancer of the membrane lining the chest cavity and covering the lungs (pleura) or lining the abdominal cavity (peritoneum) is called mesothelioma. This cancer can spread to tissue surround the lungs or other organs. Amphibole asbestos fibers have a potency for causing mesothelioma at rates 100 times greater than exposure to chrysotile fibers, mainly because of increased persistence of amphiboles in the lungs.

Lung Cancer

Lung cancer is a cancer of the lung tissue, also known as bronchogenic carcinoma. The exact mechanism relating asbestos exposure with lung cancer in not completely understood. The combination of tobacco use (smoking) and asbestos exposure greatly increases the risk of developing lung cancer.

Laryngeal cancer

Laryngeal is a cancer of the larynx (voice box). In 2006, the Institute of Medicine found sufficient evidence of an association between laryngeal cancer and asbestos exposure [IOM 2006].

Non-cancerous Effects

These include *asbestosis*, a restrictive lung disease caused by asbestos fibers scarring the lung; *pleural plaques,* localized areas of thickening of the pleura; *diffuse pleural thickening*, generalized thickening of the pleura; *pleural calcification*, calcium deposition on pleural areas thickened from chronic inflammation and scarring; and *pleural effusions*, fluid buildup in the pleural space between the lungs and chest cavity. Loss of lung function or other clinical signs may or may not be associated with these non-cancerous effects [ATSDR 2001].

The DHHS, World Health Organization (WHO), and EPA have determined that asbestos is a human carcinogen. The time between diagnosis of mesothelioma and the time of initial exposure to asbestos commonly has been 15-30 years or more (i.e., long latency period). Occupational exposure to asbestos is involved in 70-80% of all malignant pleural mesothelioma cases. Insufficient evidence exists to conclude whether inhalation of asbestos fibers increases the risk of cancers at sites other than the lungs, pleura, and lining of the abdominal cavity. Ingestion of asbestos causes little or no risk of non-cancerous effects. However, some evidence suggests that acute oral exposure can induce precursor lesions of colon cancer, and that chronic oral exposure can lead to an increased risk of gastrointestinal tumors. ATSDR's toxicological profile for asbestos reviewed the published literature about possible immunological effects, such as rheumatoid arthritis, lupus, or fibromyalgia, due to asbestos exposure. Not enough evidence exists to say whether asbestos exposure or resulting asbestos-related disease could increase a person's likelihood of experiencing autoimmune disease [ATSDR 2001]. But the associations that have been discovered between immunological changes and asbestos exposure indicate that this question deserves further research.

Cancer Risk Evaluation

The ABS events on-site showed a significant increase in airborne asbestos fibers, compared to when soils are not disturbed, especially in the pile and park parcels of the site. Due to the fact that the locations of these were on-site, *actual current* human exposures, if any, would be expected to be of less frequent and shorter durations than the calculations assume. At present the community has restricted access to the site, off-site data do not indicate air transport of fibers, and on-site construction and soil disturbing activities have been occurring in a controlled manner. The data suggest that on-site airborne asbestos when soil is vigorously disturbed could pose a threat to public health. Therefore, any direct soil disrupting activity should be avoided by visitors or trespassers and property owners. Asbestos materials are not hazardous unless asbestos fibers are released into the air and inhaled. If the soil is not disturbed or agitated, the potential for exposure to asbestos in soil would be lower. This is indicated by the community ambient air sampling data. The levels of asbestos in ambient air do not indicate asbestos is migrating from the site at level that can harm people's health.

Historical exposure to asbestos is not captured by this predictive cancer risk assessment methodology using the current sampling data. The historical sampling data collected near the site, mostly related to the Ambler Asbestos Piles site, presents a complicated picture in terms of determining the health implications of asbestos exposure due to the various collection methods, analytical techniques, and lack of detailed information. Airborne asbestos concentrations were expected to be higher during active operation of the facility (and prior to the remediation of the Ambler Asbestos NPL site) than were measured in this PHA. Assuming this to be the case, significant asbestos exposures could have occurred in the past. With an estimated latency period of approximately 20 to 30 years for mesothelioma, recent observations of asbestos-related respiratory illness in facility workers and their immediate families or contacts and in the community surrounding the plant would be expected to be due to historical exposures.

To evaluate the risk of inhalation of asbestos fibers on or near the BoRit site based on the recent sampling data, PADOH grouped potential exposures, based on the location (on-site, residential or recreational) and the exposed population (children, adults or maintenance workers). The following is a summary of exposure scenarios that PADOH evaluated for this PHA:

Park Parcel – worker and trespassers (adult and children) exposures based on ABS data, from both personal air monitors and area perimeter air sampling;

Pile Parcel - worker and trespassers (adult and children) exposures based on ABS data from both personal air monitors and area perimeter air sampling;

Reservoir Parcel - worker and trespassers (adult and children) exposures based on ABS data from both personal air monitors and area perimeter air sampling;

Residential Areas – adult and children residential exposures based on ABS data from both personal air monitors and area perimeter air sampling;

Ambient Air-adult and children residential exposures based on ambient air data;

Walking trails - adult and children recreational exposures from ABS data from both personal air monitors and area perimeter air sampling;

Former K&M building – past adult and children trespasser exposures based on ABS from both personal air monitors and residential exposures air sampling based on ambient air data outside the buildings.

Cancer Risk Calculations

Estimated cancer risk calculations can be used to determine whether airborne concentration of asbestos are associated with unacceptable risks to people near a site, trespassers or visitors to the site, and to site workers. PADOH used the EPA's IUR for asbestos to calculate an estimated cancer risk that would occur if a population was exposed to a contaminant given the assumed exposure conditions at a site, above current background cancer levels. Based on the EPA framework, the IUR is adjusted based on an age-adjusted exposure duration, as described further below. *It should be* *noted that the estimated cancer risk does not predict if an exposed person will get cancer* but offers a general characterization for potential risk in an exposed population.

PADOH used available cancer risk information in EPA's IRIS database for asbestos. Potency factors in IRIS are based on PCME fibers of all mineral types (chrysotile, amphibole). EPA IRIS model is based on fourteen major studies and include both epidemiology and animal research. There is some debate as to the toxicity of the different mineral types. For example, many scientists agree that amphibole asbestos fibers have potency for causing mesothelioma at rates 100 times greater than exposure to chrysotile fibers, mainly because of increased persistence of amphiboles in the lungs [ATSDR 2011]. Potency factors in the EPA IRIS database are derived from occupational studies of exposed workers to both chrysotile and amphibole fibers. At the BoRit site the primary fibers detected are chrysotile. Risk calculations are based solely on prediction of excess cancer risk for inhalation exposure, since the greatest health concern for asbestos is inhalation exposures. The following equation can be used to estimate risk from inhalation exposures:

Excess cancer risk = EPC x TWF x IUR

Where:

EPC= Exposure point concentration, or the concentration of asbestos fibers in air (f/cc) for the specific activity being assessed
IUR = Inhalation unit risk
TWF = Time weighted factor. This factor accounts for a less-than-continuous exposure and is based on: Exposure time (hours per day) x Exposure frequency (days/year)

To determine TWF, EPA's Asbestos Framework document establishes typical exposure scenarios. The exposure duration and frequency is based on likely hours, days per year, and years a resident, trespasser, recreational visitor, or on- site worker would actively disturb the soil and potentially be exposed to airborne asbestos. Exposure duration and frequency are one of the factors that influence potential risk. The exposure time is based on the 90^{th} or 95^{th} percentile value in EPA's Exposure Factors Handbook, by activity type. The EPA Asbestos Framework document recommends evaluation of childhood exposures (from 0 to 6 years), adult exposures (based on 24 years exposure duration), and childhood with adult exposures (based on an exposure duration of 30 years) [EPA 2008a]. The following table summarizes the exposure durations and frequencies, by area, population and activity.

Exposed Population	Exposure Frequency	Exposure Years
Trespassers or visitors to the site – based on aggressively disturbing the on-site soil	2 hours per day/50 days per year	Adult-24 years Children -6 years Adult and Children – 30 years
On-site workers - based on aggressively disturbing the on-site soil	4 hours per day/100 days per year	Adult workers- 20 years
Residential – based on lawn maintenance and playing scenarios from off-site ABS data	2 hours per day/100 days per year	Adult-24 years Children -6 years Adult and Children – 30 years
Recreational – based on jogging/walking and soil disturbance on walking trails	1 hour per day/100 days per year	Adult-24 years Children -6 years Adult and Children –30 years
Trespassers to the former K&M/Nicolet Buildings – based on horseplay activities and ABS data inside the buildings	2 hours per day/100 days per year	Adult-24 years Children -6 years Adult and Children –30 years
Residential from ACM disturbance in K&M/Nicolet Buildings - based on community ambient air data collected during horseplay/ABS in the buildings	2 hours per day/100 days per year	Adult-24 years Children -6 years Adult and Children –30 years

The default EPA IUR (0.23 f/cc) is based on continuous exposures from birth, for 70 years and from PCME fibers. To account for less than this amount of time and to determine site-specific risk based on likely activities, PADOH adjusted the IUR to reflect the exposure duration. The selection of a less than lifetime IUR takes into account the age at first exposure and the duration of the exposure. This approach is used in the Asbestos Framework document and EPA guidelines for Carcinogenic Risk Assessment [EPA 2005b]. For example, for a person exposed from birth to age 30, EPA uses an IUR of 0.173f/cc. PADOH applied a less-than-lifetime IUR for adults (24 years) of 0.121 f/cc, children (6 years) 0.055 f/cc, adult and children exposures (30 years) of 0.173 f/cc, and on-site worker (20 years) of 0.067 f/cc [EPA 2008a]. The cancer risks are expressed as 1E-04, 1E-5, and 1E-06 or in other words 1 excess cancer in 10,000, 100,000 and 1,000,000 exposed people, respectively. Currently only fibers reported under the PCME binning category are used by regulatory and public health agencies to estimate cancer health threat. In PCME analysis, only fiber greater than 5µm in length are counted [EPA 1993].

Cancer Risk Evaluation Results

As described above, PADOH calculated an estimated excess cancer risk for the various exposure scenarios and populations. The following table is a summary of the cancer risk calculations, based on the maximum detected values, with detailed discussions in the sections below.

Location/Type	Adult	Children	Adult combined with Children	On-site Workers
Pile *				
Personal air monitoring data	5.90E-05	3.30E-06	5.30E-05	1.10E-04
Area perimeter data	1.90E-05	2.30E-06	3.30E-05	3.60E-04
Park *				
Personal air monitoring data	2.10E-04	1.00E-05	1.60E-04	4.00E-04
Area perimeter data	7.80E-05	8.80E-06	1.40E-04	1.50E-04
Reservoir *				
Personal air monitoring data	No fibers detected	No fibers detected	No fibers detected	No fibers detected
Area perimeter data	No fibers detected	No fibers detected	No fibers detected	No fibers detected
On-site during intrusive work				
Maximum on Pile based on 8-hour TWA	N/A	N/A	N/A	1.30E-04
Perimeter sample during intrusive work	N/A	N/A	N/A	7.90E-06
Residential - ABS				
Personal air monitoring data	8.90E-06	1.00E-06	1.60E-06	N/A
Area perimeter data	2.80E-05	2.40E-06	3.70E-05	N/A
Residential - Ambient Air				
Ambient samples in community	3.98E-05	4.53E-06	7.12E-05	N/A
Walking trails and Wissahickon -ABS **				
Personal air monitoring data	No fibers at adult height	4.20E-08	6.52E-07	N/A
Area perimeter data	2.30E-06	2.60E-07	4.80E-06	N/A
Former K&M/Nicolet Buildings				
Personal air monitoring data *	8.30E-06	1.70E-06	2.70E-05	N/A
Ambient samples in community	3.80E-07	4.30E-08	6.80E-07	N/A

* Assumes trespassing/visiting, for adult and children
** Assumes recreational exposures
N/A = not applicable

Pile Parcel Cancer Risk Evaluation
ABS personal air monitor data and area perimeter data collected on the pile parcel were evaluated (Appendix E, Table 1-2). The estimated cancer risk based on maximum ABS personal air monitor data were 5.9E-05, 3.4E-06, 5.3E-05, and 1.1E-04 for adult trespassers/visitors, children trespassers/visitors, combined adult and childhood trespassers/visitors exposures, and on-site workers, respectively. The estimated cancer risk based on maximum perimeter air data while ABS occurred were 1.9E-05 for adult trespassers/visitors, 2.3E-06E for children trespassers/visitors, 3.3E-05 for combined adult and childhood trespassers/visitors exposures, and 3.6E-04 for on-site workers. Cancer risk levels lower than 1 E-4 or 1 in 10,000 persons are generally considered low by EPA. Therefore, based on these risk calculations, exposures to on-site workers on the Pile, while soil is being aggressively disturbed could result in an increased cancer risk above EPA's target risk range. Since the site has received a layer of clean fill and hydroseeding, which took place after the sampling events, this would reduce potential exposures.

Park Parcel Risk Evaluation
Adult worker and visitor or trespassers (adult and children) exposures were evaluated, based on ABS sampling data and area perimeter data collected on the park parcel (Appendix E, Table 1-2). The estimated cancer risk based on maximum ABS personal air monitor data collected in the Park are 2.1E-04 for adult trespassers/visitors, 1.0E-05 for children trespassers/visitors, 1.6E-04 for combined adult and childhood trespassers/visitors exposures, and 4.0E-04 for on-site workers. The estimated cancer risk based on maximum area perimeter air data during ABS are 7.8E-05 for adult visitors or trespassers, 8.8E-06 for children visitors or trespassers, 1.4E-04 for combined adult and childhood exposures and 1.5E-04 for on-site workers. Cancer risk levels lower than 1 E-4 or 1 in 10,000 persons are generally considered low by EPA.

Based on these risk calculations, exposures to on-site workers and adult and children visitors or trespassers to the Park over a long duration, while soil is being aggressively disturbed could result in an increased cancer risk above EPA's target risk range. This conclusion is based on the maximum, or worst case scenario and exposures to the average levels of asbestos during ABS would not represent a cancer risk above EPA's target risk range for adult visitors or trespassers. For example, risk calculations from the average personal air monitors during ABS in the Park were 9.1E-06, 1.9E-06, 3.0E-05, and 3.2E-05, for adult trespassers or visitors, child trespassers/visitors, combined adult and childhood trespassers/visitors exposures, and on-site workers, respectively. Since the site has received a layer of clean fill and hydroseeding, this would reduce potential exposures.

Reservoir Parcel Risk Evaluation
No asbestos fibers were detected during ABS activities, including personal air monitors or area perimeter sampling (Appendix E, Table 1).

Risk during Active and Intrusive Site Work
EPA collected personal air monitoring data, including a 30-minute and 8 hour time weighted average and area perimeter air data during intrusive on-site work such as subsurface drilling. Air samples were collected at the Park, Asbestos Pile and Reservoir Parcels (Appendix E, Table 3). For worker exposure scenarios, air samples were compared with OSHA limits and not EPA risk-based levels. The maximum 8-hour TWA level (0.15 f/cc via PCME), observed in Asbestos Pile corresponds to an estimated cancer risk of 1.3E-04. This level is slightly above EPA's target cancer risk level and therefore indicates a potential hazard for on-site workers during site intrusive work. Only one perimeter sample had detectable asbestos (0.009 f/cc), near the Asbestos Pile. Based on this level, the estimated cancer risk is 7.9E-06, which is considered very low.

Residential areas Risk Evaluation
Eight residential homes were evaluated for cancer risk from exposures to airborne asbestos exposure, based on ABS data collected from personal air monitors and area perimeter monitors while residential soil was aggressively disturbed (Appendix E, Table 4-5). These events were conducted in an effort to evaluate adult exposure during lawn maintenance activities and childhood exposure while playing outside during lawn maintenance activities. One residential location (residential #4) had detectable levels of asbestos in the surface soil. Asbestos in surface soil was detected at 0.6%, which is below the soil screening level.

During ABS sampling, no sample results exceeded the PCME residential screening level of 0.040 f/cc. The highest personal air monitor result for PCME of 0.0094 f/cc was detected at residence #4, at the child sampling height. Using the exposure duration assumptions described above, estimated cancer risk from this level would translate into 8.9E-06, 1.0E-06, and 1.6E-05 for adult, children and adult combined with children exposure, respectively. The maximum concentration of asbestos detected in area perimeter monitors was 0.039 f/cc (residential #3). None of samples collected during the area perimeter monitors while ABS occurred exceeded the raking/lawn maintenance scenario screening value (0.04 f/cc); however, the some values are greater than the ambient air screening value established for long-term residential exposure (0.001 f/cc). Estimated cancer risk calculations from the maximum perimeter results (0.039 f/cc) were 2.8E-05 for adults, 2.4E-06 for childhood exposures, and 3.7E-05 for adult plus childhood exposures. Therefore, PADOH conclude that exposures to asbestos fibers detected during residential ABS events, are not likely to cause an increase in cancer above EPA's risk range.

Ambient Air Data Risk Evaluation
During the ambient air sampling events conducted in 2010 to 2010, no ambient results exceeded the screening value of 0.001 f/cc (Appendix E, Table 6). Asbestos PCME concentrations ranged from non-detect to 0.001 f/cc, which occurred at monitoring location 1. Based on this level, estimated cancer risk levels for the community would be 3.98E-05 for adults, 4.5-06 for children and 7.1E-05 for adult (24 years) combined with childhood exposures (6 years). These estimated cancer risk levels are within EPA's target risk range. Based on this information, it does not appear asbestos is migrating from the site at levels that could harm people's health.

Walking trails and Wissahickon Risk Evaluation
Asbestos results during ABS personal air monitors and area perimeter air sampling of the walking trails and Wissahickon Creek were below EPA's ABS screening value of 0.04 f/cc (Appendix E, Table 4-5). For the Green River data set, no asbestos fibers were detected from the PCME analysis but 0.0098 f/cc were observed via the TEM analysis. Therefore, a cancer risk cannot be calculated. However, given that this concentration is below the screening value, the cancer risk would be very low. For the sampling event along the Wissahickon and walking trails in 2011, asbestos fibers were detected for children's sampling height (only one sample at 0.0008 f/cc via PCME) but not at adult sampling height. The resulting childhood estimated cancer risk from that concentration would be 4.2E-08, which is considered very low risk. Area perimeter air sampling results during ABS showed one sample, out of six collected, had PCME fibers (0.005 f/cc). This translates into an excess cancer risk of 2.3-E-06, 2.6E-07, and 4.8E-06 for adult, children, and combined adult/children, respectively, during recreational activities. These levels are generally characterized as very low to low increase risk. Therefore, recreational exposures to asbestos on the trails near the BoRit are within EPA's target risk range for cancer.

