Health Consultation

Zonolite/W.R. Grace Site

35 Industrial Drive
Hamilton Township, Mercer County, New Jersey

CERCLIS Number: NJD067387472

Prepared by:

New Jersey Department of Health and Senior Services
Division of Public Health Protection and Emergency Preparedness

Under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Foreword: ATSDR's National Asbestos Exposure Review

Vermiculite was mined and processed in Libby, Montana, from the early 1920s until 1990. We now know that this vermiculite, which was shipped to many locations around the United States for processing, contained asbestos.

The National Asbestos Exposure Review (NAER) is a project of the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is working with other federal, state, and local environmental and public health agencies to evaluate public health impacts at sites that processed Libby vermiculite.

The evaluations focus on the processing sites and on human health effects that might be associated with possible past or current exposures. They do not consider commercial or consumer use of the products of these facilities.

The sites that processed Libby vermiculite will be evaluated by (1) identifying ways people could have been exposed to asbestos in the past and ways that people could be exposed now and (2) determining whether the exposures represent a public health hazard. ATSDR will use the information gained from the site-specific investigations to recommend further public health actions as needed. Site evaluations are progressing in two phases:

Phase 1: ATSDR has selected 28 sites for the first phase of reviews on the basis of the following criteria:

- The U.S. Environmental Protection Agency (EPA) mandated further action at the site based upon contamination in place

- or -

- The site was an exfoliation facility that processed more than 100,000 tons of vermiculite ore from Libby mine. Exfoliation, a processing method in which ore is heated and "popped," is expected to have released more asbestos than other processing methods.

The following document is one of the site-specific health consultations ATSDR and its state health partners are developing for each of the 28 Phase 1 sites. A future report will summarize findings at the Phase 1 sites and include recommendations for evaluating the more than 200 remaining sites nationwide that received Libby vermiculite.

Phase 2: ATSDR will continue to evaluate former Libby vermiculite processing sites in accordance with the findings and recommendations contained in the summary report. ATSDR will also identify further actions as necessary to protect public health.

Statement of Issues

Vermiculite is a naturally occurring fibrous mineral mined in Libby, Montana from the 1920s until 1990. The vermiculite mined in Libby contained naturally occurring asbestos fibers, including the amphibole varieties tremolite and actinolite, as well as the related asbestiform minerals winchite, richterite, and ferro-edenite (U.S. Geological Survey 2002). Libby vermiculite ore collected by the U.S. Environmental Protection Agency (EPA) in 1980 contained up to 26% tremolite-actinolite by mass (EPA 1982). Samples of the various grades of unexpanded Libby vermiculite typically shipped to processing sites across the nation contained 0.3-7% fibrous tremolite-actinolite by mass (EPA 1982). The characteristic composition of asbestos contained in vermiculite mined in Libby is referred to in this document as Libby asbestos.

Asbestos exposure has been associated with the incidence of asbestosis, lung cancer, mesothelioma, and pleural plaques. Asbestosis is a chronic, degenerative lung disease caused by the scarring of lung tissue. Mesothelioma, a rare disease, is a cancer of the membranes which line the chest (pleural) or abdominal (peritoneal) cavities. Asbestos exposure has also been associated with lung cancer and, to a lesser extent, gastrointestinal cancers (esophageal, stomach, colon, and rectal). Asbestos exposure may also result in other non-cancerous effects of the respiratory system (e.g., pleural plaques which are a thickening of the lining of the lungs) (Appendix A).

Seven New Jersey facilities have been identified by the EPA to have received vermiculite ore from the Libby mine. This health consultation addresses one of the New Jersey facilities, the former Zonolite/W.R. Grace facility in Hamilton Township, Mercer County, which was the only exfoliating facility in New Jersey. Exfoliation is a process that expands the vermiculite mineral layers; this process is likely to release more asbestos than other processes which utilize vermiculite in its unexpanded state (e.g., some gypsum board manufacturing processes) (EPA 1985).

The New Jersey Department of Health and Senior Services (NJDHSS), in conjunction with the Agency for Toxic Substances and Disease Registry (ATSDR), has prepared a health consultation for the Hamilton Township site. The main goal of this effort was to evaluate the health impact of exposure to Libby asbestos and to propose appropriate actions at the Zonolite/W.R. Grace site. This health consultation includes: 1) a review of available information on environmental contamination; 2) identification of past and current human exposure pathways to Libby asbestos; 3) an evaluation of the public health implications of these exposures; and 4) recommendations for health-related follow-up activities.

Background

Vermiculite

Vermiculite is the common name given to hydrated laminar magnesium-aluminum-iron-silicate which resembles mica in appearance. All vermiculite ores contain a range of other minerals formed along with the vermiculite in the rock. Vermiculite ores from some sources have been found to contain asbestos fibers. Vermiculite mining is a surface operation where ore is separated from other minerals, then screened or classified into several particle sizes. When subjected to heat, vermiculite has the unusual property of exfoliating or expanding into worm-like pieces (the name vermiculite is derived from the Latin 'vermiculare' - to breed worms). This characteristic of exfoliation, the basis for commercial use of the mineral, is the result of the mechanical separation of the layers by the rapid conversion of contained water to steam. The increase in bulk volume of commercial grades of vermiculite is 8 to 12 times, but individual flakes may expand as much as 30 times. There is a color change during expansion that is dependent upon the composition of the vermiculite and furnace temperature. Vermiculite is found in various parts of the world. Currently, the predominant commercial mines are in Australia, Brazil, China, Kenya, South Africa, United States, and Zimbabwe.

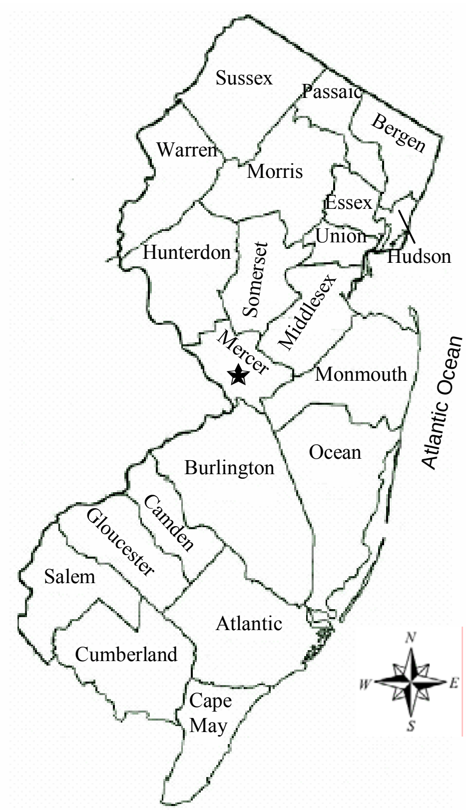

Figure 1: Location of Zonolite/W.R. Grace Site

In the 1920s, the Zonolite Company was formed and began mining vermiculite ore in Libby, Montana. Later sold to the W.R. Grace & Company, the mine was finally closed in 1990. While in operation, the vermiculite mine in Libby may have produced 80% of the world's supply of vermiculite. Not all vermiculite contains asbestos, and it is still mined worldwide. Vermiculite has been used as loose fill insulation, fertilizer carrier, and an aggregate for concrete. The raw vermiculite ore is used in gypsum wallboard, joint compound, cinder block, and many other building products.

Site Description

The Zonolite/W.R. Grace site is located at 35 Industrial Drive in Hamilton Township, Mercer County, New Jersey (Figure 1). The 8.44 acre site is situated in a zoned industrial area, with the nearest residence about 0.25 miles to the west. The property is comprised of two lots. The northwestern lot (Block 1581, Lot 19.01) is 4.24 acres and includes a parking lot and a large brick building currently owned by MLB Properties, LLC. This building was used in the past to house the vermiculite processing facility. The building is now leased to an affiliated company, Accurate Document Destruction, Inc. of New Jersey (ADDI) (see Photograph 1). ADDI runs a paper shredding and recycling operation at the site. Lot 19.01 also includes a building with storage and truck loading docks as well as a truck weighing station. The southeastern lot (Block 1581, Lot 19.02) is 4.2 acres and was a heavily wooded area with dense undergrowth. This lot is owned by the Amtrak railroad. Amtrak also owns property to the north and east, known as the Millham Yard. The site is bounded on the east by Amtrak train tracks. There is a vacant lot to the northwest, and other commercial and industrial buildings to the south and southwest. The site is partially fenced, and only accessible from the south via Industrial Drive.

Based on the 2000 United States Census data, ATSDR estimates that there are approximately 4,000 homes with more than 10,000 individuals living within one mile of the site (Figure 2). Children six years of age and younger represent nearly 10% of the total population in this area.

The Zonolite Company began vermiculite exfoliation operations at the site on land leased from the Penn Central Transportation Corporation/Amtrak Railroad in 1948. The vermiculite-based products included structural fireproofing (MonoKote®), thermal insulation for masonry, lightweight concrete aggregates, and horticultural vermiculite. Chrysotile asbestos was added to the MonoKote® to increase its fireproofing properties. In 1963, W.R. Grace & Company purchased Zonolite and continued exfoliation operations until the early 1990s. The property was vacant from the time W.R. Grace closed the facility until ADDI began its paper shredding and recycling operation in January 2000.

The Zonolite/W.R. Grace facility used three vermiculite expanding furnaces and one mixer for the manufacture of vermiculite-based products. Most of the raw vermiculite was obtained from the Zonolite/W.R. Grace mine located in Libby, Montana. From 1966 through 1988, an estimated 317,870 tons (representing 3,346 shipments) of vermiculite ore was received by the facility (unpublished information from EPA's database of W.R. Grace invoices). Actual tonnage shipped to this facility may be higher or lower. In response to an EPA Region 2 request, W.R. Grace reported that from 1957 through 1991, 197,076 tons of vermiculite was shipped to the Hamilton facility[1]. A separate inquiry into the Libby shipping invoice database revealed that the total tonnage shipped to Hamilton was 357,724[2]. Variations in the tonnage estimates may be due to duplicate invoices, a lack of invoices for all the years of operation, and inaccuracies in

[1] Response for information from Nelson, Mullins, Riley & Scarborough, LLP, to Michael Ferriola, EPA Region 2, March 28, 2001.
[2] Invoice inquiry dated February 1, 2001.

collecting and estimating totals from thousands of invoices.

In 1995, W.R. Grace retained Environmental Resources Management, Inc. to conduct a Preliminary Assessment/Site Investigation of the facility. Based on the results of this investigation and in accordance with the New Jersey Industrial Site Recovery Act (N.J.S.A. 13:1K-6), the New Jersey Department of Environmental Protection (NJDEP) approved the site for no further action (NFA) in November 1995. This approval allowed W.R. Grace to close the facility and transfer ownership of the property.

Since the Zonolite/W.R. Grace site was an exfoliation facility that processed more than 100,000 tons of vermiculite ore, it was identified as a potential problem by the ATSDR following a national evaluation of facilities that received vermiculite ore from the Libby, Montana mine.

Site Visit

On November 19, 2002, James Pasqualo, Jeffrey Winegar, Stella Tsai, and Mary Baird of the NJDHSS conducted a site visit at the Zonolite/W.R. Grace site. The NJDHSS team was accompanied by the EPA Region 2 On-Scene Coordinator (OSC) Michael Ferriola. Also present were representatives of the Hamilton Township Division of Health and the Lawrenceville Health Department. The OSC led the group on a walk-through of the grounds of the property and described the site history and present conditions. The following observations were made during the site visit:

- The site is located in an industrial area. The closest residences are several blocks away (approximately 0.25 miles).

- The former Zonolite/W.R. Grace facility is currently occupied by ADDI, a paper shredding and recycling operation. The large, one-story brick building has an attached office and a concrete pad area in the back where vermiculite storage silos were located.

- An asphalt parking lot is located in front (i.e., the south side) of the brick building. On the southeastern side of the building is an unpaved, dirt parking lot and a truck weighing station. Several truck trailers were parked on the property. The areas beyond the dirt were covered with weeds, understory plant growth, and woods.

- Access to the site is uncontrolled due to the lack of a continuous fence.