Former K&M/Nicolet Buildings Risk Evaluation
PADOH calculated a potential estimated cancer risk for past adult and children trespasser exposures, which is based on personal air monitors during ABS sampling (Appendix E, Table 4-5). Cancer risk for residential exposure during ABS, based on ambient data collected outside the buildings, was also computed. EPA's site specific level established at the BoRit site for acceptable risk to trespassers and residential ambient air exposures is 0.001 f/cc. Based on the maximum ABS personal air monitor result collected inside the buildings (0.033 f/cc) the estimated cancer risk to adult, child, and adult combined with children exposed trespassers is 8.3E-06, 1.7E-06, and 2.7E-05, respectively. The maximum off-site ambient air data (0.0004 f/cc) would result in an estimated cancer risk of 3.8E-07, 4.3E-08, and 6.8E-07, for adult, children and adult combined with children exposure, respectively. These risk levels are very low. Therefore, at the maximum level detected, an occasional trespasser or resident living near the buildings would not be likely experience a significant increase cancer risk from this level of exposure. Since the ABS samples were collected in these buildings, they are undergoing clean-up. Therefore air exposures at these buildings is not a current exposure pathway, but do represent a past potential exposure pathway

Non-Cancer Risk
The occurrence of non-cancer disease is an important component of the adverse effects experienced by humans with excess exposure to asbestos. Some experts acknowledge at very high levels, shorter fibers can contribute to asbestosis and can cause overloading of lung clearance mechanisms, which may lead to increased toxicity of longer fibers. Short fibers at very high levels may also act as dust/particulate matter and thus may contribute to adverse health effects on the lung similar to those associated with exposures to dust [ATSDR 2003].

A few studies have linked short fiber exposure to an increase in fibrosis. A study of tissues from chrysotile asbestos miners and millers reported an inverse relationship between fibrosis grade and length of tremolite fibers retained in the lung. In other words, the most severe fibrosis was observed among those with smaller (on average) tremolite fibers in their lungs. Another study and a study recently submitted for publication examined fibrosis grades for different length intervals of tremolite fibers: 0–5 µm, 5–10 µm, and 10–20 µm. Both studies found the highest average fibrosis grade occurred among those with the lowest tremolite fiber length interval, or for those with average tremolite fiber length less than 5 µm. Overall, there is limited evidence of non-cancerous toxicity being associated with fibers less than 5 µm in length, with two exceptions. First, very high doses to short fibers, especially those that are durable in intracellular fluids, may have the propensity to cause interstitial fibrosis. Second, exposure to short, thin durable fibers may play a role in development of pleural plaques or diffuse pleural fibrosis if the dose is high enough. For asbestos fibers, no studies have examined the effects of exposures exclusively to short fibers. Given data collected in Libby, Montana, however, some scientists questioned whether short fibers might play a role in the observed cases of pleural plaques and diffuse pleural fibrosis; but others cautioned against inferring that the risk results from exposure to short fibers, given that the Libby samples contained significant numbers of long fibers as well (Mohr et al 2005). Based on the data evaluated, levels of asbestos exposure at BoRit are far below any level at which short fibers would be suspected of causing these non-cancer effects.

There is no IRIS inhalation reference concentration (RfC) available for the assessment of non-cancer risks from airborne asbestos exposure and ATSDR does not currently have a MRL for these exposures. Therefore, non-cancerous endpoints from asbestos exposures including asbestosis and pleural changes cannot be quantified, at this time [ATSDR 2003]. This represents a significant data gap in the overall evaluation of asbestos-related risks.

Health Outcome Data

As described in detail in the previous Health Consultations for the BoRit site[ATSDR and PADOH 2009] available health outcome data were analyzed and summarized for malignant mesothelioma and lung cancer in the Ambler, Blue Bell, and Fort Washington communities for 1996-2005. Since the release of the health outcome data health consultation, PADOH reviewed additional years of cancer registry data for Ambler community (Appendix F). This section describes the updated health outcome data review.

Methods

Indirect age-adjusted incidence rates were calculated for residents of Ambler, Pennsylvania for "*all cancers combined*," 18 individual anatomical sites, and malignant mesothelioma. The rates described in Appendix F: Table 1 represents the most current case counts, and cover a 22-year period from 1990 to 2011. The initial PHA for the BoRit Asbestos site, released in October 2013, covered cancer reporting data from a 17-year period (1992 to 2008). Therefore, this version of the PHA covers an additional five years of cancer reporting data.

Cancer risks (incidence rates) for residents of ZIP code 19002 were compared to the risks (incidence rates) for the entire state during the 22 year period analyzed. The statistic used to evaluate population rates for this analysis is the Standardized Incidence Ratio or SIR, the same used in the previous version of the PHA. The SIR is the ratio of the rate for Ambler (ZIP code 19002) compared to the rate for the entire state. This is mathematically equivalent to the ratio between the numbers of cases that were diagnosed (*observed*) to the number that would be *expected [obs./ exp.]*

had residents of Ambler experienced the same risks as all Pennsylvanians during the same time period.

Incidence counts were obtained from the files of the Pennsylvania Cancer Registry (PCR). Statewide incidence has been available starting in 1985. The registry was established by the Pennsylvania Cancer Control and Prevention Act of 1980. The PCR relies on coding sites and histology using the International Classification of Disease (ICD) system. Specifically the PCR uses the ICD Oncology Code, 3rd edition (ICD0-3). These data are submitted to the PADOH Bureau of Health Statistics and Research. The PCR receives monthly reports from all acute care hospitals and pathology laboratories electronically and the data represents cancer incidence rates. The number of cancers refers to the number of primary sites reported, not the number of people. Although some individuals may have more than one cancer during the period of interest, in general the number of primary sites is expected to be relatively similar to the number of persons with cancer.

Population counts used to calculate the expected cases for the 22 year period were derived utilizing 1990, 2000, and 2010 U.S. Census data [US Census 2010]. Expected cases for Ambler were derived by multiplying the number of residents by the statewide incidence rates. This was performed for 14 age groups and the expected cases were summed across all age groups to obtain the total expected. This was repeated for each cancer.

Expected cases were compared to the numbers of cases recorded in the PCR to determine the SIR for each cancer type. When an incidence ratio was larger than 1.00, the rate in the study population was considered higher than the state. A ratio less than 1.00 indicated the cancer rate in the study area was lower than the state, while a value of nearly 1.00 indicated cancer risks were essentially the same. Statistical testing was based on the Poisson distribution, where the sampling error of each SIR was compared to the expected or 1.00.

Results

Appendix F: Table F-1 describes the number of cancer cases diagnosed (observed), the number *expected*, and each ratio or SIR for; mesothelioma, 18 major cancer types and all cancer sites combined. Between 1990 and 2011, there were 3,596 new cases diagnosed among Ambler residents [PADOH 2011, 2012]. Based on Pennsylvania's statewide incidence rates for the same time period, 4,460.5 cases would be expected. The ratio of 0.81 [3,596 obs. / 4,461 exp. = 0.81] indicates the cancer rate or risk was 19 percent lower [1.00-0.81= 0.19] for Ambler residents compared to Pennsylvania. The likelihood that the difference between rates could have occurred from chance variations was sufficiently small to regard it statistically significant. Ratios for individual cancer types remained close to the values reported previously for the 17-year period (1992-2008). Appendix F, Table 1 shows that nearly all risk ratios were either below 1.00 or close to 1.00.

The only cancer types that demonstrated incidence rates **higher** than the state were mesothelioma (SIR=2.71), thyroid cancer (SIR=1.13), and brain and central nervous system tumors (SIR=1.18). The higher than expected incidence rate for mesothelioma in Ambler was the only one that was statistically significant. This means that the incidence of mesothelioma is most likely due to exposure to asbestos and not "normal variation" of the incidence rates. The increase in the thyroid cancer as well as for brain and central nervous system tumors incidence rates are small and most likely due to "normal variation" or chance.

Other cancers showing rates **lower** than the state included mouth (SIR=0.78), esophagus (SIR=0.70), stomach (SIR=0.73), colon-rectum (SIR=0.71), lung (SIR= 0.72), breast (SIR=0.80), and bladder

(SIR=0.65). The lower than expected incidence rates for all of these cancers in Ambler were all statistically significant.

While the mesothelioma rates were elevated, the incidence rates of cancers of the lung and bronchus were lower than statewide rates. Even though lung cancer can be linked to asbestosis, it is most strongly related to tobacco use, accounting for about 85 percent of cases.

Though cigarette smoking combined with asbestos exposures can multiply the mesothelioma risk, asbestos exposure does not demonstrate a multiplicative effect on lung cancer rates in Ambler. The rates of cancers of the lung and bronchus were in fact lower than expected in Ambler with 327 cases diagnosed versus 449 expected based on Pennsylvania's state-wide lung cancer incidence rates. The lower incidence rates for lung and bronchus cancers were statistically significant compared to the state. This suggests smoking rates were lower in the Ambler population, though mill workers have historically demonstrate higher smoking rates compared to other occupations. While this smoking pattern is not consistent with laborers in mill jobs and blue collar workers in general, it is possible that smoking was not accepted in this work environment, and/or the population defined by zip code 19002 represented numerous economic groups and heterogeneous smoking patterns.

Risk was also examined in relation to age. Appendix F: Figure F-1 provides a graphic display of this information. Based on an analysis of age of diagnosis of mesothelioma, the risk of malignant mesothelioma was greatest among residents in their mid-eighties. The analysis by age of diagnosis did not identify any individuals younger than 45 years of age**.** In addition, cases were evaluated by gender. Appendix F, Table F-2 summarizes this information. The majority of the mesothelioma cases were diagnosed in men. Of the 32 mesothelioma cases reported to the cancer registry for the Ambler zip code from 1990-2011, 23 of these cases were in males and 9 were in females. For the lung cases, the gender distribution was more similar. Of the 419 lung and bronchus cases reported to the cancer registry for the Ambler zip code from 1990-2011, 211 of these cases were in males and 208 were in females.

In summary, mesothelioma was observed at an increased rate in Ambler, based on a 22 year review of cancer incidence rates. PADOH concludes the elevated mesothelioma rates in Ambler are most likely due to past exposures to workers, when the asbestos manufacturing facilities were operating, or in some cases their household contacts. Current ambient air monitoring data, as discussed in the above sections, do not indicate current exposures of asbestos to the community. Since all incidence rates vary somewhat when compared to the Commonwealth as a whole, when the rates vary slightly, such as in this case for thyroid cancer and brain and central nervous system tumors, the variation is attributed to "normal variation". PADOH's Health Assessment Program will continue to work with PADOH's Cancer Registry Program to obtain updated cancer statistics for the site area, and will review this information on a periodic basis. As discussed in the previous health consultation documents for the BoRit site, PADOH continues to remain interested in learning about any non-occupationally exposed individuals with mesothelioma in the community. Residents who would like to share information about individuals diagnosed with mesothelioma without any known occupational exposures can contact the PADOH Division of Environmental Health Epidemiology at (717) 547-3310.

Child Health Considerations

PADOH recognize that infants and children might be more vulnerable than adults to exposure in communities faced with environmental contamination. Because children depend on adults for risk identification and management decisions, PADOH are committed to evaluating their special interests at the site. The effects of asbestos on children are thought to be similar to the effects on adults. However, children could be especially vulnerable to asbestos exposures because they are more likely to disturb asbestos fiber-laden soil or indoor dust while playing, and they are closer to the ground and thus more likely to inhale contaminated soil or dust. In addition, children have a higher risk of developing disease after asbestos exposure because they have a longer life expectancy and thus more time to develop asbestos-related respiratory diseases, which have long latency periods between exposure and onset of disease.

Differences between Children and Adults

An important body of scientific literature is available describing the significant anatomic and physiological differences between the developing lungs of children and those of mature adults. PADOH and ATSDR incorporated the analysis of this information contained in the California Environmental Protection Agency Air Resources Board's review of the "Health Effects of Particulate Matter" [CA EPA 2004] in the following paragraphs, to assist in the understanding of these differences as they relate to children's exposures at the BoRit site.

Specifically, the anatomic and physiological differences between children and adults include the size and shape of the conducting airways, the number and orientation of physiologically active gas exchange regions, and ventilation rates. Though the basic structure of the airways is established in utero, most of the alveoli (> 85%) develop in infancy and early childhood [Snodgrass 1992]. Lung volume expands disproportionately in relation to the increasing number of alveoli during somatic growth, indicating enlargement of individual alveoli [Murray 1986]. Repeated episodes of injury and inflammation may therefore have long-term consequences on the lung's functional abilities. Due to these differences in anatomy, activity, and ventilation patterns, children are likely to inhale and retain larger quantities of pollutants per unit body weight than adults [Adams 1993]. Phalen et al. (1985) developed a model incorporating airway dimensions measured in lung casts of people (aged 11 days to 21 years) to predict that particle deposition efficiency would be inversely related to body size, which would tend to accentuate differences in exposure related to activity and ventilation patterns.

Inhalation experiments comparing particle deposition patterns in children and adults have produced somewhat inconsistent results. Schiller-Scotland et al. (1994) reported greater fractional deposition in healthy children, aged 3 - 14 years, compared with adults, when breathing 1, 2 or 3 mm particles spontaneously through a mouthpiece. The differences were greater with the larger particles. However, as noted by the authors, these children were breathing more deeply than expected, which is a common tendency when breathing through a mouthpiece.

Children demonstrate lower absolute minute ventilation at rest than adults, despite having higher breathing rates. Relative to lung volume, however, children demonstrate higher minute ventilation than adults. Thus, Bennett and Zeman (1998) noted that children tended to have a somewhat greater normalized deposition rate (by about 35%) than the combined group of adolescents and adults, suggesting that children at rest would receive higher doses of particles per unit of lung surface area than adults. This tendency might be additionally enhanced by activity patterns, as children spend more time than adults in activities requiring elevated ventilation rates [Bennett and Zeman 1998].

The above studies suggest that children may experience proportionately greater particle deposition than adults. It is also possible that, especially in very young children, immature respiratory defenses may result in lower clearance rates in relation to those observed in adults.

In addition to the physiological differences discussed above, children are also of special concern because their exposures occur earlier in their lives. The cancer risk models for mesothelioma include a time function, so early-lifetime exposures contribute more to lifetime risk than exposures later in life. Therefore, a 30-year exposure beginning at age 6 is expected to have greater risk than the same exposure (concentration, frequency, and duration) occurring later in life. There is a delay of 10 to 50 years or longer from first exposure to disease effect. Therefore, the longer one lives after asbestos exposure, the greater the probability of contracting mesothelioma or lung cancer. The mesothelioma probability is dependent on the cube of the elapsed time since first exposure. Separate cancer risk calculations accounting for early life exposures were not conducted in this document. Making an adjustment in this direction would result in an estimate of a higher cancer risk for this sensitive population [EPA 2005b].

During EPA's sampling of the site, ABS activities were conducted. One of the activity scenarios was for potential child exposures. During ABS, at both on-site and off-site residential and recreational locations, a personal air monitor was positioned at a lower height to simulate a child breathing zone. The monitor was placed at 2.5 to 3.5 feet. Based on the data collected, personal monitors for childhood exposures during ABS exceeded the screening values (0.04 PCME f/cc) in the Pile and Park locations, but not in off-site residential or recreational areas. The highest child personal monitor during ABS, based on PCME was 0.2 f/cc, at the Park location. Although it is unlikely a young child, under the age of 6, would be exposed to these levels, since this ABS scenario occurred on site.

To evaluate potential excess cancer from exposure to asbestos, PADOH calculated an estimated cancer risk for childhood exposure. Based on 0.2 f/cc, and an exposure frequency of 2 hour per day, 50 days per year over 6 years, the estimated cancer risk for childhood exposures is 1.04E-05 or 1.4 extra cancers in 100,000 exposed. This value falls within EPA's target risk range, and is generally considered low risk. Estimated cancer risk for childhood exposures was also computed based on ABS data collected in the residential areas and along the recreational walking trails. The highest residential and recreational ABS samples were 0.005 f/cc and 0.005 f/cc (area perimeter sample), respectively. These samples are below the residential screening value of 0.04 f/cc. Therefore, exposure to asbestos based on these ABS air sampling results does not pose a risk to children.

Community Health Concerns

Since being involved with the BoRit, PADOH has addressed numerous community concerns, Some of these community concerns have been addressed in the previous health consultations, as described in the Public Health Involvement Section. Since being involved with the BoRit Asbestos site, PADOH has focused on addressing community health concerns by conducting outreach with the impacted community as well as partnering with community based organizations, including the following:

- BoRit Community Advisory Group
- Ambler Business Owners
- Whitpain Residents Organization
- Wissahickon Valley Watershed Association
- Upper Dublin Township
- Citizens for a Better Ambler
- Clean Water Action
- Ambler Borough
- West Ambler Civic Association
- Whitpain Township

- North Penn Visiting Nurse Association
- Bux-Mont Nurse Practitioners Association
- Ambler Community Cupboard
- American Legion Post
- Montgomery County Health Department
- University of Pennsylvania School of Medicine

Individual activities are included in the public health action plan which is detailed below. As part of the public health assessment process, PADOH will review and respond to community concerns and questions to this document and issue a future document. In addition, community concerns have been addressed in each of the previous health consultations, as described in the Public Health Involvement Section. Over the next months and years, PADOH anticipates addressing concerns about the safety of the future use of the site, whatever that will be, and the safety of the final remedy chosen for the site. PADOH also note that while we have conducted significant outreach, our experience tells us that many of these same issues will continue to periodically be raised as circumstances and residents change in the community.