- At various locations on the site and around the building, vermiculite was observed mixed into the top soil (see Photographs 2, 3, and 4). It is not known at this time if this material has spread beyond the site boundary.

- Areas with soil asbestos levels at or above 1% were cordoned with orange safety netting.

These areas of concern are mainly located at the eastern portion of the site adjacent to the parking lot (Figure 3). EPA is conducting a removal action (i.e., excavation and offsite disposal of contaminated soils) for these areas. The first phase removal action began in November 2003 and was completed in March 2004. It should be noted that the conditions that are described in this health consultation are based upon the conditions that existed prior to the start of the EPA removal action.

- No on-site piles of vermiculite or vermiculite waste rock were observed.

On July 16, 2003, a second site visit was performed by representatives of the NJDHSS. The purpose of the site visit was to assess the present status of the cordoned Libby asbestos contaminated areas. Staff present were Julie Petix, Steven Miller, Sharon Kubiak and Tariq Ahmed. White vermiculite debris was observed within the cordoned areas established by the EPA. While inspecting the exterior property, staff were met by the ADDI plant manager and the property owner. The property owner stated that he would like to erect a fence to keep out trespassers who dump on the property. He added that two teenagers (approximately 12-15 years of age) routinely ride their bicycles in the ADDI parking lot. The property owner has not observed trespassers going beyond the orange safety netting that delineate the asbestos contaminated areas. The property owner also stated that he would like to expand ADDI operations to include the recycling of cans, glass, and plastic and is eager for the property to be remediated.

Soil Contamination

On October 5, 2000, the EPA Environmental Response Team (EPA-ERT) and its contractor conducted limited soil sampling at the former Zonolite/W.R. Grace site. A total of 24 samples were collected for asbestos analysis by both Polarized Light Microscopy (PLM) (Method EPA 600/R-93/116) and Transmission Electron Microscopy (TEM) (Method NYS ELAP 198.4 X). Sampling locations were determined using historical aerial photographs for the time period 1944 through 1999 obtained from the Environmental Photographic Interpretation Center (EPA 2001a). Other factors considered in establishing sampling grids were locations of former waste piles, surface runoff pathways, and prevailing wind directions. Samples were collected from the surface (0-3 inches) and subsurface (18-24 inches) at nine locations and at an additional six locations for surface samples only. Results indicated asbestos concentrations of up to 2.9% tremolite asbestos and up to 3.9% chrysotile asbestos.

On March 28, 2001, the EPA-ERT collected surface and subsurface soil samples from locations previously sampled during the October 2000 investigation. The purpose of re-sampling was to implement the EPA Region I Standard Operating Procedure for the Screening Analysis of Soil and Sediment Samples for Asbestos Content. Thirteen samples were collected, and up to 4.5% tremolite/actinolite asbestos and 2.7% chrysotile asbestos were detected.

Another subsequent, more intensive soil sampling was conducted by the EPA's Removal Support Team (RST) in August 2001 (EPA 2001b). Based on earlier sampling results, EPA defined a sampling strategy to include the entire 8.44 acre site (Lots 19.01 and 19.02). The sampling area was divided into 50 feet grids, and surface and subsurface samples were collected from each grid node. Samples were analyzed for asbestos using California Air Resources Board (CARB) 435 PLM methodology; 30 samples were also analyzed using the TEM method (see Appendix A). Approximately 25% of the sampling locations had asbestos concentrations ≥1%, with the majority of the elevated concentrations in subsurface soils. Only six of the 110 (6%) surface soil samples contained asbestos levels ≥1%. The elevated levels were clustered at the eastern portion of the site with the highest asbestos concentrations (>4%) detected in the wooded areas and subsurface soil (Figure 3). This is consistent with the historical aerial photograph shown in Figure 4. Of the 30 samples analyzed using the TEM method, concentrations of up to 6.4% asbestos, measured as actinolite, were detected.

No off-site (i.e., residential and other adjacent properties) soil sampling has been conducted near the Zonolite/W.R. Grace site to date.

Industrial Hygiene (IH) Monitoring

In response to an EPA inquiry, W.R. Grace provided on-site IH sampling results from 1986 through 1991. A number of workplace hazard indicators were monitored, including respirable (i.e., breathable) asbestos fibers, total dust, respirable dust, respirable crystalline silica, and noise. Selected air sample locations included work areas near the retroguard bagger, forklift operator, receptionist, retroguard mixer, and sweeper/cleaner. In addition, samples were collected from the baghouse and waste rock drop areas for respirable asbestos fibers. The results indicated that exposures to respirable crystalline silica and respirable asbestos fibers during the years 1986 through 1991 were below regulatory limits. Exposure to total dust to the retroguard mixer and retroguard bagger, however, were above the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 10 milligrams of total dust per cubic meter (mg/m^3) of air.

Additional IH data from W.R. Grace were obtained by the EPA through an informal 104(e) request. Past air data at the Zonolite/W.R. Grace site as well as data from other W.R. Grace-owned facilities indicated that former employees were exposed to much higher levels of asbestos in air (unpublished information from EPA database of W.R. Grace documents; J. Durant, ATSDR, personal communication, 2003). The data also show that airborne asbestos concentrations decreased over time as a result of improvements in the implementation of pollution control and dust suppression methods.

Post Closure Sampling

In response to an EPA Region 2 inquiry, W.R. Grace provided a "close-out" IH evaluation report for the site. The report documented the effectiveness of plant clean-up procedures after equipment removal and plant washdown were completed. Air samples were collected from warehouse and production areas, and building exterior (silo area). The Occupational Safety and Health Administration (OSHA) time-weighted average (TWA) was calculated for these areas and was found to be below the 0.1 asbestos fibers per cubic centimeter of air (f/cc) permissible exposure limit (PEL).

Community Concerns

In order to gather information on community health concerns regarding the site, the NJDHSS reviewed records containing complaint information received by the NJDHSS and, in later years, the NJDEP Central Field Office. During the entire operation period of Zonolite/W.R. Grace, there were numerous concerns and complaints about fugitive dusts from the facility. Most complaints were made by nearby businesses. In the early 1970s, complaints from at least one residential neighborhood located north of the facility were about unknown white particulate material. At the time, the NJDEP determined that this material was likely associated with the site.

The NJDHSS and ATSDR expect to document additional community concerns upon interviewing nearby residents as part of planned follow-up activities for the site.

Worker Interviews

In June 2002, the EPA and ATSDR conducted interviews with three former Zonolite/W.R. Grace employees. Information documented included employment history, specifics of the vermiculite exfoliation operation, workplace environment, product delivery procedures, installation and performance of control equipment, availability and use of personal protective equipment (PPE), personal health problems or health problems experienced by other plant workers, and waste disposal practices. Two of the individuals interviewed had performed a variety of job functions in the facility, while the third was employed as a truck driver. The two individuals who worked in the facility each had over 20 years employment and both stated they had been diagnosed with asbestosis. All three individuals indicated that several former coworkers were either diagnosed with or died from asbestos-related diseases.

According to the former employees, the facility was a 24 hour a day, seven day a week operation with three work shifts (7:00 am to 3:00 pm; 3:00 to 11:00 pm; and 11:00 pm to 7:00 am). Vermiculite from Libby, Montana was delivered by railcar. Originally, the vermiculite was dumped on the floor of the plant. Later, storage tanks were installed in the plant but leaked.

Beginning in March and through the summer months, product demand was high, and the three individuals all reported routinely working overtime in addition to their regular work shifts.

All three individuals described the vermiculite processing as an extremely dusty operation, particularly during exfoliation and MonoKote® mixing operations. Most employees did not eat in the lunch room because of the dust and dirt. The mixer, which did not have a lid, was located above the lunch room but was eventually moved and had a lid installed. The furnaces ran throughout the night and baghouse filters were not efficient at removing dust generated.

Respiratory protection consisted of dust masks with an elastic band. Coveralls were eventually provided, but workers were not required to wear them. Management staff, however, appeared to have been aware of the associated health hazards and regularly used PPE. A room was available where workers could shower and change into clean clothing. Some individuals opted to use the company's laundry service while others took their work clothes home to be laundered either by themselves or their spouse. Some used an air hose to blow dust off themselves before leaving for home. None of the three individuals interviewed realized that they were working with asbestos until the end of their careers.

One of the individuals interviewed reported that the dust was deposited in and on automobiles parked in the parking lot. Once inside the automobile, dust was blown onto interior surfaces when the heat and/or air conditioner was turned on. Area residents and local businesses often complained about dust settling on parked cars. The former worker, who still lives nearby (0.5 miles east of the site), indicated that he occasionally had dust in his swimming pool. He also reported that most of the complaints were from residents who lived on Whitehead Road, which is located west of the site.

All three former employees stated that they were not aware of anyone taking products home for residential use. One former worker stated that he did not recall seeing children near or playing on the site.

The truck driver noted the different handling methods utilized by clients during the delivery of products. Some required that their staff as well as the truck driver wear a hard hat, respirator, and coveralls during the unloading process, while others did not. Sometimes bags were damaged during the unloading process, and dust was generated in the truck as well as on the ground.

Discussion

The vermiculite processed at the Zonolite/W.R. Grace site originated from the mine in Libby, Montana known to be contaminated with asbestos. Studies conducted in the Libby community indicate health impacts that are associated with asbestos exposure (ATSDR 2002; Peipins et al. 2003). The findings at Libby provided the impetus for investigating sites across the nation that received asbestos-contaminated vermiculite from the Libby mine. Asbestos exposure conditions documented in the Libby community, however, are in many ways unique and not necessarily present at other sites that processed or handled Libby vermiculite. The health consultation prepared for the Zonolite/W.R. Grace site is part of a national effort to identify and evaluate potential asbestos exposures that may be expected at these other sites.

Exposure Assessment and Toxicologic Evaluation

Evaluating the health effects of exposure to Libby asbestos requires extensive knowledge of both exposure pathways and toxicity data. The toxicological information currently available is limited, and therefore the exact level of health concern for different sizes and types of asbestos remains controversial (Appendix A). Site-specific exposure pathway information is also limited or unavailable. These limitations include the following:

- Limited information is available on past concentrations of Libby asbestos in air in and around the plant. Also, significant uncertainties and conflicts in the methods used to analyze asbestos exist. This makes it difficult to estimate the levels of Libby asbestos individuals may have been exposed to.

- Not enough information is known about how much and how often people came in contact with the Libby asbestos from the plant because most exposures happened long ago. This information is necessary to accurately calculate exposure doses.

- Not enough information is available about how some vermiculite materials, such as waste rock (also called stoner rock), were handled or disposed. This makes identifying and assessing past and present potential exposures difficult.

Given these limitations, the public health implications of past operations at this site were evaluated qualitatively. Current health implications were likewise evaluated qualitatively. The following sections describe the various types of evidence used to evaluate exposure pathways and to reach conclusions about the site.

Exposure Pathway Analysis

An exposure pathway is the means by which a person comes in contact with chemicals originating from a source of contamination. Every exposure pathway consists of the following five elements: 1) a *source* of contamination; 2) an *environmental media,* such as air or soil, through which the contaminant is transported; 3) a *point of exposure* where people can contact the contaminant; 4) a *route of exposure* by which the contaminant enters or contacts the body; and 5) a *receptor population*. A pathway is considered complete if all five elements are present and connected. A pathway is considered potentially complete if the pathway elements are (or were) likely present, but insufficient information is available to confirm or characterize the pathway elements. A pathway may also be considered potentially complete if it is currently missing one or more of the pathway elements, but the element(s) could easily be present at some point in time. An incomplete pathway is missing one or more of the pathway elements, and it is likely that the elements were never present and not likely to be present later. An eliminated pathway is one that was a potential or completed pathway in the past, but which has had one or more of the pathway elements removed to prevent present and future exposures.

Based on information from Libby, Montana and from facilities that processed vermiculite ore from Libby, a list of possible exposure pathways for vermiculite processing facilities was developed. All pathways have a common source - vermiculite from Libby contaminated with Libby asbestos, and a common route of exposure - inhalation. Although asbestos ingestion and dermal exposure pathways could exist, health risks from these pathways are minor in comparison to those resulting from inhalation exposure to asbestos and will not be evaluated.