Public Comments

The following section summarizes the comments PADOH received during the public comment period for the BoRit PHA, and PADOH's responses. The public comment period was from July 25, 2013 through September 30, 2013. PADOH offered the public comment version of the PHA for public review and comment via the EPA BoRit website, ATSDR website, PADOH website, at local libraries, and at the BoRit Community Advisory Group (CAG) meeting on August 2013. Public comments were received from concerned community members and the BoRit CAG members. After reviewing the comments and incorporating any changes or revisions, this version of the PHA now reflects PADOH's final conclusions and recommendations for the BoRit site, based on the information available about the site at this time.

Comment: The report considers only the contaminant of original concern, i.e. asbestos. It makes no reference to contaminants other than asbestos found at BoRit since the EPA began its work, namely those contaminants found in groundwater and subsurface soils. It was felt that PADOH should make reference to other contaminants of concern that have been found at BoRit.

Response: PADOH acknowledges that other contaminants have been detected in the sub-surface at the site. Previous site investigations have detected contaminants, including metals, semi-volatiles and dioxins, in the sub-surface soils. As indicated in the document, the focus of the PHA is on the asbestos data, because PADOH has identified asbestos as the only contaminant that represents a concern for public health at this site. Other identified contaminants are not present at levels of public health concern and/or do not exist in areas where people may have contact with them. [ATSDR and PADOH 2012] PADOH recognizes that community members still have questions about other contaminants detected at the site. To address some of these questions, on 8-3-2012, PADOH prepared a separate health consultation document on the groundwater sampling data at this site. This groundwater health consultation included, in addition to asbestos, a review of inorganic and organic contaminants detected in groundwater at and near the site. The full report is available on the internet at:
www.atsdr.cdc.gov/HAC/pha/BoRitAsbestosSite/BoRitAsbestosSiteHCPC08032012.pdf

Comment: The conclusion on off-site surface water results is only valid for those drinking from public water sources. The risk is uncertain or undetermined for those consuming water from private wells since there is no data on asbestos fiber levels in those sources.

Response: This conclusion evaluates exposure to surface water and not groundwater sources. We are not aware of any public water system intakes near the site. Although public water is the main source of drinking water in the area, there may be private wells in the area. No private wells are documented in Ambler Borough or Upper Dublin, but there are some private wells documented in Whitpain Township. A few of these wells appear to be approximately 2 miles from the BoRit site. PADOH agree that private well data in the area are not available. A more detailed discussion can be found in the BoRit Groundwater Health Consultation document available at: http://www.portal.state.pa.us/portal/server.pt/community/environmental_health/14143/health_assessment_program/954979

Comment: It was noted that the high levels of asbestos above the MCL found in the reservoir and Wissahickon creek were not considered a health risk to the public in Ambler as neither are a source of public drinking water. However it is understood that the Schuylkill River at Philadelphia, which is fed by the Wissahickon, does provide Philadelphia with a portion of its drinking water. Has any testing for asbestos at public water intakes downstream of Ambler been conducted or has downstream municipal authorities been informed?

Response: PADOH is not aware of asbestos sampling in surface water further downstream of the site. However, given the distance from the site/Wissahickon Creek to the confluence with the Schuylkill River (approximately 13 miles), it does not seem like a significant exposure source. Further, agency communications with the City of Philadelphia's drinking water authorities confirms that asbestos from any surface water sources has not been identified as a concern in their public drinking water supply.

Comment: PADOH and EPA state high levels of asbestos (above MCL) were found in surface waters both at the reservoir and the Wissahickon creek, and that the reservoir discharges into the creek via a seep at the base of the reservoir berm. It is understood that the U.S. Army Corps of Engineers is currently studying the reservoir parcel. In the meantime, the CAG requests clarification from PADOH/EPA as to the legal position regarding a Superfund site discharging material into a public waterway.

Response: The statement in the PHA that the reservoir discharges to the creek was based on information contained in the NPL listing document [EPA 2012a]. Since the release of the PHA, the Army Corps of Engineers has been conducting work on the reservoir parcel. It is our understanding that this work will help delineate if the reservoir discharges to the creek via a seep. PADOH functions as a health advisory agency and does not have regulatory authority under CERCLA. PADOH defers to the environmental agencies regarding this legal question about Superfund sites. PADOH will remain available to evaluate additional sampling data related to the reservoir and the surface waters at this site, if requested.

Comment: Has past flooding had a role in depositing ACM on the stream banks (along the walking trails) in addition to manufacturing and disposal activities?

Response: Prior manufacturing and disposal activities have deposited ACM in the creeks, on the stream banks, and adjacent trails. Natural activities related to the creeks, including flooding and erosion have played a role in the movement of ACM materials in and around the creeks. EPA has performed removal efforts on an annual basis to address visible ACM along the creeks near the site. However, there is still a chance that ACM may be present in the banks and trails and therefore, PADOH advises residents not to disturb this material. In order to assess the potential human health risk from ACM on the stream banks, EPA has performed sampling of asbestos along the stream banks and walking trails. These areas have been known to flood in the past. Surface soil sampling results (along the stream banks and walking trails) for asbestos ranged from non-detect to 0.8%. During ABS air sampling of the walking trails, no samples had asbestos levels exceeding the asbestos health-based air screening value. Therefore, exposure to asbestos along the banks and walking trails for persons engaging in normal activities is not likely to cause harmful effects

Comment: In terms of the surface water sampling data, the scenario of evaporation of the water leaving asbestos-containing sediment that could subsequently become airborne should be considered.

Response: From the environmental perspective, the EPA sediment sampling conducted along the creek addressed this potential scenario. The sediment samples collected in the creek did not show asbestos levels exceeding 1% environmental screening value. EPA collected samples along the creek banks to address the potential influence of flooding, as described in the above comment response. Currently there are not reliable methods to estimate concentrations of asbestos in air based on concentrations in other environmental media, including surface water or sediments. Therefore, inhalation risk for people cannot be estimated using local surface water, sediment and creek bank sampling results. PADOH concludes the most appropriate evaluation of people's health exposures to the ACM in and around the creeks and walking trails is based on the ABS air sampling results. As stated in the previous response, this air sampling did not indicate any asbestos at levels of health concern for people disturbing these materials near the creeks.

Comment: The calculated residential screening value of 0.0006 f/cc was not used to decide which asbestos levels may indicate a potential risk. Rather a "rounded" value of 0.001 f/cc was used. This higher value allows for greater risk than the EPA health acceptable risk (1 in 10^{-4}). The risk evaluation should be revised, using 0.0006 f/cc, or a more conservative rounded down screening value (0.0005 f/cc or 0.0001 f/cc). In addition, a multi- agency workgroup used a health-based long-term risk benchmark of 0.0009 f/cc for residential exposures in Lower Manhattan after the World Trade Center (WTC) disaster. What is the reason this level was not considered appropriate for residential exposure situations in Ambler?

Response: The EPA IUR by design factors in sensitive populations and the calculated residential risk-based screening value for the BoRit site assumes a worst-case scenario (i.e., people being exposed for 24 hours a day, 350 days per year). Following the WTC disaster, EPA established a residential asbestos health-based benchmark value of 0.0009 f/cc. The final indoor air assessment document for the WTC was published in May 2003. The WTC sites were distinct in that asbestos was not only found in ambient outdoor air, but also inside homes [EPA 2003b]. When calculating the WTC asbestos benchmark health-based screening value, EPA used the IUR value of 0.23 f/cc [EPA 2013]. The EPA's IUR of 0.23 f/cc is based on a lifetime of 70 years (i.e., 70 years × 365 days/year). Since the release of the WTC indoor air document, EPA published the Asbestos Framework document, which is used as guidance in evaluating asbestos at Superfund sites [EPA 2008b]. In the EPA Asbestos Framework Document, EPA recommends the use of an adjusted IUR for less than lifetime exposures (not the 0.23 f/cc) to account for exposure time of less than 70 years. An adjusted IUR of 0.17 f/cc was used for 30 years of residential exposure. Based on this, EPA recommends using a screening value of 0.001 f/cc for residential exposures, based on a 10^{-4} cancer risk [(EPA, 2008a]. In an effort to maintain consistency, the calculated risk-based screening level of 0.0006 f/cc was rounded up to 0.001 f/cc to align with the WTC value (0.0009 f/cc). Given the assumptions and uncertainties associated with predicting toxicity and risk, all these values (0.001 f/cc, 0.0006 f/cc and 0.0009 f/cc) result a similar level of risk.

Comment: An off-site ambient value of 0.0006 f/cc would not be removed from further consideration if either the calculated value of 0.0006 or a value rounded down was used for screening. Recalculations based on the results of a modified screening process could potentially alter the conclusions of the risk assessment.

Response: The detection of asbestos at 0.0006 f/cc occurred via the TEM method and not PCMe. EPA's risk calculations and assessment are based on the PCMe method. Please refer to the discussion of the residential screening level in the comment above. Recalculations using the slight variants in screening level proposed would not have resulted in any additional PCMe detections requiring further evaluation, and, therefore, would not change any of the conclusions of this public health evaluation.

Comment: The fact that similar ABS was performed at an Illinois location is of interest but does not establish that the sampling was valid, in that it accurately portrayed risk. Has this sampling method been validated?

Response: Asbestos is an inhalation hazard only when asbestos containing soils or materials are disturbed. ABS has long been a cornerstone of industrial hygiene where workplace exposures are routinely assessed via personal exposure monitoring. ABS is the recommended method established by the EPA Asbestos Framework document and has been used at a number of diverse sites across the country. ABS simulates routine activities in order to mimic and evaluate personal exposures from disturbance of materials potentially contaminated with asbestos [EPA 2007].

Comment: It was noted that ABS at the reservoir parcel, whilst producing no detections of asbestos fibers, was limited to sampling at one location only. Considering the size of the perimeter of the reservoir parcel, is a single site test location sufficient to represent the reservoir parcel as a whole?

Response: While only one ABS air sample in the reservoir might seem limited, there were several surface soil samples collected on the reservoir parcel. During EPA's sampling, there were 11 surface soil samples collected on the reservoir parcel. The results showed 8 of the 11 samples were below the non-health based environmental screening value of 1%, with a range of non-detect to 1.8%. The ABS was conducted at the location with the highest asbestos in soil concentration. The ABS and personal air monitoring occurred at the soil sampling location with a concentration of 1.8%.

Comment: In terms of past air sampling data, where were the samples that had air levels as high as 2 f/cc collected?

Response: While the specific information on past sampling in the community is very limited, this sample was most likely collected as part of Ambler Asbestos Pile site and before the removal actives at the Ambler Asbestos Pile site.

Comment: Is there any data on the prevalence of pleural plaques (non-cancerous risk) in Ambler?

Response: Pleural plaque is not a reportable condition, under Chapter 27 of Pennsylvania's disease reporting rules [Pa Code 2002]. Therefore, at this time, PADOH is not able to evaluate data on pleural plaques.

Comment: PADOH comments on the now demolished K&M buildings are noted. However, we are concerned about the vast amount of building rubble and still intact basement floors and walls. The buildings potentially have ACM exposed to the air uncovered and unprotected. EPA, PADOH and PADEP [should] investigate the nature of the asbestos risk to the public health from this site.

Response: PADOH agrees that the ACM debris at these locations, although not officially part of the BoRit site investigations and remediation, represent a potential public health concern if disturbed. Due to this concern, PADOH continues to recommend that the community not trespasses on the former K&M/Nicolet properties. PADOH recommends the environmental agencies evaluate how the development of these properties will alter the potential for community exposures to asbestos.

Comment: What were the ages of individuals diagnosed with mesothelioma in Ambler?

Response: PADOH reviewed the age distribution of mesothelioma cases in Ambler, based on cancer reporting data in the PA Cancer Registry. Based on an analysis of age of diagnosis of mesothelioma, the risk of malignant mesothelioma was greatest among residents in their mid-eighties; this is the cohort that included former employees and their household contacts. The analysis by age of diagnosis did not identify any individuals younger than 45 years of age**.** It is likely, given the long latency period (the time that passes between being exposed to asbestos and having symptoms) that these individuals worked at the asbestos manufacturing plant or were household contacts of workers.

Comment; The CAG and other groups have an interest in prospects and possibilities for long-term reuse of the contaminated areas. Is the document addressing the exposures children would have if the BoRit site was to be used in the future for recreational activities?

Response: PADOH's risk evaluation included children's exposures based on the ABS results prior to the addition of clean fill on the site. At this time, however, PADOH is not addressing the future potential uses of the site. PADOH remains available in the future, to review data and offer public health guidance on the future use of the site.

Conclusions

Based on a review of the environmental sampling and Cancer Registry data, PADOH concludes the following for the BoRit site:

1. Based on a review of the 2008-2011 ambient air sampling data collected along the site perimeter and in the community, current exposures to the off-site airborne asbestos levels are not expected to harm people's health. Results of these sampling events did not show asbestos at levels exceeding EPA screening values for residential exposure. Based on the sampling data, PADOH concludes that asbestos is not migrating off-site to the local community at levels that would harm their health.

2. Exposures to asbestos in surface water are not expected to harm people's health. EPA collected surface water samples from the on-site Reservoir and the Wissahickon, Tannery Run and Rose Valley Creeks, which are adjacent to the site. Several of the samples exceeded EPA's maximum contaminant level (MCL) for asbestos in drinking water. However, the public is currently not using the surface water as a drinking water source. Therefore, this is not a completed exposure pathway. For people living near the site, occasional recreational exposures to surface water are not expected to be a public health concern.

3. After reviewing the off-site ABS data, collected in the residential areas and recreational walking trails, PADOH concludes that current exposures to the airborne asbestos levels (when off-site soils are being aggressively and vigorously disturbed) are not expected to harm people's health. The ABS sampling results in the residential areas were low and below the EPA risk-based screening levels and therefore there is no unacceptable risk to child or adult residents from aggressive soil disturbance activities at these properties. This conclusion is based on air sampling data collected while off-site soils were aggressively disturbed by raking, mowing, jogging, and hiking, and children playing outside during lawn maintenance activities.

4. PADOH does not expect past exposures (after industrial operations ceased) to asbestos detected during ABS and ambient air sampling of the former Keasbey and Mattison/Nicolet buildings to harm people's health. EPA collected air samples from personal air monitors during ABS inside the buildings and concurrent ambient air samples collected in the community, while ABS occurred and when no ABS occurred. A few ABS samples collected inside the building, during scenarios that attempted to simulate trespasser and horseplay activities, exceeded EPA's risk-based residential screening value but were below the ABS screening value. No samples collected in the community exceeded the risk-based ambient air. The buildings sampled during this event have since been demolished. However, there is still the potential for ACM in the soil near these buildings as well as additional former manufacturing properties, which may contain ACM, near the site.

5. PADOH concludes that on-site exposures to asbestos fibers when on-site soils and asbestos-containing material (ACM) are aggressively disturbed during ABS events could harm people's health. Asbestos fibers show significant increases in on-site airborne levels when soils and ACM are disturbed through ABS. PADOH made this conclusion for several reasons; including (1) an estimated cancer risk for on-site exposures during ABS that approaches EPA lower level of acceptable risk; (2) the quantity of buried asbestos and ACM at the site; (3) the current proximity of a residential community, and (4) the potential for re-development/re-use of this site in the future. Any direct soil activity should be avoided by visitors or trespassers at this site based on the on-site sampling results. However, given that the site is undergoing removal and remedial work and there is a layer of clean soil on parts of the site, this potential for exposure to asbestos is reduced.

6. PADOH reviewed the cancer registry data for all reportable cancers from 1990 to 2011 for Ambler [PADOH 2012]. A statistically significant increase in the incidence of mesothelioma was observed in Ambler, compared to the expected number of cases in the Commonwealth of Pennsylvania as a whole. Since the previous cancer analysis, the standard incidence rate (SIR) used to calculate the rates of cancer for mesothelioma in Ambler

decreased from 3.08 to 2.71. These data show that rates of mesothelioma in the community during the additional years of study are not increasing, based on a comparison with state wide rates. The risk of malignant mesothelioma was greatest among residents in their mid-eighties; this is the cohort that included former employees and their household contacts. The majority of the mesothelioma cases were diagnosed in men. Of the 32 mesothelioma cases reported to the cancer registry for the Ambler zip code from 1990-2011, 23 of these cases were in males and 9 were in females. PADOH consider that the cases of mesothelioma are most likely due to past exposures when the asbestos manufacturing facilities were occurring in Ambler and workers and household contacts were exposed. The rates of lung and bronchus cancers, which are linked to asbestos exposure but more strongly related to tobacco smoking, were lower than expected in Ambler compared to statewide rates. Due to the long latency period of mesothelioma and cancer, the health outcome data in this PHA will be updated periodically to capture newly diagnosed cases of asbestos related disease resulting from exposures that occurred years or decades ago.

Recommendations

Recommendations for the Public

1. Prior manufacturing and disposal activities have left ACM in the Creeks, on the stream banks, and adjacent trails. EPA removal efforts, including removal of debris and stream stabilization efforts, have addressed ACM in the Creek and banks. However, it is still possible that ACM is present in these areas and the public could be exposed during recreational activities. WWWA sponsors a stream cleanup along the Wissahickon Creek each spring and these activities include the removal of trash and other litter in and along the stream. The health concern is if pipes or tiles containing asbestos materials were removed from the creek and the dried material was broken, asbestos could be released into the air. For this reason, PADOH recommend the following:
    - Residents do not remove or disturb pieces of pipe or tile found along the Wissahickon or in the vicinity of the BoRit Asbestos and Ambler Asbestos Superfund sites, since they may contain asbestos;
    - If you do come in contact with suspected ACM, clean your shoes outside and wash your hands;
    - If you think you may have come in contact with asbestos, wash your clothes separately from your regular laundry;
    - If you have concerns or questions about ACM, please contact PADOH at 717-547-3310 or EPA at 215-814-5540.

2. PADOH recommends that visitors or trespassers at this site avoid direct contact with soil or activities that disturb the on-site soils. This recommendation is based on ABS data for airborne asbestos when site soils are aggressively disturbed.

3. PADOH recommends that the community not trespass on the former K&M/Nicolet properties. In addition, careful evaluation is given to any redevelopment plan, ensuring that any remaining ACM is contained or removed and the public is protected from any potential release of ACM.
4. PADOH remains interested in learning of any cases of non-occupationally exposed asbestos-related disease in the community. Residents can contact the PADOH Division of Environmental Health Epidemiology at (717) 547-3310.

5. PADOH encourages residents who are concerned about their potential exposure to asbestos or are symptomatic to take the following steps:
   - Visit your physician for more information on asbestos-related diseases;
   - Quit smoking because asbestos exposure combined with smoking greatly increases a person's risk of developing lung cancer. Smoking cessation will, over time, reduce the risk of cancer form asbestos in former smokers;
   - Consult with a health care provider about getting a flu shot, to help reduce the chance of lung infections.

Recommendations for the EPA

1. PADOH supports EPA's efforts to continue site assessment activities and remedial plans. PADOH recommends that EPA implement strategies to mitigate potential releases and hazards that may cause health effects as a result of exposure to airborne asbestos.

2. PADOH recommends that, during any future removal and remediation activities at this site, that the results of future air monitoring activities (on-site, off-site, and personal air monitors) be shared with the community in a timely matter.

3. PADOH recommends that annual spring clean-up activities or inspection efforts for ACM be conducted along the stream banks, due to the potential ongoing resurfacing of ACM in these public areas.

4. PADOH recommends that access be restricted to the site and maintain warning signs along the perimeter of the site alerting the public to the site and the presence of asbestos containing waste until mitigation and remediation work is completed.

5. To determine if the one residential perimeter air ABS concentration found to exceed ambient air screening value is anomalous, perhaps due to laboratory counting error or indicative of an asbestos source not associated with the residential yard, PADOH recommends EPA consider re-sampling this area (ambient air).

6. Although not officially part of the BoRit site investigations and remediation activities, PADOH recommends that the environmental agencies continue oversight at the former manufacturing buildings in Ambler that might contain ACM to reduce the potential for community exposures to asbestos debris.

Public Health Action Plan

The public health action plan for the site contains a description of actions that have been or will be taken by PADOH. The purpose of the public health action plan is to ensure that this health assessment both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from exposure to hazardous substances.

Public health actions that have been taken

Since its formation in 2007, PADOH serves as a member of the BoRit CAG and the Health, Environment, and Risk Subcommittee. Responsibilities include attending a bimonthly meeting and periodic subcommittee conference calls. PADOH has presented at three monthly meetings on air sampling data, cancer incidence, and the public health assessment process.

Since 2007, PADOH participated in two West Ambler Civic Association community events and one neighborhood cleanup.

In 2007-2009, PADOH prepared 3 previous health consultations for the site, including two health consultations evaluating on-site and off-site air sampling data for asbestos and one health consultation on health outcome data.

In 2007-2009, PADOH conducted 4 grand rounds at two local hospitals, the county medical society and health department, and the local visiting nurse association that serves the Ambler area.

In 2007-2011, PADOH prepared four community factsheets addressing the community's health concerns, air quality sampling results, and the incidence of cancer in the community.

In 2010 and at the request of the community, PADOH evaluated potential exposures on the Green Ribbon Trail and determined that walking on the trail does not pose an increased health risk. A flyer was prepared and distributed to stream clean up volunteers to increase awareness of those areas where asbestos waste may found along the trail.

In 2011, at the request of the community, PADOH prepared an updated cancer evaluation in the communities surrounding the site.

In 2011, PADOH prepared a community fact sheet on the updated cancer evaluation for the Ambler area and distributed it to the community.

In 2011, PADOH collaborated with the University of Pennsylvania Occupational Medicine Program and conducted outreach to medical practices serving the Ambler community, and distributed a poster on asbestos risk factors which is designed to encourage at-risk individuals to discuss their concerns with their primary health provider.

In 2011, PADOH in collaboration with the University of Pennsylvania Occupational and Environmental Medicine Program, conducted a grand rounds with a local nurse practitioner association, presented to members of the local senior citizen center, and met with interested members of the local community.

In 2012, PADOH prepared a health consultation document on the groundwater sampling data for the site.

In 2013, PADOH prepared this public health assessment for the site.

<u>Public health actions that currently are being or will be implemented</u>

PADOH on-going public health actions:
PADOH will review any additional environmental sampling data, collected at the site and consider producing a document.

PADOH will make this health assessment available to residents for comment and review and will be available to answer the residents' health questions. PADOH will continue to work with the community to answer questions and address ongoing concerns.

PADOH will remain available to discuss any public health questions or concerns related to the site with community members and local authorities.

PADOH's Health Assessment Program will continue to work with PADOH's Cancer Registry Program to obtain updated cancer statistics for the site area, and will review this information on a periodic basis.

PADOH will attend meetings with the community, as well as state and local government agencies.

PADOH will continue to educate the public and health care providers on public health issues relating to the site.

EPA's on-going public health actions:

EPA's short term/removal program is continuing their actions at the site. This includes excavation, covering with two feet of clean fill material remaining areas of the park (cover already completed at pile and south part of park), and active dust suppression activities, as well as air sampling to determine the effectiveness of dust suppression activities as needed.

EPA's remedial/long term program is currently continuing their remedial investigation and feasibility study (RI/FS) work at this site. The RI/FS is studying the nature and extent of contamination at the site, health risks, and long term cleanup options. EPA will consider a range of possible long term remedies for this site, including any needed long term operation and maintenance considerations that might be appropriate for the proposed remedies.

EPA's Removal and Remedial programs, as well as public health agencies, will continue discussions with federal/state/local agencies and property owners about future actions at the site and will continue to keep the community informed of any site activities and progress.

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Report Authors and Reviewers

This Public Health Assessment for the BoRit Site was prepared by the Pennsylvania Department of Health (PADOH) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database, and the approving agency reviewers are listed below.

Author

Christine Lloyd, M.S.
Epidemiology Program Specialist
PADOH, Health Assessment Program
Division of Environmental Health Epidemiology

Co-Authors

Farhad Ahmed, MBBS, MPH
Principle Investigator
PADOH, Health Assessment Program
Division of Environmental Health Epidemiology

Barbara Allerton, MPH, RN
Epidemiology Research Associate
PADOH, Health Assessment Program
Division of Environmental Health Epidemiology

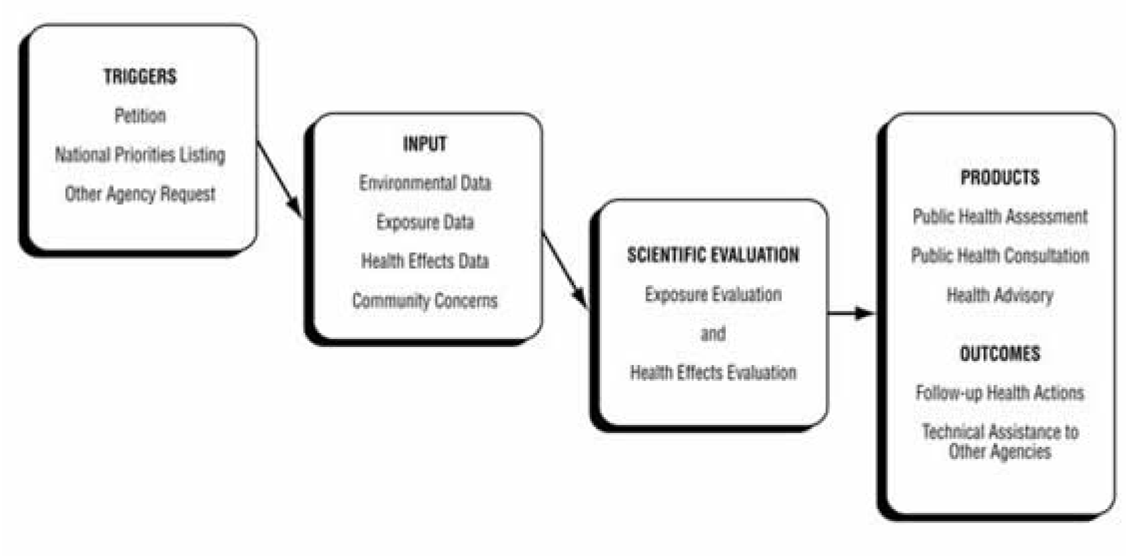
ATSDR Reviewers

Region 3
    Lora Werner, MPH, Regional Director

Division of Community Health Investigations
    Tina Forrester, Ph.D., Acting Division Director
    Jennifer Freed, MPH, Technical Project Officer
    Greg Ulirsch, Ph.D., Associate Director for Science, Eastern Branch
    Lynn Wilder, Ph.D., Associate Director for Science

Appendix A: ATSDR Screening Process

ATSDR has developed a method to evaluate the public health implications of exposures to environmental contamination. This method is called the *public health assessment* process. The public health assessment process serves as a mechanism for identifying appropriate public health actions for particular communities. The process may be triggered by a site's listing on the National Priorities List or a specific request (or petition) from a community member or another government agency. The purpose of the process is to find out whether people have been, are being, or may be exposed to hazardous substances and, if so, whether that exposure is harmful, or potentially harmful, and should therefore be stopped or reduced. The process also serves as a mechanism through which the agency responds to specific community health concerns related to hazardous waste sites. The following diagram summarized the ATSDR screening process (ATSDR, 2005):



The public health assessment process involves two primary scientific evaluations—the exposure evaluation and the health effects evaluation (ATSDR, 2005).

- **Exposure Evaluation:** ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by federal and state government agencies and/or their contractors, potentially responsible parties, and the public. When adequate environmental or exposure information is not available to evaluate exposure, ATSDR will indicate what further environmental sampling may be needed and may collect environmental and biologic samples when appropriate.

- **Health Effects Evaluation:** If the exposure evaluation shows that people have or could come into contact with hazardous substances, ATSDR evaluates whether this contact may result in harmful effects. ATSDR uses existing scientific information, which can include the results of medical, toxicological, and epidemiologic studies and data collected in disease registries, to determine what health effects may result from exposures.

The public health assessment process enables ATSDR to prioritize and identify additional steps needed to answer public health questions. Public health assessments are conducted by agency health assessors, often supported by a multi-disciplinary team of scientists, health communication specialists, health educators, and/or medical professionals. ATSDR solicits and evaluates information from local, state, tribal, and other federal agencies; parties responsible for operating or cleaning up a particular site; and the community. All of these stakeholders play an integral role in the public health assessment process. For completed or potential exposure pathways identified in the exposure pathway evaluation, the screening analysis may involve (ATSDR, 2005):

- Comparing media concentrations at points of exposure to health-based "screening" values (based on protective default exposure assumptions).
- Estimating exposure doses based on site-specific exposure conditions to compare against health-based guidelines.
- For those pathways and substances identified in the screening analysis as requiring more careful consideration, a host of factors assist in determining whether site-specific exposures are likely to result in illness and whether a public health response is needed. Exposures are studied in conjunction with substance-specific toxicological, medical, and epidemiologic data.
- Based on available exposure, toxicological, epidemiologic, medical, and site-specific health outcome data, are adverse health effects likely in the community*?* In this step potential health impacts on the general community and impacts of site-specific exposures to any uniquely vulnerable populations (e.g., children, the elderly, women of child-bearing age, fetuses, and lactating mothers) are also reviewed.

Appendix B: Figures

Figure 1 – BoRit site map

Figure 2 – Demographic map for the population with-in one mile of the BoRit site

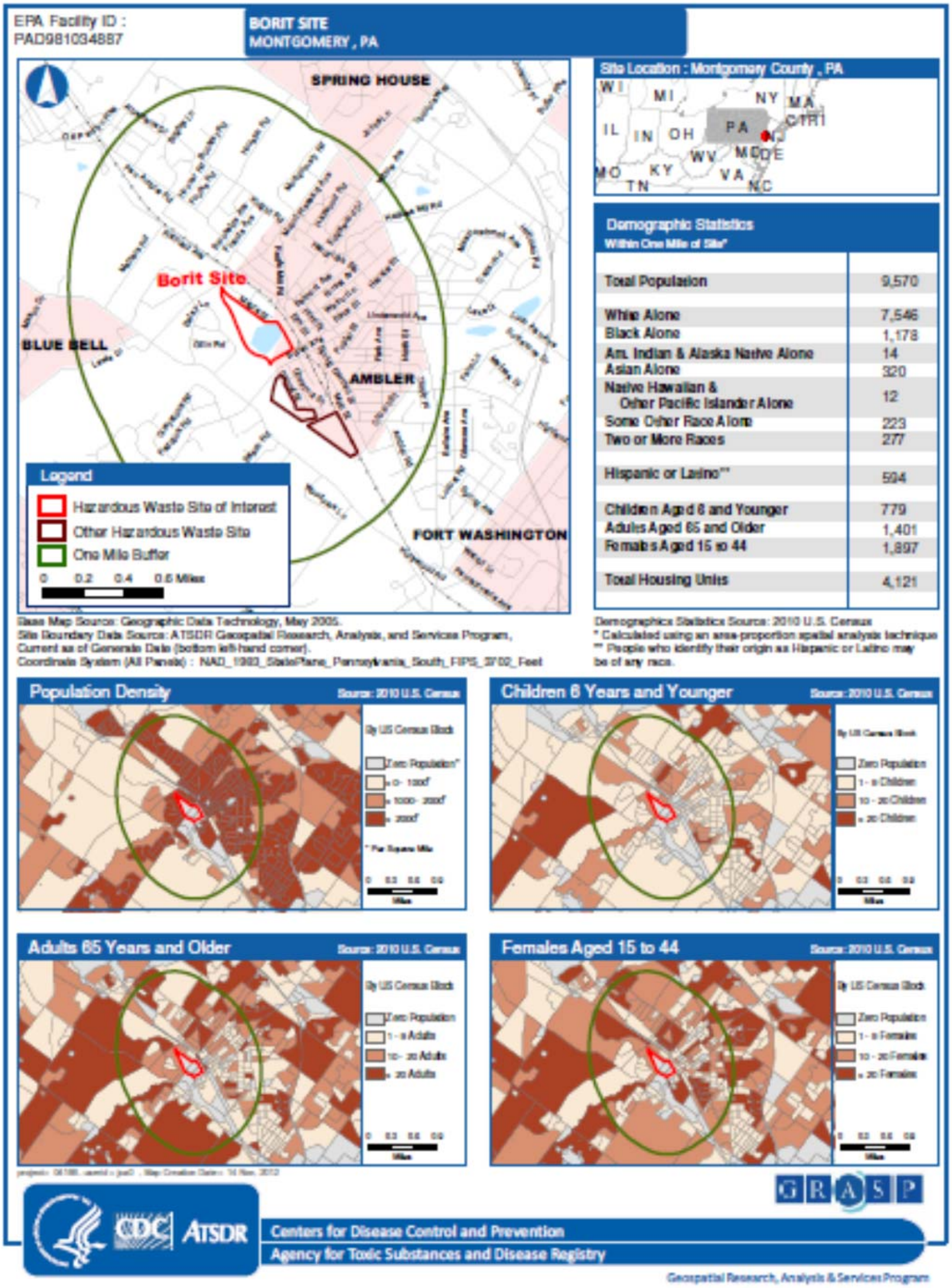
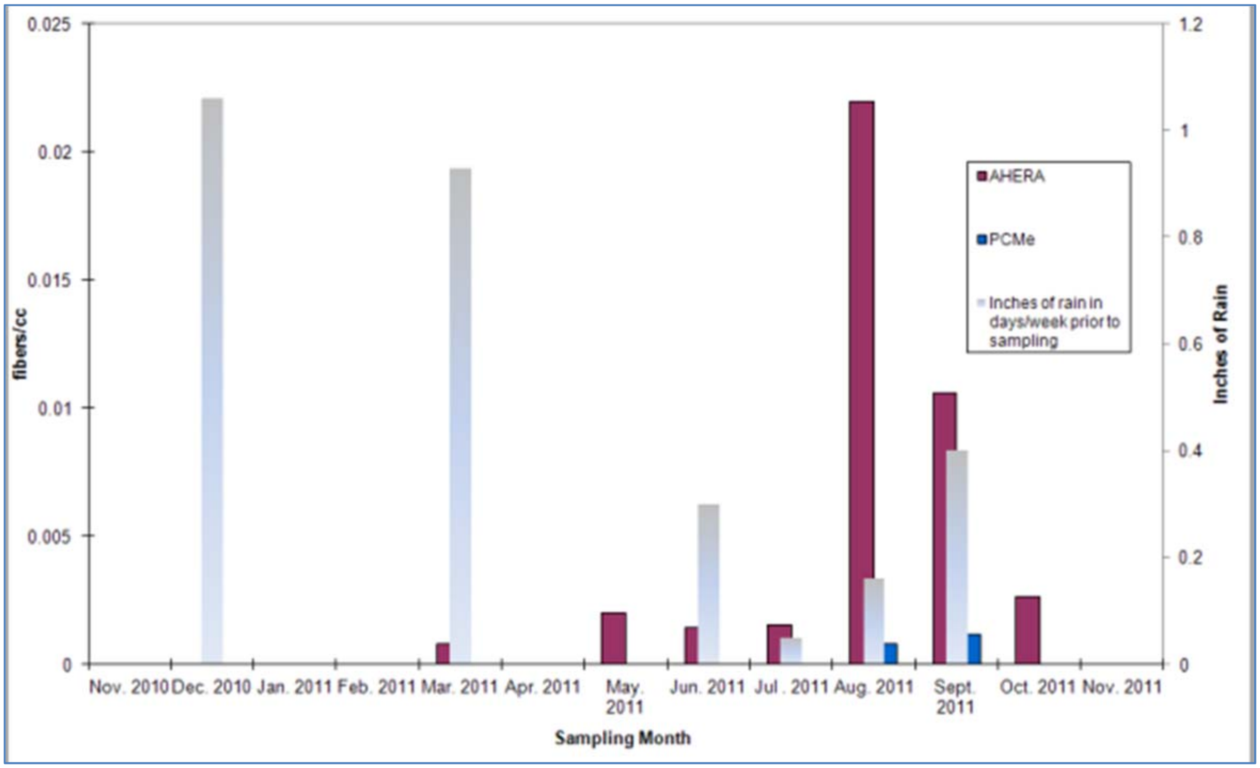