This health consultation considers a set of relevant exposure pathways (Appendix B) and evaluates those pertaining to the Zonolite/W.R. Grace site (Table 1). Not every pathway identified in Appendix B was considered to be a significant source of exposure for this site.

Table 1: Summary of Inhalation Pathways Considered for the Zonolite/W.R. Grace Site

Pathway Name	Exposure Scenario(s)	Past Pathway Status	Present Pathway Status	Future Pathway Status
Occupational	Former workers exposed to airborne Libby asbestos during handling and processing of contaminated vermiculite	Complete	Not applicable	Not applicable
	Current workers exposed to airborne Libby asbestos from residual contamination inside former processing buildings and on-site soils	Not applicable	Potential	Potential
	Workers of clients receiving product shipments	Potential	Not applicable	Not applicable
Household Contact	Household members exposed to airborne Libby asbestos brought home on workers' clothing or body	Complete	Potential	Potential
Waste Piles	Community members (particularly children) playing in or otherwise disturbing on-site piles of contaminated vermiculite or stoner rock	Potential	Eliminated	Eliminated
On-site Soils	Current on-site workers, contractors, or community members disturbing contaminated on-site soils (residual contamination, buried waste)	Not applicable	Potential	Potential
Ambient Air	Community members or nearby workers exposed to airborne fibers from facility emissions during handling and processing of contaminated vermiculite	Potential	Not applicable	Not applicable
Residential Outdoor	Community members using contaminated vermiculite or waste material at home (for gardening, paving driveways, fill material)	Potential	Potential	Potential
Residential Indoor	Community members disturbing household dust containing Libby asbestos from facility emissions, workers' clothing, or residential outdoor waste use	Potential	Potential	Potential
Consumer Products	Community members, contractors, and repair personnel disturbing consumer products containing contaminated vermiculite	Potential	Potential	Potential

Occupational Exposure Pathway (Past, Present and Future)

W.R. Grace conducted IH surveys at the Zonolite/W.R. Grace facility and reported the results as TWAs. For the years 1976 through 1983, TWAs for employees ranged from 0.04 to 1.46 f/cc (unpublished information from EPA database of W.R. Grace documents). Approximately 68% of the reported TWAs for these years exceeded the current OSHA PEL (0.1 f/cc)[3]. Results for

[3]The OSHA PEL in 1976 was 5 f/cc, and has been lowered over time to its current limit.

the years 1986 through 1991 indicated that employee exposures were below 0.1 f/cc. Interviews with former employees suggested that past safe work practices, including the use of PPE, were insufficient to reduce worker exposures at the site. In addition, these former long-time employees corroborated that the work environment was extremely dusty. Based on asbestos-related diseases and deaths reported by former employees, site-specific IH data, past occupational exposures to Libby asbestos at the Zonolite/W.R. Grace site is a completed pathway of concern.

In 1995, W.R. Grace collected samples to assess the effectiveness of plant clean-up procedures after equipment removal and plant washdown was completed. Air samples were found to be below the 0.1 f/cc OSHA PEL. However, results of on-site EPA soil sampling (2000 and 2001) indicated that some areas where ADDI is currently operating are contaminated with Libby asbestos (Figure 3). Areas with soil asbestos levels ≥1% were cordoned with orange safety netting to prevent access and delineate areas of concern. Surface soil asbestos concentrations <1% have also been detected at the site. The 1% preliminary remediation goal is not, however, a health-based cleanup level; disturbing soils containing <1% amphibole asbestos can suspend fibers at levels of health concern (Weis 2001). Presently, trucks access the site on a daily basis; this activity has the potential to suspend asbestos fibers from contaminated soils into the air. Recontamination of the building where ADDI operates is possible. The EPA has recommended the development of risk-based, site-specific action levels for soil/debris containing <1% asbestos (EPA 2004). Prior to the 2000 EPA sampling, areas with asbestos contamination ≥1% were unrestricted and exposures may have occurred to ADDI workers, visitors, and trespassers. These individuals may have also tracked asbestos-contaminated soil into the on-site building. Based on this information, past, present and future occupational exposures to Libby asbestos is a potential pathway of concern.

In an EPA and ATSDR interview, a former Zonolite/W.R. Grace employee who worked as a truck driver stated that how his truck was unloaded varied depending on who was doing the unloading. Some clients did not require their staff or the Zonolite/W.R. Grace truck driver to wear respirators or filter masks during the unloading process. Sometimes bags were damaged during the unloading process, and dust was generated in the truck as well as on the ground. Based on this information, past occupational exposures to workers of clients receiving Zonolite/W.R. Grace product shipments is a potential pathway of concern.

Several studies have reported on occupational exposure pathways and health effects of former workers at other exfoliation facilities that used Libby vermiculite. A study of 512 employees at a facility that exfoliated vermiculite primarily from the Libby, Montana mine documented increased pleural changes among workers (Lockey et al. 1984). A recent case study documented a worker who died of asbestosis whose only known exposure to Libby asbestos-contaminated vermiculite was during two consecutive summers of employment (1951 and 1952) at a vermiculite exfoliation facility in Southern California (Wright et al. 2002).

Household Contact Exposure Pathway (Past, Present, and Future)

In the past, workers in the Zonolite/W.R. Grace facility may have brought dust containing asbestos home on clothing, shoes, hair, or automobiles. As a result, household contacts (i.e., family members or others living in the home with the Zonolite/W.R. Grace employee) may have been exposed to Libby asbestos. Quantitative evaluation of household contacts is difficult because data on Libby asbestos concentrations associated with take-home contamination and behavior-specific factors (e.g., worker practices, household laundering practices) are unavailable. Nevertheless, exposure to asbestos resulting in asbestos-related disease in household contacts of asbestos industry workers has been well-documented (Anderson et al. 1976; Kilburn et al. 1985). In Libby, Montana, a high prevalence of pleural abnormalities was observed in household contacts of W. R. Grace mine and vermiculite processing facility workers (ATSDR 2001). Based on this information, past exposures to household contacts of the Zonolite/W.R. Grace facility is a completed pathway of concern.