Figure 3 - Plot of the maximum fiber concentration during ambient off-site air sampling (2010 to 2011) versus the amount of rain in the days and/or week prior in Ambler



Appendix C: Asbestos Sampling Data

Table 1 – Summary of historical air sampling data, collected near the Ambler Asbestos Pile site and the BoRit site

Historical Sampling Date(s)	Range of Concentrations	Analysis Method	Notes/Key Findings
Nov. 1971& Jan. 1972	Not specified	PCM?	Dust emissions observed; samples positive for asbestos (no quantatitve data)
Oct. 1973	3.1-2600 ng/m3	PCM?	Ten sample locations w/ levels exceeding Philadelphia background levels of 45-1000 ng/m3
Nov. 1976	0.0005-0.066 f/cc	PCM/TEM	75 samples from 13 locations
Nov. 1976	01017-0.085 f/cc	TEM	4 of 75 samples detected chrysotile
Jul. 1977	0.035-0.0093 f/cc	PCM	12 samples collected
Jul. 1977	0.048-0.18 f/cc	TEM	4 of 8 samples detected chrysotile. The maximum concentrations exceeded current occupational standards
Jun. 1983	ND-0.02 f/cc	PCM	Two air samples. Dust samples (between 3-35% chrysotile) led to closutre of adjacnet playground. Removal action at Ambler Asbestos Pile site started
Dec. 1983	ND - 0.01 f/cc	SEM	Three air samples collected
Apr. 1984	ND - 0.012 f/cc	SEM &TEM	Five locations, over four days. On-stier was ND to 0.07 f/cc. 0.12 f/cc detected at sample station located near a break repair shop
Sep. 1984	None above background	TEM	Dust samples collected from inside homes adjacent to BoRit
Oct. 1986	ND	TEM	Six limited air samples collected before the RI, with no asbestos detected
Dec. 1986	0.01-0.2 f/cc	TEM	Four samples, as part of initial RI sampling for Ambler Asbestos Piles site. Max detection was upwind along road with heavy traffic
Jan. 1987	0.01-0.08 f/cc (on-site) 0.2-1.95 f/cc (off-site)	TEM	6 on-site and 10 off-site location. Background sample was 0.5 f/cc chrysotile. Highest values fround on Main St. However, several confounders were found in the study
Apr. 1987	0.01-0.08 f/cc	TEM	Drilling/test pit activity sampling. Amosite detected in waste pile.
1988- Nicolet ceases operation			
Jul.-Nov. 1992	ND-0.05 f/cc	TEM	Sampling conducted during EPA Remedial activites at Ambler Asbestos Pile Site. Litte additional information. Results not deemed significant
Summer 2001	ND	TEM	One sample near BoRit pile, no asbestos detected
May 2004	ND - 0.004 f/cc	PCM	Two samples collected near BoRit Reservoir
2006 -2007	0.00061-0.039 f/cc	TEM	Six samples around BoRit

ND = non-detect
TEM = transmission electron microscopy
PCM = phase contrast microscopy
SEM = Scanning electron microscopy

Table 2- Sample results for asbestos in the cover/waste interface and surface grab samples in the Pile

	Cover/Waste Interface				Surface Soil			
Analyte	Average*	Range	Depth (ft.)	#Samples>1%	Average*	Range	Depth (inches)	#Samples >1%
Pile Location								
Total Asbestos (%)	5.00	ND to 15	Composite between 0 to 2.0	1 of 3	6.12	ND to 15	Grab 0 to 3	5 of 9
Chrysotile (%)	5.2	ND to 15	Composite between 0 to 2.0	1 of 3	6.53	ND to 15	Grab 0 to 3	8 of 9
Park Location								
Total Asbestos (%)	2.66	ND to 12	Composite 0 to 1.7	3 of 6	0.11	ND to 0.5	Grab 0 to 3	0 of 9
Chrysotile (%)	4.20	15	Composite 0 to 1.7	3 of 6	0.11	ND to 0.5	Grab 0 to 3	0 of 9
Crocidolite (%)	ND	ND	Composite 0 to 1.7	0 of 6	0.00	ND	Grab 0 to 3	0 of 9

* Total is less than chrysotile because one sample did not get a result
ND=Non-detect

Table 3 – Sample results for asbestos in surface soil collected from soil borings and grab samples prior to ABS at the Pile

Analtye	Screening Level	Sample Name	AP-ABSS01-A	AP-ABSS02-A	AP-ABSS03-A	APSL-SS01-A	APSL-SS01-B	APSL-SS02-A	APSL-SS02-B	APSS-01
		Sample Date	7/6/11	7/6/11	7/11/11	10/7/10	10/7/10	10/7/10	10/7/10	8/17/10
Asbestos (%)	1		2.2	3.5	1.3	0	0	0	0.2	0

Table 4 -Park surface soil sampling before ABS from surface soil in soil borings and grab samples prior to ABS

		Surface soil prior to ABS					Soil Borings and Surface Soil							
SL		PK-SB06 ABS	PK-SB08 ABS	PK-SB10 ABS	PK-SB40 ABS	PK-SS01 ABS	PK-SB06	PK-SB08	PK-SB10	PK-SB12	PK-SB40	PK-SB29	PK-SS01	PK-SS02
	Sample Date	10/19/10	10/19/10	10/18/10	10/19/10	10/19/10	8/17/10	8/17/10	8/17/10	8/17/10	8/17/10	8/17/10	8/17/10	8/17/10
1		<0.1	<0.1	<0.1	<0.1	<0.1	1.5	1.1	0.7	<0.25	0.9	<0.25	1.2	0.4

Table 5 -Reservoir surface soil sampling from surface soil in soil borings and grab samples prior to ABS

	Soil borings surface soil									Surface soil before ABS	
Analyte	RVSB04-SS-2926	RVSB08-SS-2930	RVSB12-SS-2892	RVSB17-SS-2586	RVSB19-SS-2862	RVSB24-SS-2962	RVSB25-SS-3580	RVSB26-SS-3581	RVSB27-SS-3582	RV-ABSS01-A	RVSS-01
Asbestos (%)	0.4	1.2	0.5	ND	0.1	ND	0.8	1.1	0.1	<0.1	1.8
Chrysotile (%)	0.4	1.2	0.5	ND	0.1	ND	0.8	1.1	ND	<0.1	1.8

ND=non-detect

Table 6- Sample results for asbestos in surface water collected in the Reservoir and Creeks

Analyte	Average	Range	# Samples > 7 MFL
Reservoir			
Total Asbestos (MFL)	58.3	ND to 160.33	5 of 16
Chrysotile (MFL)	58.3	ND to 160.33	5 of 16
Creeks			
Total Asbestos (MFL)	6.22	ND to 30	4 of 14
Chrysotile (MFL)	6.22	ND to 30	4 of 14

MFL = millions of fibers (asbestos) per liter

Table 7 - Sample results for asbestos in the sediments, collected in the Reservoir and Creeks and surface soil in the flood plain

Analyte	Average	Depth (in.)	Range	#> 1% Scrrening Level
Reservoir				
Total Asbestos (%)	0.2	0-3	ND to 0.5	0
Chrysotile (%)	0.2	0-3	ND to 0.5	0
Creeks				
Total Asbestos (%)	0.12	0 to 3	ND to 0.8	0
Asbestos, chrysotile (%)	0.11	0 to 3	ND to 0.8	0
Crocidolite (%)	0.10	0 to 3	ND to 0.1	0
Surface Soil in Flood Plain				
Total Asbestos (%)	0.21	0 to 2	ND to 0.5	0
Asbestos, chrysotile (%)	0.21	0 to 2	ND to 0.5	0

ND = non-detect

Table 8 - Sample results for asbestos in surface soil in the other side of the Wissahickon from soil borings and grab samples collected prior to ABS

	Surface soil borings along Wissahickon			**Before ABS**
Analyte	**OWSB01-SS-3180**	**OWSB02-SS-3181**	**OWSB03-SS-3182**	**OSW ABS**
Total Asbestos	ND	0.1	ND	0.3
Chrysotile (%)	ND	0.1	ND	0.3

ND = non-detect

Table 9 - Green Ribbon Walking Trails surface soil sampling before ABS to determine ABS Soil Samples

Analyte	Green River Surface Soil 1	Green River Surface Soil 2
Total Asbestos (%)	ND	<1.0
Chrysotile (%)	ND	<1.0

ND = non-detect

Table 10 - Residential surface soil sampling before ABS to determine ABS Soil Samples

Analyte	Unit	SL	Sample Name	Residential 1	Residential 2	Residential 3	Residential 4	Residential 5	Residential 6	Residential 7	Residential 7	Residential 8
			Sample Date	10/13/10	10/13/10	10/13/10	10/13/10	10/13/10	10/13/10	7/14/11	10/13/10	10/13/10
Asbestos	%	1		<0.1	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1

Table 11 - Sample results, for asbestos in surface soil in the Kids Park

Unit	SL	Depth (in.)	Kids Park Surface Soil 1	Kids Park Surface Soil 2
%	1	0 to 3 (under mulch)	<0.1	<0.1

Appendix D: Ambient Air Sampling and Activity-Based Sampling

Table 1 - 2008-2009 Off-site Ambient Air Sampling collected by the EPA Removal Program

Sampling Location	Date collected	PCM Analysis (f/cc)	TEM Analysis (f/cc)
5	7/10/2008	0.0018	<0.0003
	7/11/2008	0.0012	0.0006
	7/15/2008	<0.0007	
	7/16/2008	<0.0006	
6	7/15/2008	<0.0007	
	7/16/2008	<0.0012	
	7/31/2008	0.0021	<0.0021
	10/14/2008	<0.0007	
	11/10/2008	<0.0015	
	11/11/2008	<0.0007	
8	9/19/2008	0.0012	<0.0006
	10/17/2008	0.0007	<0.0006
	10/30/2008	<0.0006	
9	7/31/2008	0.0013	<0.0013
	8/1/2008	0.0014	<0.0006
	8/21/2008	0.0008	<0.0006
	9/19/2008	<0.0006	
	10/17/2008	<0.0006	
	11/11/2008	<0.0007	
	11/18/2008	<0.0006	
	8/12/2009	<0.0006	<0.0006
14	8/8/2008	<0.00007	
	8/20/2008	0.0008	<0.0006
	8/21/2008	0.0006	<0.0006
	10/3/2008	0.0006	<0.0006
	10/6/2008	<0.0006	
	10/6/2008	<0.0006	
	10/31/2008	<0.0006	
	8/10/2009	<0.0006	
	8/11/2009	0.0007	<0.0006
	8/12/2009	<0.0007	
	8/25/2009	<0.0006	
	8/27/2009	<0.0006	
	9/1/2009	0.0007	
	11/18/2008	<0.0006	
19	9/2/2009	0.0007	
25	9/2/2009		<0.0006

TEM = transmission electron microscopy
PCM = phase contrast microscopy

Table 2 –Ambient Outdoor Air monitoring for asbestos, collected in 2010-2011, as part of the RI/FS

Method/Analyte	Location 1			Location 2			Location 3			Location 4		
	Avg	Max	#≥SL (14 total)	Avg	Max	#≥SL (14 total)	Avg	Max	#≥SL (14 total)	Avg	Max	#≥SL (14 total)
PCME Analysis Method												
Actinolite	0	0		0	0	0	0	0	0	0	0	0
Amosite	0	0	0	0	0	0	0	0	0	0	0	0
Anthophyllite	0	0	0	0	0	0	0	0	0	0	0	0
Crocidolite	0	0	0	0	0	0	0	0	0	0	0	0
Libby amphibole	0	0	0	0	0	0	0	0	0	0	0	0
Other amphibole	0	0	0	0	0	0	0	0	0	0	0	0
Other mineral class	0	0	0	0	0	0	0	0	0	0	0	0
Solid Soln: Amosite	0	0	0	0	0	0	0	0	0	0	0	0
Solid Soln: Trem-Act	0	0	0	0	0	0	0	0	0	0	0	0
Total Amphibole	0	0	0	0	0	0	0	0	0	0	0	0
Total Asbestos	0	0.001	1	0	0	0	0	0	0	0.00005	0.0008	0
Total Chrysotile	0	0.001	1	0	0	0	0	0	0	0.00005	0.0008	0
Tremolite	0	0	0	0	0	0	0	0	0	0	0	0
TEM-EPASM Analysis Method												
Actinolite	0	0		0	0		0	0		0	0	
Amosite	0	0		0	0		0	0		0	0	
Anthophyllite	0	0		0	0		0	0		0	0	
Crocidolite	0	0		0	0		0	0		0	0	
Libby amphibole	0	0		0	0		0	0		0	0	
Other amphibole	0	0		0	0		0	0		0	0	
Other mineral class	0	0		0	0		0	0		0	0	
Solid Soln: Amosite	0	0		0	0		0	0		0	0	
Solid Soln: Trem-Act	0	0		0	0		0	0		0	0	
Total Amphibole	0	0		0	0		0	0		0	0	
Total Asbestos	0.001	0.014		0.0003	0		0.0004	0.0026		0.0004	0.003	
Total Chrysotile	0.001	0.014		0.0003	0		0.0004	0.0026		0.0004	0.003	
Tremolite	0	0		0	0		0	0		0	0	
AHERA Analysis Method												
Actinolite	0	0		0	0		0	0		0	0	
Amosite	0	0		0	0		0	0		0	0	
Anthophyllite	0	0		0	0		0	0		0	0	
Crocidolite	0	0		0	0		0	0		0	0	
Libby amphibole	0	0		0	0		0	0		0	0	
Other amphibole	0	0		0	0		0	0		0	0	
Other mineral class	0	0		0	0		0	0		0	0	
Solid Soln: Amosite	0	0		0	0		0	0		0	0	
Solid Soln: Trem-Act	0	0		0	0		0	0		0	0	
Total Amphibole	0	0		0	0		0	0		0	0	
Total Asbestos	0.0008	0.011		0.0003	0		0.0003	0.0015		0.0002	0.002	
Total Chrysotile	0.0008	0.011		0.0003	0		0.0003	0.0015		0.0002	0.002	
Tremolite	0.0000	0		0	0		0	0		0	0	
BCPS (2003) Analysis Method												
Actinolite	0	0		0	0		0	0		0	0	
Amosite	0	0		0	0		0	0		0	0	
Anthophyllite	0	0		0	0		0	0		0	0	
Crocidolite	0	0		0	0		0	0		0	0	
Libby amphibole	0	0		0	0		0	0		0	0	
Other amphibole	0	0		0	0		0	0		0	0	
Other mineral class	0	0		0	0		0	0		0	0	
Solid Soln: Amosite	0	0		0	0		0	0		0	0	
Solid Soln: Trem-Act	0	0		0	0		0	0		0	0	
Total Amphibole	0	0		0	0		0.00000	0.0000		0	0	
Total Asbestos	0.0000	0.0004		0	0		0.00003	0.0004		0	0	
Total Chrysotile	0.0000	0.0004		0	0		0.00003	0.0004		0	0	
Tremolite	0.0000	0		0	0		0	0		0	0	

Table 2 (continued) -Ambient Outdoor Air monitoring 5-7B 2010-2011

Method/Analyte	Location 5			Location 6-Background			Location 7			Location 7B		
	Avg	Max	#≥SL (14 total)	Avg	Max	#≥SL(14 total)	Avg	Max	#≥SL (8total)	Avg	Max	#≥SL (6 total)
PCME Analysis Method												
Actinolite	0	0	0	0	0	0	0	0	0	0	0	0
Amosite	0	0	0	0	0	0	0	0	0	0	0	0
Anthophyllite	0	0	0	0	0	0	0	0	0	0	0	0
Crocidolite	0	0	0	0	0	0	0	0	0	0	0	0
Libby amphibole	0	0	0	0	0	0	0	0	0	0	0	0
Other amphibole	0	0	0	0	0	0	0	0	0	0	0	0
Other mineral class	0	0	0	0	0	0	0	0	0	0	0	0
Solid Soln: Amosite	0	0	0	0	0	0	0	0	0	0	0	0
Solid Soln: Trem-Act	0	0	0	0	0	0	0	0	0	0	0	0
Total Amphibole	0	0	0	0	0	0	0	0	0	0	0	0
Total Asbestos	0	0	0	0	0	0	0	0	0	0.0001	0.0008	0
Total Chrysotile	0	0	0	0	0	0	0	0	0	0.0001	0.0008	0
Tremolite	0	0	0	0	0	0	0	0	0	0	0	0
TEM-EPASM Analysis Method												
Actinolite	0	0		0	0		0	0		0	0	
Amosite	0	0		0	0		0	0		0	0	
Anthophyllite	0	0		0	0		0	0		0	0	
Crocidolite	0	0		0	0		0	0		0	0	
Libby amphibole	0	0		0	0		0	0		0	0	
Other amphibole	0	0		0	0		0	0		0	0	
Other mineral class	0	0		0	0		0	0		0	0	
Solid Soln: Amosite	0	0		0	0		0	0		0	0	
Solid Soln: Trem-Act	0	0		0	0		0	0		0	0	
Total Amphibole	0	0		0	0		0	0		0	0	
Total Asbestos	0.00003	0.0004		0	0		0.0004	0		0.0046	0.024	
Total Chrysotile	0.00003	0.0004		0	0		0.0004	0		0.0046	0.024	
Tremolite	0	0		0	0		0	0		0	0	
AHERA Analysis Method												
Actinolite	0	0		0	0		0	0		0	0	
Amosite	0	0		0	0		0	0		0	0	
Anthophyllite	0	0		0	0		0	0		0	0	
Crocidolite	0	0		0	0		0	0		0	0	
Libby amphibole	0	0		0	0		0	0		0	0	
Other amphibole	0	0		0	0		0	0		0	0	
Other mineral class	0	0		0	0		0	0		0	0	
Solid Soln: Amosite	0	0		0	0		0	0		0	0	
Solid Soln: Trem-Act	0	0		0	0		0	0		0	0	
Total Amphibole	0.00000	0		0	0		0	0		0	0	
Total Asbestos	0.00003	0.0004		0	0		0.0002	0		0.0042	0.022	
Total Chrysotile	0.00003	0.0004		0	0		0.0002	0		0.0042	0.022	
Tremolite	0	0		0	0		0	0		0	0	
BCPS (2003) Analysis Method												
Actinolite	0	0		0	0		0	0		0	0	
Amosite	0	0		0	0		0	0		0	0	
Anthophyllite	0	0		0	0		0	0		0	0	
Crocidolite	0	0		0	0		0	0		0	0	
Libby amphibole	0	0		0	0		0	0		0	0	
Other amphibole	0	0		0	0		0	0		0	0	
Other mineral class	0	0		0	0		0	0		0	0	
Solid Soln: Amosite	0	0		0	0		0	0		0	0	
Solid Soln: Trem-Act	0	0		0	0		0	0		0	0	
Total Amphibole	0	0		0	0		0	0		0	0	
Total Asbestos	0	0		0	0		0	0		0.0001	0.0008	
Total Chrysotile	0	0		0	0		0	0		0.0001	0.0008	
Tremolite	0	0		0	0		0	0		0	0	

SL= screening level
AHERA= Asbestos hazard emergency response act
TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent

Table 3- Samples with asbestos detections (f/cc), by sampling month and asbestos counting method from the 2010-2011 ambient air sampling events

	Nov. 2010	Dec. 2010	Jan. 2011	Feb. 2011	Mar. 2011	Apr. 2011	May. 2011	Jun. 2011	Jul . 2011	Aug. 2011	Sept. 2011	Oct. 2011	Nov. 2011
AHERA													
					0.0008		0.0020	0.0015	0.0008	0.0008	0.0106	0.0008	
					0.0039				0.0015	0.0011	0.0008	0.0004	
									0.0015	0.0008		0.0004	
										0.0220		0.0026	
PCMe													
										0.0008	0.001		
										0.0008			
TEM													
					0.0008		0.0020	0.0025	0.0008	0.0008	0.0137	0.0008	
					0.0004				0.0019	0.0027	0.0008	0.0004	
									0.0019	0.0034		0.0004	
										0.0239		0.0026	
Berman Crump													
									0.0004	0.0008	0.0004		

AHERA= Asbestos hazard emergency response act
TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent

Table 4 - Ambient air meteorological data during the 2010-2011 sampling

Date	Temperature (°F) high	Temperature (°F) avg	Temperature (°F) low	Humidity (%) high	Humidity (%) avg	Humidity (%) low	Wind (mph) high	Wind (mph) avg	Wind (mph) gust	Precipitation (in) sum	Wind Direction monthly avg
12-Nov-10	64	41	26	78	47	1	0	0	7	0	WSW
13-Nov-10	66	44	28	82	53	12	0	0	2	0	
14-Nov-10	64	44	27	92	60	15	2	0	11	0	
15-Nov-10	57	49	41	84	76	58	1	0	4	0	
12-Dec-10	56	48	40	83	75	64	5	2	21	1.06	WNW
13-Dec-10	41	31	18	74	48	31	5	3	16	0	
14-Dec-10	25	21	17	55	35	25	5	4	16	0	
15-Dec-10	28	24	21	61	40	28	5	3	16	0	
12-Jan-11	30	26	22	74	56	39	5	2	23	0	WSW
13-Jan-11	29	22	8	56	42	30	4	2	15	0	
14-Jan-11	30	17	6	63	51	37	2	0	8	0	
15-Jan-11	36	26	10	65	54	40	4	1	15	0	
12-Feb-11	40	28	14	76	50	22	5	2	18	0	W
13-Feb-11	47	36	19	83	47	19	6	2	16	0	
14-Feb-11	58	47	39	56	33	12	6	3	20	0	
15-Feb-11	38	30	21	59	39	22	5	2	19	0	
15-Mar-11	51	38	24	90	57	27	4	1	14	0	WSW
16-Mar-11	58	46	38	79	67	45	3	1	12	0.66	
17-Mar-11	64	52	38	71	47	19	3	1	12	0	
18-Mar-11	79	63	46	78	40	15	4	2	13	0	
24-Apr-11	82	67	57	82	64	28	4	1	16	0.27	SSW
25-Apr-11	84	69	57	82	61	30	5	1	16	0	
26-Apr-11	79	72	63	77	56	35	8	4	23	0	
27-Apr-11	77	71	66	77	67	56	6	3	20	0.04*	
10-May-11	74	60	46	73	41	9	2	0	9	0	SW
11-May-11	72	60	44	82	52	29	2	1	9	0	
12-May-11	77	63	49	86	56	27	3	1	9	0	
13-May-11	70	60	49	79	58	43	3	1	10	0	
17-Jun-11	84	72	65	100	80	50	3	0	8	0.31	SW
18-Jun-11	87	73	60	100	78	49	2	0	7	0.01	
19-Jun-11	87	73	61	100	74	40	2	0	5	0	
20-Jun-11	81	72	63	92	71	44	4	1	8	0	
18-Jul-11	95	83	70	94	68	42	5	1	12	0	SSW
19-Jul-11	99	84	71	97	71	40	4	1	10	0.05	
20-Jul-11	92	81	68	100	78	56	5	1	10	0.01	
21-Jul-11	99	86	72	100	74	44	6	2	15	0	
10-Aug-11	86	75	64	100	76	48	1	0	4	0.11	SW
11-Aug-11	84	72	61	99	69	38	1	0	4	0.01	
12-Aug-11	86	70	54	98	68	30	2	0	7	0.01	
13-Aug-11	85	70	59	100	83	43	4	1	8	0	
29-Aug-11	78	67	53	99	73	43	2	0	3	0.04	SW
30-Aug-11	84	67	53	100	76	37	1	0	4	0	
31-Aug-11	85	68	55	100	79	40	1	0	3	0	
1-Sep-11	82	70	58	100	78	50	3	1	7	0	S
10-Sep-11	79	72	66	100	92	75	1	0	3	0.18	S
11-Sep-11	73	67	64	100	95	85	1	0	5	0.09	
12-Sep-11	84	69	62	100	89	56	2	0	5	0.13**	
13-Sep-11	85	70	59	100	84	55	3	1	9	0	
6-Oct-11	68	53	40	98	74	33	1	0	4	0	SSW
7-Oct-11	70	52	39	100	77	34	2	0	5	0	
8-Oct-11	78	57	42	100	81	42	1	0	5	0	
9-Oct-11	84	63	46	100	80	43	1	0	2	0	
20-Oct-11	70	61	54	100	77	56	9	4	18	0.05	SSW
21-Oct-11	57	52	45	91	72	58	1	0	8	0.01	
22-Oct-11	58	49	39	100	81	62	1	0	4	0	
23-Oct-11	64	49	36	100	80	49	1	0	6	0	

-Bolded dates are the actual sampling dates. The other dates are given to show rainfall prior to sampling and that ambient samples were not collected during a rain event.
-If rainfall exceeded 0.25 inches, EPA waited 24 hours to collect ambient air samples. If rainfall exceeded 0.5 inches, EPA waited 48 hours to collect ambient samples

Table 5 – Summary of PCME ABS sampling, for personal air monitors and area perimeter air data during ABS

Location	Screening Value - PCME	Personal Monitors during ABS		Ambient Air - Perimeter of ABS area	
	(f/cc)	Range (f/cc)	# Over screening value	Range (f/cc)	# Over screening
Pile	0.04	0.04 - 0.096	6 of 6	0 -0.041	1 of 9
Park	0.04	0.0012-0.2	8 of 12	0-0.17	6 of 18
Reservoir	0.04	0-0	0 of 2	0-0	0 of 3
Residential	0.04	0 -0.0094	0 of 16	0 -0.0094	0 of 24
Wissahickon and nearby walking trails	0.04	0-00-0.0008	0 of 4	0-0.005	0 of 6
Green River Sampling	0.04	0	0 of 2	0-0	0 of 3

PCME = phase contrast microscopy equivalent

Table 6 – Air sampling results (personal air monitor and area perimeter results) while ABS occurred on the Pile

Binning category (f/cc)	Residential Screening Value	Pile1				
		Child High Vol	Adult Low Vol	Perimeter Low Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	**0.041**	**0.058**	**0.041**	0.016	0.032
AHERA	NV	0.28	2.9	0.83	0.16	0.29
Total TEM	NV	0.48	4.4	1.5	0.27	0.48
Berman Crump	NV	0.014	0.087	0.016	0.008	0.017
		Pile 2				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	**0.04**	**0.096**	0	0.023	0.03
AHERA	NV	5	0.65	1.2	1.2	1.7
Total TEM	NV	5.9	1.2	1.6	1.5	2
Berman Crump	NV	0	0.03	0.012	0.069	0.06
Binning category		Pile 3				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCME (s/cc)	0.04	**0.065**	**0.13**	0.015	0.02	0.0008
AHERA (s/cc)	NV	0.8	1.0	0.29	0.51	0.032
Total TEM-ISO (s/cc)	NV	1.3	1.6	0.47	0.68	0.049
Berman Crump (s/cc)	NV	0.0081	0.0098	0.0074	0	0.0012

AHERA= Asbestos hazard emergency response act
TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent

Table 7 - Air sampling results (personal air monitor and area perimeter results) while ABS occurred on the Park

Residential Screening Value	Park1				
	Child High Vol	Adult High Vol	Perimeter High Vol	PK01-PA02-L	Perimeter High Vol
0.04	**0.04**	**0.16**	0.024	**0.14**	0.01
NV	0.67	1.5	0.15	0.74	0.086
NV	0.72	1.6	0.19	0.89	0.11
NV	0.013	0.043	0.0095	0.014	0.0043
Residential Screening Value	Park2				
	Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
0.04	**0.074**	0.009	0.00065	0	0
NV	0.26	0.11	0.065	0.019	0.0028
NV	0.31	0.12	0.073	0.023	0.0028
NV	0	0.0023	0	0.0004	0
Residential Screening Value	Park3				
	Child Low Vol	Adult High Vol	Perimeter High Vol	Perimeter Low Vol	Perimeter Low Vol
0.04	**0.086**	0.024	**0.072**	**0.09**	**0.17**
NV	1.1	1.3	0.36	1.9	1.5
NV	1.2	1.3	0.38	2	1.6
NV	0.043	0.012	0.014	0.036	0.046
Residential Screening Value	Park4				
	Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter Low Vol	Perimeter High Vol
0.04	**0.057**	0.031	0	0.019	0.0077
NV	1.5	0.54	0.44	0.94	0.77
NV	1.6	0.56	0.46	1.3	1.1
NV	0.085	0.026	0.0082	0	0.0077
Residential Screening Value	Park5				
	Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter Low Vol	Perimeter Low Vol
0.04	**0.2**	**0.46**	**0.056**	**0.05**	0.016
NV	13	6.7	0.63	0.72	0.8
NV	16	9.3	0.71	0.76	0.9
NV	0	0	0	0.014	0.016
Residential Screening Value	Park6				
	Child High Vol	Adult Low Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
0.04	**0.044**	0.0012	0.0004	0	0
NV	0.74	0.0052	0.0028	0.0004	0
NV	0.82	0.0052	0.0028	0.0004	0
NV	0	0.0008	0.0004	0	0

AHERA= Asbestos hazard emergency response act
TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent

Table 8 - Air sampling results (personal air monitor and area perimeter results) while ABS occurred near the Reservoir

Binning category (f/cc)	Residential Screening Value	Resevoir				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCME	0.04	0	0	0	0	0
AHERA	NV	0	0	0.00079	0.0012	0.00039
Total TEM	NV	0	0	0.00079	0.0012	0.00039
Berman Crump	NV	0	0	0	0	0

AHERA= Asbestos hazard emergency response act
TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent

Table 9 - Air sampling results (personal air monitor and area perimeter results) while ABS occurred on the Green River Trail data collected in June 2010 *

Location	Maximum Ambient Air		Maximum ABS	
	TEM Analysis (f/cc)	PCME Analysis (f/c	TEM Analysis (f/cc)	PCME Analysis (f/c
Green River Trail -1	0	0	0	0
Green River Trail -2	0	0	0.00098**	0
Green River Trail -3	0	0	0	0
Green River Trail -4	0	0	0	0

TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent
* Two samples collected for both ABS and ambient
** represents detection of crocidolite in the amphibole class

Table 10- Air sampling results (personal air monitor and area perimeter results) while ABS occurred on the along the Wissahickon and nearby walking trails, collected in 2011

Binning category (f/cc)	Residential Screening Value	Walking Trails				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter Low Vol
PCME	0.04	0	0	0	0.005	0
AHERA	NV	0.0036	0	0	0.13	0
Total TEM	NV	0.0048	0	0	0.14	0
Berman Crump	NV	0	0	0	0	0

Binning category (f/cc)	Residential Screening Value	Other side of the Wissahickon Creek				
		Child High Vol	Adult Low Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	0.0008	0	0	0	0
AHERA	NV	0.008	0	0.0072	0.0014	0.0008
Total TEM	NV	0.008	0	0.0072	0.0014	0.0008
Berman Crump	NV	0.0008	0	0	0	0.0004

AHERA= Asbestos hazard emergency response act
TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent
NV = no value

Table 11 - Air sampling results (personal air monitor and area perimeter results) while ABS occurred on the Residential properties

Binning category (f/cc)	Residential Screening Value	Residential 1				
		Child Low Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	0	0	0.0004	0	0
AHERA	NV	0	0.0008	0.0032	0.0008	0.0012
Total TEM	NV	0	0.0008	0.004	0.0008	0.0012
Berman Crump	NV	0	0	0	0	0
		Residential 2				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	0	0.0012	0	0	0
AHERA	NV	0.006	0.0036	0.0004	0	0
Total TEM	NV	0.0072	0.004	0.0004	0	0
Berman Crump	NV	0	0	0	0	0
		Residential 3				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter Low Vol	Perimeter Low Vol
PCMe	0.04	0	0	0.0094	0.039	0.018
AHERA	NV	3.7	3.1	0.13	0.5	0.45
Total TEM	NV	4	3.2	0.14	0.51	0.51
Berman Crump	NV	0	0.031	0.0013	0	0.0045
		Residential 4				
		Child High Vol	Adult Low Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	0.0094	0.0073	0.0004	0.0004	0
AHERA	NV	0.058	0.073	0.0012	0.0016	0.0004
Total TEM	NV	0.062	0.077	0.0012	0.0016	0.0004
Berman Crump	NV	0	0	0	0	0
		Residential 5				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	0.0016	0.00077	0	0	0.0004
AHERA	NV	0.026	0.0069	0	0	0.002
Total TEM	NV	0.035	0.008	0	0	0.0048
Berman Crump	NV	0.00039	0	0	0	0
		Residential 6				
		Child High Vol	Adult Low Vol	Perimeter High Vol	Perimeter High Vol	Perimeter Low Vol
PCMe	0.04	0.0004	0	0	0	0.0004
AHERA	NV	0.008	0.0004	0.0075	0.0036	0.0092
Total TEM	NV	0.008	0.0004	0.009	0.0044	0.01
Berman Crump	NV	0	0	0	0	0
		Residential 7				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	0	0	0.0004	0.0004	0
AHERA	NV	0.0004	0.0004	0.0008	0.0036	0
Total TEM	NV	0.0004	0.0004	0.0008	0.0044	0
Berman Crump	NV	0.0004	0	0	0	0
		Residential 8				
		Child High Vol	Adult High Vol	Perimeter High Vol	Perimeter High Vol	Perimeter High Vol
PCMe	0.04	0	0	0	0	0
AHERA	NV	0	0	0	0	0
Total TEM	NV	0	0	0	0	0
Berman Crump	NV	0	0	0	0	0

AHERA= Asbestos hazard emergency response act
TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent
NV = no value

Table 12 – Air sampling results (personal air monitor and area perimeter results) during active site activities such as monitoring well drilling (PCME)

Location	Boring or monitoring well of sampling	Sample Date	Sample Type	Asbestos result s/cc
Pile	GT-04	11/8/10	8-Hour TWA	0.017
	GT-05	11/8/10	30 Minute Excursion	<0.039
	GT-06	11/10/10	High Volume Perimeter Air	<0.005
	GT-06	11/10/10	High Vol Perimeter (North)	<0.005
	GT-06	11/10/10	High Vol Perimeter (South)	<0.005
	GT-06	11/10/10	High Vol Perimeter (West)	<0.005
	GT-06	11/10/10	8-Hour TWA	0.023
	GT-07	11/9/10	High Vol Perimeter (East)	<0.014
	GT-07	11/10/10	High Volume Perimeter Air	<0.014
	GT-07	11/9/10	High Volume Perimeter Air	<0.015
	GT-07	11/10/10	High Volume Perimeter Air	<0.014
	GT-07	11/9/10	High Vol Perimeter (South)	<0.014
	GT-07	11/10/10	High Vol Perimeter (South)	<0.014
	GT-07	11/9/10	High Vol Perimeter (West)	<0.013
	GT-07	11/10/10	High Vol Perimeter(West)	<0.014
	GT-07	11/10/10	30 Minute Excursion	<0.040
	GT-07	11/9/10	8-Hour TWA	0.038
	GT-07	11/10/10	8-Hour TWA	0.15
	GT-08	11/9/10	8-Hour TWA	<0.009
	GT-09	11/9/10	30 Minute Excursion	<0.039
	GT-09	11/9/10	8-Hour TWA	<0.023
	MW04	11/1/10	30 Minute Excursion	<0.044
	MW04	10/27/10	8-Hour TWA	<0.009
	MW04	11/1/10	8-Hour TWA	NR
	MW05	10/27/10	High Vol Perimeter (East)	<0.009
	MW05	10/28/10	High Vol Perimeter (East)	<0.008
	MW05	10/27/10	High Vol Perimeter (North)	<0.009
	MW05	10/28/10	High Vol Perimeter(North)	<0.008
	MW05	10/27/10	High Vol Perimeter (South)	<0.009
	MW05	10/28/10	High Vol Perimeter(South)	0.009
	MW05	10/27/10	High Vol Perimeter (West)	<0.009
	MW05	10/28/10	High Vol Perimeter(West)	<0.008
	MW05	10/27/10	30 Minute Excursion	<0.044
	MW05	10/29/10	30 Minute Excursion	<0.044
	MW05	10/27/10	8-Hour TWA	<0.019
	MW05	10/28/10	8-Hour TWA	NR
	MW05	10/29/10	8-Hour TWA	<0.010
	MW06	11/3/10	30 Minute Excursion	<0.044
	MW06	11/1/10	8-Hour TWA	<0.014
	MW06	11/2/10	8-Hour TWA	<0.011
	MW06	11/3/10	8-Hour TWA	<0.021
Park	MW01	10/20/10	High Vol Perimeter(East)	<0.010
	MW01	10/20/10	High Vol Perimeter(North)	<0.010
	MW01	10/20/10	High Vol Perimeter (South)	<0.011
	MW01	10/20/10	High Vol Perimeter(West)	<0.009
	MW01	10/20/10	30 Minute Excursion	<0.044
	MW01	10/21/10	30 Minute Excursion	<0.044
	MW01	10/20/10	8-Hour TWA	<0.028
	MW01	10/21/10	8-Hour TWA	<0.013
	MW01	10/26/10	8-Hour TWA	NA
	MW01	11/11/10	8-Hour TWA	<0.007
	MW01	11/11/10	8-Hour TWA	<0.015
	MW02	10/21/10	High Vol Perimeter (East)	<0.010
	MW02	10/21/10	High Vol Perimeter (North)	<0.009
	MW02	10/21/10	High Vol Perimeter (South)	<0.009
	MW02	10/21/10	High Vol Perimeter (West)	<0.009
	MW02	10/22/10	30 Minute Excursion	<0.044
	MW02	10/26/10	8-Hour TWA	<0.044
	MW02	10/21/10	8-Hour TWA	<0.015
	MW02	10/22/10	8-Hour TWA	<0.009
	MW02	10/25/10	8-Hour TWA	<0.022
	MW02	10/26/10	30 Minute Excursion	<0.014
	MW03	10/25/10	30 Minute Excursion	<0.044
	MW03	10/22/10	8-Hour TWA	0.051
	MW03	10/25/10	8-Hour TWA	<0.013
	MW04	11/11/10	30 Minute Excursion	<0.039