Although individuals who currently access the Zonolite/W.R. Grace site (i.e., ADDI employees, visitors, trespassers) may not be exposed to the same Libby asbestos levels as past employees, on-site soils remain contaminated. Asbestos fibers from soils may become airborne and contaminate on-site buildings and automobiles. As such, there is a potential for current and future exposures to household contacts of ADDI employees and others.

Waste Piles Exposure Pathway (Past, Present, and Future)

The waste product from the exfoliation process contained high concentrations of amphibole asbestos. Two major types of waste products generated included stoner rock and baghouse fines. Stoner rock was generated when raw vermiculite failed to expand during the exfoliation process. The baghouse fines were dust particles collected from the furnace vent system. Based on a review of 1961-1970 historical aerial photographs, former employee interviews, and soil sampling results, it was concluded that some waste materials were disposed on-site (EPA 2002). Waste materials stored on-site were possibly accessible to area residents. Exposures to waste piles in the past are considered a potential pathway of concern.

No on-site vermiculite waste piles were observed during the November 19, 2002 or July 16, 2003 site visits. Therefore, current and future exposures to waste piles are an eliminated exposure pathway.

On-Site Soil Exposure Pathway (Past, Present and Future)

Results of August 2001 soil sampling at the Zonolite/W.R. Grace site indicated concentrations of Libby asbestos up to 6.4% by the TEM method. On-site areas identified as containing ≥1% asbestos were cordoned with orange safety netting. ADDI began its paper shredding and recycling operation at the site in 2000. Therefore, ADDI employees, contractors, and community members may have been potentially exposed to on-site soils contaminated with Libby asbestos. Current and future exposures from on-site soils are considered a potential pathway of concern.

Remediation workers employed during the soil removal activities may be exposed to asbestos contaminated soils. This exposure pathway will be eliminated by the development and implementation of an appropriate health and safety plan.

Ambient Air Exposure Pathway (Past)

Community members in the areas surrounding the Zonolite/W.R. Grace site may have been exposed to Libby asbestos from facility emissions, including furnace stacks, ventilation system, fugitive emissions from materials handling (i.e., unloading Libby vermiculite, stockpiling vermiculite or stoner rock, disturbing on-site soils contaminated with Libby asbestos), and asbestos fiber release from soil and waste piles. At this time, insufficient data are available to assess the community exposures associated with this pathway. Historical aerial photographs indicated that white areas near the Zonolite/W.R. Grace facility were covered with dusts which may have contained asbestos (Figure 4). The NJDHSS currently does not have information on dust emissions from plant stacks, or any data concerning ambient asbestos levels during the former Zonolite/W.R. Grace operation period.

Based upon weather station data from the Philadelphia International Airport located 45 miles southwest of the site, the prevailing wind direction between the years 1975-1979 at the Zonolite/W.R. Grace site was northwest, west and southwest (Figure 5).

Air dispersion models may be utilized to predict ambient asbestos levels at the site and the surrounding community. Results of modeled exposure data can delineate potential high exposure areas; this data can be used to calculate incremental cancer risks for the community. Limitations of this effort include: 1) availability of past facility asbestos emissions data; 2) lack of soil asbestos fiber release data[4]; and 3) the knowledge that air dispersion models are based on particulate rather than fiber transport. As such, past ambient air exposures associated with Zonolite/W.R. Grace facility asbestos emissions are considered a potential pathway of concern.

Residential Outdoor Exposure Pathway (Past, Present and Future)

Asbestos fibers may have been deposited in residential yards from facility stack emissions, fugitive dust emissions from the site, or when workers or community members brought home waste material for personal use. Based upon interviews with three former employees, there is no indication that contaminated vermiculite or waste material was brought off-site for residential

---

[4]This involves the selection of the analytical method appropriate for risk assessment.

use (e.g., gardening, driveways, fill material). Results of on-site soil samples indicate asbestos contamination is present at the site (levels range from less than 1% up to 6.4%), therefore there is the potential for migration of asbestos fibers to off-site locations. Anecdotal evidence and historical aerial photographs indicate that off-site airborne transport of dust and/or emissions from the site occurred in the past (Figure 4). Off-site soil sampling has not been conducted to identify and delineate the extent of potential transport of Libby asbestos contamination into the surrounding community near the site. As such, past, present, and future residential outdoor exposures near the Zonolite/W.R. Grace site are considered a potential pathway of concern.

Residential Indoor Exposure Pathway (Past, Present and Future)

Dust released during Zonolite/W.R. Grace site operations contained Libby asbestos. Residences located approximately 0.25 mile from the site may have been contaminated with Libby asbestos from past facility emissions. On-site soil remains contaminated and the potential for fugitive dust deposition in nearby residences is a concern. Residents disturbing indoor dust containing Libby asbestos may have or may continue to inhale asbestos fibers. As previously discussed, ambient and indoor air asbestos concentrations are unavailable. Off-site soil sampling and the use of air dispersion models will assist in evaluating this exposure pathway. As such, past, present and future residential indoor exposures are considered a potential pathway of concern.

Consumer Product Exposure Pathway (Past, Present and Future)

Individuals who purchase and use products containing Libby vermiculite may be exposed to asbestos fibers from the use of these products in and around their homes. At this time, determining the public health impact of commercial or consumer use of company products (such as home insulation or vermiculite gardening products) that contain Libby vermiculite is beyond the scope of this health consultation. It is important to note, however, that disturbing or using these products may result in airborne asbestos fiber concentrations higher than the OSHA PEL (Weis 2001). Additional information concerning products that contain Libby vermiculite has been developed by the EPA, ATSDR, and the National Institute for Occupational Safety and Health and is available at www.epa.gov/asbestos/insulation.html. As such, past, present and future consumer product exposures containing Libby vermiculite are considered a potential pathway of concern.

Proposed Removal Actions

The EPA has initiated a removal action to remove asbestos contaminated soils from the Zonolite/W.R. Grace site (EPA 2002) under the Federal Superfund Removal/Emergency Response Program. The goal of this removal action is to remove soils contaminated with asbestos at concentrations ≥1% by PLM method. The excavation depth has been estimated to be approximately 24 inches. The main components of the removal actions are as follows:

- Excavation and off-site disposal of asbestos-contaminated soils at an approved off-site disposal facility.