TWA = time weighted average

Table 12 (continued) – Air sampling results (personal air monitor and area perimeter results) during active site activities such as monitoring well drilling (PCME)

Location	Boring or monitoring well of sampling	Sample Date	Sample Type	Asbestos result s/cc
Reservoir	MW03	10/22/10	High Vol Perimeter (East)	<0.026
	MW03	10/25/10	High Vol Perimeter (East)	<0.006
	MW03	10/22/10	High Vol Perimeter(North)	<0.026
	MW03	10/25/10	High Vol Perimeter (North)	<0.006
	MW03	10/22/10	High Vol Perimeter(South)	<0.026
	MW03	10/25/10	High Vol Perimeter (South)	<0.006
	MW03	10/22/10	High Vol Perimeter (West)	<0.023
	MW03	10/25/10	High Vol Perimeter(West)	<0.006
	MW03	10/28/10	30 Minute Excursion	<0.044
	MW03	10/28/10	8-Hour TWA	<0.019
	MW04	11/2/10	30 Minute Excursion	<0.034
	MW04	11/2/10	8-Hour TWA	<0.006

TWA= time weighted average

Table 13 - Ambient Air (AA) Sampling Results for the former K&M/Nicolet Buildings both inside and outside the building (ABS occurring in buildings)

Sample Number	TEM Total Structures	TEM Air Concentration (f/cc)	PCME Total Structures	PCME Air Concentration (f/cc)
AA-1*	1	0.00022	0	0
AA-2	0	0	0	0
AA-3	0	0	0	0
AA-4	0	0	0	0
AA-5*	12	0.0049	1	0.00041 (chyrsotile)
AA-6	53	0.069	6	0.0065 (chrysotile)
				0.0013 (tremolite)
AA-7	53	0.059	2	0.0022 (chrysotile)
AA-8	20	0.0045	4	0.00089 (chrysotile)
AA-9	51	0.085	4	0.0066 (chrysotile)
AA-10	40	0.041	3	0.0031 (chrysotile)
AA-11	2	0.00079	0	0
AA-12*	2	0.0008	1	0.0004 (chrysotile)
AA-13*	1	0.00039	1	0.00039 (chrysotile)

TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent
*Samples collected outside of the K&M buildings, in ambient air. Samples AA-12 and AA-13 were collected down-wind of the buildings. The remainder of the samples was collected inside the buildings during ABS activity

Table 14 - Ambient Air (AA) Results from the former K&M/Nicolet Buildings both inside and outside the buildings (No ABS in buildings, only ambient air samples)

Sample Number	TEM Total Structures	TEM Air Concentration (f/cc)	PCME Total Structures	PCME Air Concentration (f/cc)
AA-1	No Sample Collected Due to Pump Malfunction			
AA-2	7	0.0027	0	0
AA-3	No Sample Collected Due to Pump Malfunction			
AA-4	0	0	0	0
AA-5*	0	0	0	0
AA-6	0	0	0	0
AA-7	0	0	0	0
AA-8	9	0.0037	0	0
AA-9	7	0.0069	0	0
AA-10	2	0.00065	0	0
AA-11	29	0.011	1	0.00037
AA-12*	2	0.0008	1	0.00044

AHERA= Asbestos hazard emergency response act
TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent
*Samples collected outside of the K&M buildings, in ambient air. Samples AA-12 and AA-13 were collected down-wind of the buildings. The remainder of the samples was collected inside the buildings

Table 15 – Air samples from personal air monitors during ABS (trespasser/horseplay activities) inside the former K&M/Nicolet Buildings

Sample Number	TEM Total Structures	TEM Air Concentration (f/cc)	PCME Total Structures	PCME Air Concentration (f/cc)
ABS-1 (Processing Bldg)	52	1.7	1	0.033 (chyrsotile)
ABS-2 (Processing Bldg)	55	0.35	1	0.0063 (chrysotile)
ABS-3 (Manufacturing Bldg)	59	0.62	1	0.011 (chrysotile)
ABS-4 (Manufacturing Bldg)	50	0.27	6	0.027 (chrysotile) 0.0055 (Libby amphibole)

TEM = transmission electron microscopy
PCME = phase contrast microscopy equivalent

Table 16 - Bulk (BK) Asbestos Sample Results from the former K&M/Nicolet buildings, analyzed by Polarized Light Microscopy (PLM)

Sample Number	Sample Material	% Asbestos	Asbestos Type	TEM (Asbestos Weight %)	Asbestos Type
BK-1	Fabric Material Manufacturing Building	ND	-	ND	-
BK-2	Fabric Material Manufacturing Building	ND	-	ND	-
BK-3	Fabric Material Manufacturing Building	ND	-	ND	-
BK-4	Slurry Material Manufacturing Building	39.5	Chrysotile	-	-
BK-5	Pipe Wrap Processing Building	4.75 50.25	Chrysotile Amosite	-	-

ND=non-detect
TEM = transmission electron microscopy

Appendix E: Cancer Risk Evaluation

Table 1 – Cancer risk evaluation based on the on-site personal air monitors during ABS activities

Location	Population	Exposure Duration	TWF	Exposure Years	IUR⊥	ABS Air level-PCME (f/cc)	Cancer Risk from Mean	Maximum ABS Air level-PCME (f/cc)	Cancer Risk from Maximum
Pile									
	Adult Trespassor	2 hrs day/50 days year	0.011	24	0.121	0.094	4.29E-05	0.13	5.93E-05
	Child Trespassor	2 hrs day/50 days year	0.011	6	0.055	0.048	2.49E-06	0.065	3.37E-06
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0.048	3.91E-05	0.065	5.30E-05
	On-site Worker	4 hrs day/100 days year	0.046	20	0.067	0.094	8.22E-05	0.13	1.14E-04
Park									
	Adult Trespassor	2 hrs day/50 days year	0.011	24	0.121	0.11	5.02E-05	0.46	2.10E-04
	Child Trespassor	2 hrs day/50 days year	0.011	6	0.055	0.084	4.36E-06	0.2	1.04E-05
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0.084	6.85E-05	0.2	1.63E-04
	On-site Worker	4 hrs day/100 days year	0.046	20	0.067	0.11	9.62E-05	0.46	4.02E-04
Reservior									
	Adult Trespassor	2 hrs day/50 days year	0.011	24	0.121	0	0	0	0
	Child Trespassor	2 hrs day/50 days year	0.011	6	0.055	0	0	0	0
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0	0	0	0
	On-site Worker	4 hrs day/100 days year	0.046	20	0.067	0	0	0	0

IUR⊥ = Inhalation Unit Risk, for less than lifetime exposures
TWF = Time weighted factors
PCME = Phase contrast microscopy equivalent
ABS= Activity based sampling

Table 2 – Cancer risk evaluation based on the off-site personal air monitors during ABS activities

Location	Population	Exposure Duration	TWF	Exposure Years	IUR⊥	ABS Air PCME (f/cc)	Cancer Risk from Mean	Maximum ABS Air PCME (f/cc)	Cancer Risk from Maximum
Residential Properties									
1	Adult	2 hrs day/100 days year	0.023	24	0.121	*	*	0	0
	Child	2 hrs day/100 days year	0.023	6	0.055	*	*	0	0
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	*	*	0	0
2	Adult	2 hrs day/100 days year	0.023	24	0.121	*	*	0.0012	1.14E-06
	Child	2 hrs day/100 days year	0.023	6	0.055	*	*	0	0
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	*	*	0	0
3	Adult	2 hrs day/100 days year	0.023	24	0.121	*	*	0	0
	Child	2 hrs day/100 days year	0.023	6	0.055	*	*	0	0
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	*	*	0	0
4	Adult	2 hrs day/100 days year	0.023	24	0.121	*	*	0.0094	8.90E-06
	Child	2 hrs day/100 days year	0.023	6	0.055	*	*	0.0094	1.01E-06
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	*	*	0.0094	1.59E-05
5	Adult	2 hrs day/100 days year	0.023	24	0.121	*	*	0.00077	7.29E-07
	Child	2 hrs day/100 days year	0.023	6	0.055	*	*	0.0015	1.61E-07
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	*	*	0.0015	2.54E-06
6	Adult	2 hrs day/100 days year	0.023	24	0.121	*	*	0	0
	Child	2 hrs day/100 days year	0.023	6	0.055	*	*	0.0004	4.31E-08
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	*	*	0.0004	6.77E-07
7	Adult	2 hrs day/100 days year	0.023	24	0.121	*	*	0	0
	Child	2 hrs day/100 days year	0.023	6	0.055	*	*	0	0
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	*	*	0	0
8	Adult	2 hrs day/100 days year	0.023	24	0.121	*	*	0	0
	Child	2 hrs day/100 days year	0.023	6	0.055	*	*	0	0
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	*	*	0	0
Green River Trails - 2010									
	Adult Recreational	2 hrs day/50 days year	0.011	24	0.121	0	0	0	0
	Child Recreational	2 hrs day/50 days year	0.011	6	0.055	0	0	0	0
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0	0	0	0
Walking Trails - 2011									
	Adult Recreational	2 hrs day/50 days year	0.011	24	0.121	0	0	0	0
	Child Recreational	2 hrs day/50 days year	0.011	6	0.055	0	0	0	0
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0	0	0	0
Wissahikckon Creek off-site - 2011									
	Adult Recreational	2 hrs day/50 days year	0.011	24	0.121	*	*	0	0
	Child Recreational	2 hrs day/50 days year	0.011	6	0.055	*	*	0.0008	4.15E-08
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	*	*	0.0008	6.52E-07
K&M/Nicolet Buildings									
	Adult Trespassor	2 hrs day/50 days year	0.011	24	0.067	0.0193	4.88E-06	0.033	8.34E-06
	Child Trespassor	2 hrs day/50 days year	0.011	6	0.055	0.0193	1.00E-06	0.033	1.71E-06
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0.0193	1.57E-05	0.033	2.69E-05

IUR⊥ = Inhalation Unit Risk, for less than lifetime exposures
TWF = Time weighted factors
PCME = Phase contrast microscopy equivalent
ABS= Activity based sampling
* Only one sample collected and therefore a mean value was not calculated

Table 3 - Cancer risk evaluation based on the on-site personal air monitors during active site work (such as soil borings and installation of groundwater monitoring wells)

Population	Exposure Duration	TWF	Exposure Years	IUR$^{\perp}$	Maximum 30-minute		Maximum 8 hour TWA		Maximum area perimeter	
					PCME (f/cc)	Cancer Risk	PCME (f/cc)	Cancer Risk	PCMeE(f/cc)	Cancer Risk
On-site Worker	4 hrs day/100 days year	0.046	20	0.067	<0.039		0.15	1.31E-04	0.009	7.87E-06
On-site Worker	4 hrs day/100 days year	0.046	20	0.067	< 0.039		0.051	4.46E-05	<0.009	
On-site Worker	4 hrs day/100 days year	0.046	20	0.067	<0.034		<0.006		<0.026	

IUR$^{\perp}$ = Inhalation Unit Risk, for less than lifetime exposures
PCME = Phase contrast microscopy equivalent
TWA = Time weighted average

Table 4 – Cancer risk evaluation based on the on-site area perimeter monitors during ABS activities

Location	Population	Exposure Duration	TWF	Exposure years	IUR$^{\perp}$	Mean Air Perimeter Level - PCME (f/cc)	Cancer Risk from Mean	Maximum Air Perimeter Level - PCME (f/cc)	Cancer Risk from Maximum
Pile									
	Adult Trespassor	2 hrs day/50 days year	0.011	24	0.121	0.02	9.1E-06	0.041	1.87E-05
	Child Trespassor	2 hrs day/50 days year	0.011	6	0.055	0.02	1E-06	0.041	2.13E-06
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0.02	1.6E-05	0.041	3.34E-05
	On-site Worker	4 hrs day/100 days year	0.046	20	0.067	0.02	1.7E-05	0.041	3.58E-05
Park									
	Adult Trespassor	2 hrs day/50 days year	0.011	24	0.121	0.036	1.6E-05	0.17	7.76E-05
	Child Trespassor	2 hrs day/50 days year	0.011	6	0.055	0.036	1.9E-06	0.17	8.82E-06
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0.036	2.9E-05	0.17	1.39E-04
	On-site Worker	4 hrs day/100 days year	0.046	20	0.067	0.036	3.1E-05	0.17	1.49E-04
Reservior									
	Adult Trespassor	2 hrs day/50 days year	0.011	24	0.121	0	0	0	0
	Child Trespassor	2 hrs day/50 days year	0.011	6	0.055	0	0	0	0
	Adult/Child	2 hrs day/50 days year	0.011	30	0.173	0	0	0	0
	On-site Worker	4 hrs day/100 days year	0.046	20	0.067	0	0	0	0

IUR$^{\perp}$ = Inhalation Unit Risk, for less than lifetime exposures
TWF = Time weighted factors
PCME = Phase contrast microscopy equivalent
ABS= Activity based sampling

Table 5 – Cancer risk evaluation based on the off-site area perimeter monitors during ABS events

Location	Population	Exposure Duration	TWF	Exposure years	IUR⊥	Mean Perimeter - PCME (f/cc)	Cancer Risk from Mean	Maximum Perimeter PCME (f/cc)	Cancer Risk from Maximum
Residential Properties									
1	Adult	2 hrs day/100 days year	0.023	24	0.121	0.00013	1.2E-07	0.0004	1.23E-07
	Child	2 hrs day/100 days year	0.023	6	0.055	0.00013	1.4E-08	0.0004	1.40E-08
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0.00013	2.2E-07	0.0004	2.20E-07
2	Adult	2 hrs day/100 days year	0.023	24	0.121	0	0	0	0
	Child	2 hrs day/100 days year	0.023	6	0.055	0	0	0	0
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0	0	0	0
3	Adult	2 hrs day/100 days year	0.023	24	0.121	0.022	2.1E-05	0.039	2.08E-05
	Child	2 hrs day/100 days year	0.023	6	0.055	0.022	2.4E-06	0.039	2.37E-06
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0.022	3.7E-05	0.039	3.72E-05
4	Adult	2 hrs day/100 days year	0.023	24	0.121	0.00027	2.6E-07	0.0004	2.56E-07
	Child	2 hrs day/100 days year	0.023	6	0.055	0.00027	2.9E-08	0.0004	2.91E-08
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0.00027	4.6E-07	0.0004	4.57E-07
5	Adult	2 hrs day/100 days year	0.023	24	0.121	0.00013	1.2E-07	0.0004	1.23E-07
	Child	2 hrs day/100 days year	0.023	6	0.055	0.00013	1.4E-08	0.0004	1.40E-08
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0.00013	2.2E-07	0.0004	2.20E-07
6	Adult	2 hrs day/100 days year	0.023	24	0.121	0.00013	1.2E-07	0.0004	1.23E-07
	Child	2 hrs day/100 days year	0.023	6	0.055	0.00013	1.4E-08	0.0004	1.40E-08
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0.00013	2.2E-07	0.0004	2.20E-07
7	Adult	2 hrs day/100 days year	0.023	24	0.121	0.00027	2.6E-07	0.0004	2.56E-07
	Child	2 hrs day/100 days year	0.023	6	0.055	0.00027	2.9E-08	0.0004	2.91E-08
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0.00027	4.6E-07	0.0004	4.57E-07
8	Adult	2 hrs day/100 days year	0.023	24	0.121	0	0	0	0
	Child	2 hrs day/100 days year	0.023	6	0.055	0	0	0	0
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0	0	0	0
Green River Trails - 2010									
	Adult Recreational	1 hrs day/100 days year	0.011	24	0.121	0	0	0	0
	Child Recreational	1 hrs day/100 days year	0.011	6	0.055	0	0	0	0
	Adult/Child	1 hrs day/100 days year	0.011	30	0.173	0	0	0	0
Walking Trails - 2011									
	Adult Recreational	1 hrs day/100 days year	0.011	24	0.121	0.00125	5.7E-07	0.005	2.28E-06
	Child Recreational	1 hrs day/100 days year	0.011	6	0.055	0.00125	6.5E-08	0.005	2.59E-07
	Adult/Child	1 hrs day/100 days year	0.011	30	0.173	0.00125	1E-06	0.005	4.08E-06
Wissahikckon Creek off-site - 2011									
	Adult Recreational	1 hrs day/100 days year	0.011	24	0.121	0	0	0.0008	3.65E-07
	Child Recreational	1 hrs day/100 days year	0.011	6	0.055	0	0	0.0008	4.15E-08
	Adult/Child	1 hrs day/100 days year	0.011	30	0.173	0	0	0.0008	6.52E-07
K&M/Nicolet Buildings									
	Adult	2 hrs day/100 days year	0.023	24	0.121	0.0003	2.8E-07	0.0004	3.79E-07
	Child	2 hrs day/100 days year	0.023	6	0.055	0.0003	3.2E-08	0.0004	4.31E-08
	Adult/Child	2 hrs day/100 days year	0.023	30	0.173	0.0003	5.1E-07	0.0004	6.77E-07

IUR⊥ = Inhalation Unit Risk, for less than lifetime exposures
TWF = Time weighted factors
PCME = Phase contrast microscopy equivalent
ABS= Activity based sampling

Table 6 – Cancer risk evaluation based on the 2010-2011 ambient air sampling data

Monitoring Station	Population	Exposure Duration	TWF	Exposure Years	IUR ⊥	Mean Ambient Air Level PCMe (f/cc)	Cancer Risk from Mean	Maximum Ambient Air Level PCMe (f/cc)	Cancer Risk from Maximum
1	Adult	24hrs days/350 days yr	0.960	24	0.121	0		0.001	3.98E-05
	Child	24hrs days/350 days yr	0.960	6	0.055	0		0.001	4.53E-06
	Adult/Child	24hrs days/350 days yr	0.960	30	0.173	0		0.001	7.12E-05
2	Adult	24hrs days/350 days yr	0.960	24	0.121	0		0	
	Child	24hrs days/350 days yr	0.960	6	0.055	0		0	
	Adult/Child	24hrs days/350 days yr	0.960	30	0.173	0		0	
3	Adult	24hrs days/350 days yr	0.960	24	0.121	0		0	
	Child	24hrs days/350 days yr	0.960	6	0.055	0		0	
	Adult/Child	24hrs days/350 days yr	0.960	30	0.173	0		0	
4	Adult	24hrs days/350 days yr	0.960	24	0.121	0.00005	1.99E-06	0.0008	3.19E-05
	Child	24hrs days/350 days yr	0.960	6	0.055	0.00005	2.26E-07	0.0008	3.62E-06
	Adult/Child	24hrs days/350 days yr	0.960	30	0.173	0.00005	3.56E-06	0.0008	5.69E-05
5	Adult	24hrs days/350 days yr	0.960	24	0.121	0		0	
	Child	24hrs days/350 days yr	0.960	6	0.055	0		0	
	Adult/Child	24hrs days/350 days yr	0.960	30	0.173	0		0	
6	Adult	24hrs days/350 days yr	0.960	24	0.121	0		0	
(Background)	Child	24hrs days/350 days yr	0.960	6	0.055	0		0	
	Adult/Child	24hrs days/350 days yr	0.960	30	0.173	0		0	
7	Adult	24hrs days/350 days yr	0.960	24	0.121	0		0	
	Child	24hrs days/350 days yr	0.960	6	0.055	0		0	
	Adult/Child	24hrs days/350 days yr	0.960	30	0.173	0		0	
7b	Adult	24hrs days/350 days yr	0.960	24	0.121	0.0001	3.98E-06	0.0008	3.19E-05
	Child	24hrs days/350 days yr	0.960	6	0.055	0.0001	4.53E-07	0.0008	3.62E-06
	Adult/Child	24hrs days/350 days yr	0.960	30	0.173	0.0001	7.12E-06	0.0008	5.69E-05

IUR⊥ = Inhalation Unit Risk, for less than lifetime exposures
TWF = Time weighted factors
PCME = Phase contrast microscopy equivalent
ABS= Activity based sampling

Sample Calculation for Cancer Risk Evaluation

Estimated cancer risk = EPC x TWF x IUR⊥

For example: Excess cancer risk for an adult trespasser to the pile (based on maximum personal air monitoring data collected during ABS)

$$= 0.13 \text{ f/cc} \times \left(\frac{2 \text{ hours per day}}{24 \text{ hours per day}} \times \frac{50 \text{ days per year}}{365 \text{ days per year}}\right) \times 0.11 \text{ f/cc}$$

= 5.93E-05 (or 6 estimated cancer for 100,000 exposed)

IUR ⊥ = Inhalation Unit Risk for less than life-time exposure, derived from the EPA Asbestos Framework Document

EPC= Exposure point concentration, or the concentration of asbestos fibers in air (f/cc) for the specific activity being assessed

TWF = Time weighted factor. This factor accounts for a less-than-continuous exposure and is based on:

$$\text{TWF} = \frac{\text{Exposure time (hours per day)}}{24 \text{ hours}} \times \frac{\text{Exposure frequency (days/year)}}{365 \text{ days}}$$

TWF (adult, 24 hours per day, 350 days per year) =

$$= \frac{24 \text{ hours per day}}{24 \text{ hours}} \times \frac{350 \text{ days per year}}{365 \text{ days}}$$

= 0.96

Appendix F: Health Outcome Data

Table F-1 - Cancer Incidence Rates for Ambler PA Zip Code 19002 (1990-2011) Expressed as the Ratio of the Ambler Rate to Pennsylvania's Rate [SIR]

Type	Cases Diagnosed #	Cases Expected	SIR	
Mouth	67	85.6	**0.78**	*
Esophagus	32	45.8	**0.70**	*
Stomach	48	66.2	**0.73**	*
Colon-Rectum	396	555.0	**0.71**	*
Pancreas	93	96.7	**0.96**	n.s.
Lung	419	580.8	**0.72**	*
Mesothelioma	32	11.8	***2.71***	*
Melanoma	116	155.6	**0.75**	n.s.
Breast	565	708.2	**0.80**	*
Uterus	117	137.0	**0.85**	n.s.
Ovary	53	67.2	**0.79**	n.s.
Prostate	577	623.1	**0.93**	n.s.
Kidney	102	116.8	**0.87**	n.s.
Bladder	138	213.8	**0.65**	*
Thyroid	87	77.0	**1.13**	n.s.
Brain	63	53.2	**1.18**	n.s.
NH Lymphoma	166	163.9	**1.01**	n.s.
Hodgkin's disase	19	22.0	**0.86**	n.s.
Leukemias	98	103.0	**0.95**	n.s.
All Sites	3,596	4460.5	**0.81**	*

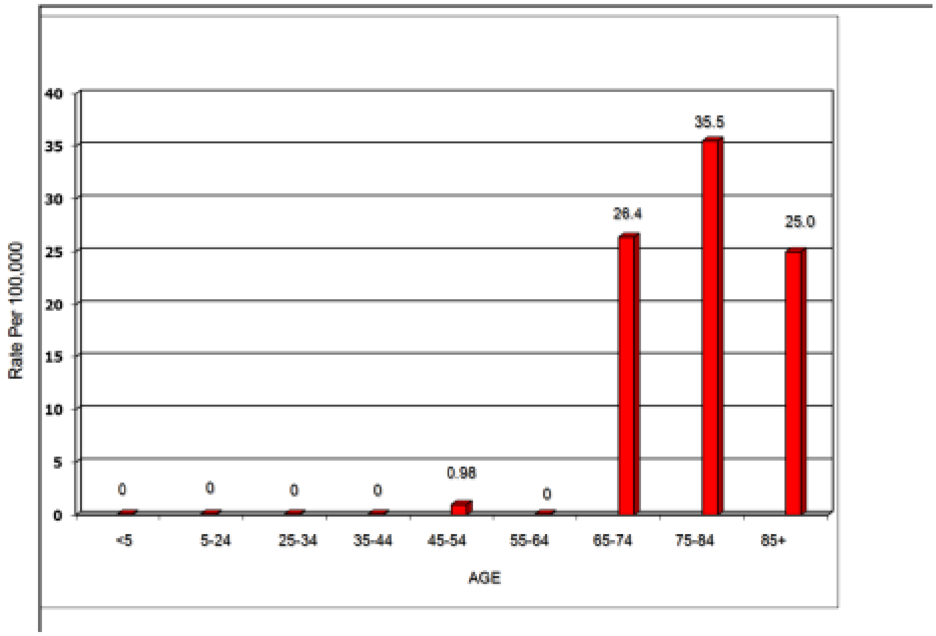
 # Source; Pennsylvania Cancer Registry, PADOH

+ SIR = Standardized Incidence Ratio = Ambler Rate / PA Rate;
** = Statistically significant*
n.s.= Not statistically significant

Table F-2 - Cancer Incidence for Ambler, PA Zip Code 19002 (1990-2011), by Gender

		Total	Males	Females
1990-2011	All Cancers*	3,596	1,748	1,848
	Oral Cavity and Pharynx	67	38	29
	Esophagus	32	23	9
	Stomach	48	29	19
	Colon and Rectum	396	183	213
	Liver and Intrahepatic Bile Duct	33	24	9
	Pancreas	93	43	50
	Larynx	27	21	6
	Lung and Bronchus	419	211	208
	Melanoma of the Skin	116	69	47
	Breast	565	2	563
	Cervix Uteri	24	0	24
	Corpus and Uterus, NOS	117	0	117
	Ovary	53	0	53
	Prostate	577	577	0
	Testis	22	22	0
	Urinary Bladder**	138	94	44
	Kidney and Renal Pelvis	102	57	45
	Brain and Other Nervous System	63	33	30
	Thyroid	87	25	62
	Non-Hodgkin Lymphoma	166	89	77
	Hodgkin Lymphoma	19	5	14
	Myeloma	41	22	19
	Leukemia	98	51	47
	Mesothelioma	32	23	9
	All Other Sites	261	107	154

Figure F-1 – Mesothelioma Incidence Rates for Ambler Zip Code 19002 (1990- 2011), by Age



Discussion of Health Outcome Data Analysis

Health outcome data evaluations are measures of disease occurrence in a defined population. Such evaluations can help to provide an overall picture of community health, and can potentially identify or confirm excess disease in a community. However, elevated rates of a particular disease may not necessarily be caused by hazardous substances in the environment. Other factors, such as socioeconomic status, occupation, and lifestyle, also may influence the development of disease. In contrast, a contaminant can contribute to illness or disease without being reflected in the available health outcome data. Certain cases may not appear in the disease registry, due to under reporting or difficulty in diagnosing the condition. In addition, since mesothelioma has a long latency period (i.e. 30 years), any elevated incidence rates detected by the analysis provide information on historical exposures potentially related to the site but do not reflect current site conditions or exposure levels.

There are many limitations, like any statistical analysis, to using the existing data to examine the relationship between environmental exposures and chronic diseases such as cancer. First, the quality of the information is directly related to the accuracy of the reporting system, and under reporting of cases is possible. However, in general Pennsylvania is considered to have a highly reliable cancer registry. Second, the analysis can only determine whether there is an increased rate of cancer in the study area. Cause and effect relationships cannot be established because other factors that may contribute to the observation, such as heredity, lifestyle, environmental exposures from other sources, and occupational exposures are unable to be accounted for. Third, the cancer registry uses only the residence of the individual at the time he or she was diagnosed with the disease. Information on previous residence and length of residency are not included in the cancer registry. Population mobility and changes in population could affect the results of this analysis. For example, a life-long Ambler resident who moves from the area and is later diagnosed with mesothelioma elsewhere would not be detected in the analysis. Fourth, since mesothelioma and lung cancer have a long latency period (30 years), the current health outcome data reflect past exposures and do not correspond to current site conditions. Most of these limitations would make it less likely (as opposed to more likely) that this health outcome data analysis would identify any potentially elevated rates of asbestos-related cancers in the communities living near the BoRit site.

In order to know whether the study areas had high cancer incidence rates, the observed number of cancers was compared to the Commonwealth of Pennsylvania. The cancer rate for the Commonwealth as a whole was used to calculate an expected number of cancer rates that would have hypothetically occurred in the study ZIP codes over the same period of time. The "observed cases", theoretically, should not vary significantly from the Commonwealth as a whole. The evaluation of cancer incidence was performed using the SIR or the ratio of the observed number of cancer incidence divided by the expected number (O:E). The interpretation of the SIR has inherent limitations. Any conclusions drawn from the ratios depend on both the ratio value and the total number of observed and expected cases. Two ratios can have the same value but be interpreted differently. For example, a ratio of 1.5 based on 2 expected cases and 3 observed cases indicates a 50% excess in cancer, but the excess is actually only a single case. However, a ratio of 1.5 based on 200 expected cases and 300 observed cases represents the same 50% excess in cancer, but because it is based upon a greater number of cases, the estimate is less likely to be attributable to chance.

Rates based on rare events over a specified period of time or sparsely populated geographic area are inherently unstable. For cancer types with a small number of cases (<5 observed cases), statistical results can be difficult to interpret. Statistical evaluations are more stable with a larger sample population (i.e. observed and expected cases) and over multiple years of study. In order to detect increases in cancer risk for a relatively rare cancer, large study populations are required. Therefore, the population of a ZIP Code needs to be large enough to reliably calculate the relevant cancer incidence rates, and to rule out any fluctuations in cancer rates due to chance variation. Mesothelioma is a relatively rare cancer and selecting a narrow study area would not be useful in detecting changes in cancer incidence rates. Chance variation is expected when looking at the occurrence of different health conditions in communities, and statisticians have developed methods to take this into account. One method is to calculate a 95% confidence interval (CI) for the SIR. The 95% CI is the range of estimated ratio values that has a 95% probability of including the true ratio for the population and is a statistical measure of precision. "Statistically significant" means there is less than 5% chance that the observed difference is merely the result of random fluctuation. The z-score, a tool used to determine statistical significance, indicates how far, and in what direction, the observed rates deviate from the mean, expressed in units of standard deviation. If a confidence interval z-score is above + 1.96, it implies there is a statistically significantly higher rate than would be expected. Similarly, if the confidence interval z-score is below - 1.96, then the number of cases is statistically significantly lower than expected.

Appendix G: Site Photograph

Photo#1 -2012 aerial view of the Pile parcel, with trees removed and clean fill covering

Appendix H: Glossary of Terms

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Activity Based Sampling
approach in which airborne concentrations of asbestos are measured during an event where the source material (soil or dust) is disturbed rather than predicted or modeled from source material concentration.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs 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 functions or cell structure that might lead to disease or health problems

Ambient
Surrounding (for example, ambient air).

Amphibole asbestos
Amphibole asbestos includes amosite, crocidolite, and fibrous forms of tremolite, anthophyllite, and actinolite

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Asbestos
any of several minerals that readily separate into long flexible fibers, that cause asbestosis and have been implicated as causes of certain cancers, and that have been used especially formerly as fireproof insulating materials

Asbestosis
A non-cancerous disease associated with inhalation of asbestos fibers and characterized by scarring of the air-exchange regions of the lungs

Asbestos Hazard Emergency Response Act (AHERA)
In 1986, the Asbestos Hazard Emergency Response Act (AHERA) was signed into law as Title II of the Toxic Substance Control Act. Additionally, the Asbestos School Hazard Abatement Reauthorization Act (ASHARA), passed in 1990, requires accreditation of personnel working on asbestos activities in schools and public and commercial buildings. See applicability discussion

Aspect Ratio
Length to width ratio of a particle or fiber.

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Cancer
Any one 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 getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

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]

Chrysotile
fibrous member of the serpentine group of minerals. It is the most common form of asbestos used commercially, also referred to as white asbestos..

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns 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. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

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

Crocidolite
A type of asbestos in the amphibole group; it is also known as blue asbestos.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Direct Preparation
In direct preparation, the filter is examined by microscopy. In contrast with indirect preparation, where a filter with too much material undergoes a separation step (commonly dispersion in water) to allow for analysis.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

EPA
United States Environmental Protection Agency.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Fibers per cubic centimeter (f/cc)
Units of measurement for asbestos in air.

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

Hazard
A source of potential harm from past, current, or future exposures.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Indirect Method
A method whereby a filter with too much material undergoes a separation step to allow for analysis.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Inhalation Unit Risk
The excess lifetime cancer risk estimated to result from continuous exposure to an agent

Integrated Risk Information System (IRIS)
EPA's IRIS systemis a human health assessment program that evaluates information on health effects that may result from exposure to environmental contaminants. The IRIS database is web accessible and contains information on more than 550 chemical substances.

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

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Mesothelioma
A malignant tumor of the covering of the lung or the lining of the pleural and abdominal cavity often associated with exposure to asbestos.

mg/kg
Milligram per kilogram.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

PCM equivalent
This refers to chrysotile and amphibole structures identified through transmission electron microscopy (TEM) analysis that are equivalent to those that would be identified in the same sample through phase contrast microscopy analysis, with the main difference being that TEM additionally permits the specific identification of asbestos fibers. PCME structures are asbestiform structures greater than 5 microns in length having at least a 3 to 1 length to width (aspect) ratio.

Personal Air Monitor
Also known as a low-flow or low-volume sample pump, this is an air sample pump that is portable so that it can be worn by a member of the sampling team during activity based sample collection. The air flow for a personal sample pump is typically 1 to 10 liters per minute.

Phase Contrast Microscopy
A light-enhancing microscope technology that employs an optical mechanism to translate small variations in phase into corresponding changes in amplitude, resulting in high-contrast images. Historically, this method was used to measure airborne fibers in occupational environments; however, it cannot differentiate asbestos fibers from other fibers.

ppb
Parts per billion.

ppm
Parts per million.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action
A list of steps to protect public health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclide’s that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public meeting
A public forum with community members for communication about a site.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

Risk
The probability that something will cause injury or harm.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or an environment.

Serpentine
name given to several members of a polymorphic group of magnesium silicate minerals--those having essentially the same chemistry but different structures or forms. Chrysotile asbestos is a member of the serpentine group

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Transmission Electron Microscope
A microscope technology and an analytical method to identify and count the number of asbestos fibers present in a sample. It uses the properties of electrons to provide more detailed images than polarized light microscopy (PLM). Capable of achieving a magnification of 20,000x.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and

progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

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)