- Removal and off-site disposal of contaminated debris in the proposed excavation areas.

- Personal and ambient air monitoring during Removal activities.

- Implementation of engineering measures to control dust during the cleanup (i.e., dust suppression with water).

- Analysis of bulk asbestos samples using standard PLM methods and, as deemed necessary, confirmed by TEM.

- Backfill of excavated areas with clean soil.

- Re-grade and compact all disturbed areas to allow proper water drainage, and restore the property with appropriate vegetation and/or asphalt, to original pre-removal condition.

An EPA Phase I removal action was completed in March 2004. Additional removal actions to address remaining asbestos-contaminated areas will be initiated in the near future.

Health Outcome Data Evaluation

The NJDHSS, in cooperation with the ATSDR, is conducting a health statistics review for seven New Jersey municipalities, including Hamilton Township, Mercer County, which had a facility that received Libby vermiculite. The first component of the health statistics review evaluates asbestos-related mortality outcomes and reference (i.e., non-asbestos-related) outcomes for each of the municipalities for the years 1979-1998. The second component evaluates cancer incidence (1986-1995) in these municipalities for asbestos-related cancers and reference cancers. Finally, for the Zonolite/W.R. Grace site, the NJDHSS is conducting a focused cancer incidence analysis by narrowing the study area to census tracts and census blocks in close proximity to the site with an expanded time period of 22 years (1979-2000). This smaller study area includes approximately 27,000 individuals residing in three municipalities (Hamilton, Trenton, and Lawrence) and provides a better estimate of the impact to this potentially exposed population. The results of these activities, which will be released as a separate health consultation, will assist in determining the need for further follow-up.

Child Health Considerations

ATSDR recognizes that infants and children are more vulnerable to exposures than adults in communities faced with environmental contamination. Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at a 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 fiber-laden soils or indoor dust while playing. Children also breathe air that is closer to the ground and may thus be more likely to inhale airborne fibers from contaminated soils or dust. Furthermore, because of the long latency period between exposure and onset of asbestos-related diseases, children who are exposed could be more at risk of actually developing asbestos-related disease than adults exposed later in life due to children living longer with residual asbestos in their lungs.

The most at risk children are likely to be those who were household contacts of former workers while the facility was in operation. Historical exposures due to on-site waste piles and facility emissions are all potential pathways that were not evaluated due to the lack of site-specific information. Current exposures to on-site asbestos-contaminated soils may pose health hazard to children due to the lack of a continuous fence around the site.

Conclusions

1. Former employees of the Zonolite/W.R. Grace facility in Hamilton Township, Mercer County, New Jersey, were exposed to hazardous levels of Libby asbestos. A number of former workers have reportedly developed asbestos-related diseases, and some of these individuals have died. Workers receiving Zonolite/W.R. Grace product shipments may have been exposed to Libby asbestos during handling and unloading. This past occupational exposure pathway represents a public health hazard.

2. Household contacts of former employees were also exposed to Libby asbestos when employees brought asbestos contamination home on their clothes, hair, shoes, and automobiles. This past household contact exposure pathway presents a public health hazard. At the present time, on-site soils are contaminated. Asbestos fibers from soils may become airborne and contaminate on-site buildings and automobiles presenting an indeterminate public health hazard to household contacts of ADDI employees and others.

3. Former employees and community members may have had contact with on-site waste piles. Since additional information is necessary to confirm these past exposures, this exposure pathway is considered an indeterminate public health hazard.

4. Current ADDI employees, contractors, and community members may have been exposed to soil contaminated with Libby asbestos at concentrations up to 6.4%. EPA is excavating and removing on-site soils contaminated with $\geq$1% asbestos, however some areas of on-site soil are contaminated with <1% levels of asbestos. Truck traffic and other on-site activities could potentially re-suspend asbestos fibers from these areas into the air. Recontamination of the building where ADDI operates is possible. This exposure pathway presents an indeterminate public health hazard.

5. Community members and nearby workers of the Zonolite/W.R. Grace site were exposed to Libby asbestos from facility emissions during handling and processing of Libby vermiculite. Since data to assess this exposure pathway are unavailable, it is considered an indeterminate public health hazard.

6. There is no indication that contaminated vermiculite or waste material was taken off-site for personal use in residential yards or driveways. However, asbestos fibers from on-site soil contamination could be re-suspended and transported into the surrounding community. Therefore, area residents may have been or may continue to be exposed to Libby asbestos from a residential outdoor pathway. Because insufficient information is available to evaluate exposures to the surrounding community, this pathway is considered an indeterminate public health hazard.

7. Dust released during Zonolite/W.R. Grace site operations contained Libby asbestos. During its period of operation, there were numerous community complaints about the facility regarding white particulate materials and fugitive dust. On-site soil is contaminated and the potential for fugitive dust deposition in nearby residences is a concern. Residents disturbing indoor dust containing Libby asbestos may have or continue to inhale asbestos fibers. As such, past, present and future residential indoor exposures it is considered an indeterminate public health hazard.

8. Individuals who purchase and use products containing Libby vermiculite may be exposed to asbestos fibers from the use of these products in and around their homes. The exposures associated with the use of commercial or consumer products containing Libby vermiculite is beyond the scope of this health consultation. Nonetheless, it is considered an indeterminate public health hazard.

A summary of ATSDR conclusion categories are given in Appendix C.

Recommendations

1. On-site soils contaminated with Libby asbestos should be remediated. Consideration should be given to implement appropriate measures to control the potential release of asbestos from areas not presently targeted for remediation (i.e., soils containing <1% asbestos).

2. Indoor and personal air monitoring should be conducted by the EPA to evaluate potential Libby asbestos exposures to current ADDI employees.

3. Off-site soils should be investigated for asbestos contamination and, if necessary, appropriate remedial actions taken.

4. Although completed exposure pathways have not been documented, former and current area residents concerned about potential exposures to Libby asbestos should be examined by their personal physicians for evidence of asbestos-related diseases. Educational and training materials should be developed and provided to local physicians and other medical personnel to assist them in this evaluation.

5. A health study and/or screening which focuses on asbestos-related diseases should be considered for former Zonolite/W.R. Grace employees and their household contacts. These individuals should also be provided with information on the health benefits of annual flu shots and smoking-cessation programs.

Public Health Action Plan

The Public Health Action Plan (PHAP) for the site describes completed, ongoing, and planned actions by the NJDHSS and ATSDR. The purpose of the PHAP is to ensure that this public health consultation not only identifies public health hazards, but provides a plan of action for mitigating and preventing adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of the ATSDR and NJDHSS to follow-up on this plan to ensure its implementation.

Actions Completed

1. Several site visits were conducted for the Zonolite/W.R. Grace site by the NJDHSS and ATSDR.

Actions Ongoing

1. ATSDR is reviewing information from the EPA database of W.R. Grace and other documents. The database includes extensive information related to Libby, Montana and other nationwide vermiculite processing sites.

2. The NJDHSS is conducting a health statistics review for asbestos-related cancer and non-cancer outcomes in communities near the Zonolite/W.R. Grace site. The results of this health statistics review will be released as a separate health consultation.

Actions Planned

1. In cooperation with the ATSDR and EPA, the NJDHSS will schedule public availability sessions to present the findings of the health consultation for the Zonolite/W.R. Grace site and gather information on individual health concerns regarding the site. Appropriate education and outreach materials concerning the site will be prepared and distributed.

2. Former workers, local residents, and others interested in the site should be updated by the NJDHSS, in cooperation with the ATSDR, on a regular basis.

3. The ATSDR will develop a comprehensive report outlining overall conclusions and strategies for addressing public health implications at the 28 Phase 1 sites that received vermiculite. ATSDR will incorporate the results of this health consultation into the final summary report.

4. The NJDHSS, in cooperation with the ATSDR, will review new information as it becomes available to determine appropriate site-specific public health actions.

5. In cooperation with the EPA and ATSDR, the NJDHSS will estimate potential asbestos concentrations in nearby residences using an air dispersion model to evaluate past and current community exposures.

6. The NJDHSS, in cooperation with the ATSDR, will prepare a public health assessment which will include findings from the health statistics review, air dispersion model results, and site-specific updates.

Authors

Tariq Ahmed, PhD, PE, DEE
Research Scientist II
Hazardous Site Health Evaluation Program
New Jersey Department of Health and Senior Services

Julie R. Petix, MPH, CPM, HO
Health Assessment and Consultation Project Manager
Hazardous Site Health Evaluation Program
New Jersey Department of Health and Senior Services

ATSDR Regional Representatives

Arthur Block
Senior Regional Representative
Office of Regional Operations, Region II

Leah T. Escobar, RS
Associate Regional Representative
Office of Regional Operations, Region II

Reviewers

John Wheeler, PhD, DABT
Toxicologist
Exposure Investigations and Consultations Branch (EICB), DHAC, ATSDR

Susan Moore, MS
Acting Branch Chief
Exposure Investigations and Consultations Branch (EICB), DHAC, ATSDR

Certification

This Public Health Consultation was prepared by the New Jersey Department of Health and Senior Services (NJDHSS) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

Gregory V. Ulirsch
Technical Project Officer
Superfund Site Assessment Branch (SSAB)
Division of Health Assessment and Consultation (DHAC)
ATSDR

Arthur Block
Senior Regional Representative
Office of Regional Operations, Region 2

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

Susan Moore
Acting Branch Chief
Exposure Investigations and Consultations Branch (EICB), DHAC, ATSDR

Roberta Erlwein
Team Lead, Cooperative Agreement Team
SSAB, DHAC, ATSDR

Reviewed Documents

Anderson HA, Lilis R., Daum SM, Fischbein AS and Selikoff IJ. 1976. Household contact asbestos neoplastic risk. Ann NY Acad Sci, 271:311–23.

ATSDR 2001. Year 2000 medical testing of individuals potentially exposed to asbestoform minerals associated with vermiculite in Libby, Montana: a report to the community. Atlanta: United States Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, August 2001.

ATSDR 2002. Health consultation on mortality in Libby, Montana. Atlanta: U.S. Department of Health and Human Services,. Agency for Toxic Substances and Disease Registry, August 2002.

EPA 1982. Collection, analysis and characterization of vermiculite samples for fiber content and asbestos contamination. Washington, DC: United States Environmental Protection Agency, Office of Pesticides and Toxic Substances, September 1982.

EPA 1985. Exposure Assessment for Asbestos-Contaminated Vermiculite. Washington, DC: United States Environmental Protection Agency, Office of Pesticides and Toxic Substances, September 1985.

EPA 2001. December 2001 Memorandum to P. Peronard from C. Weis concerning amphibole mineral endangerment to public health. Denver, Colorado. United States Environmental Protection Agency, Region 5.

EPA 2001a. Historical Aerial Photographic Analysis: Zonolite Trenton Site, Hamilton Township, New Jersey. TS-PIC-20102329S, July 2001.

EPA 2001b. Proposed excavation areas, W.R.Grace/Zonolite asbestos investigation. Roy F. Weston, Inc., Federal Programs Division & EPA Region 2 Response & Prevention Branch, Removal Support Team, Contract #68-W-00-113.

EPA 2002. Vermiculite facilities investigations - Zonolite Co./W.R. Grace fact sheet. New York: United States Environmental Protection Agency, Region 1, March 2002.

EPA 2002. November 2002 Memorandum to the Emergency and Remedial Response Division from Michael Ferriola requesting a time critical removal action at the former W.R. Grace/Zonolite Site in Hamilton Township, New Jersey. United States Environmental Protection Agency, Region 2.

EPA 2004. August 10 Memorandum to the Superfund National Policy Managers, Regions 1-10 from Michael B. Cook about clarifying cleanup goals and identification of new assessment tools for evaluating asbestos at Superfund cleanups. United States Environmental Protection, Washington, DC.

Kilburn, KH, Lilis R, Anderson HA et al. 1985. Asbestos disease in family contacts of shipyard workers. Am J Publ Health 75(6):615–17.

Lockey JE, et al. 1984. Pulmonary changes after exposure to vermiculite contaminated with fibrous tremolite. Am Rev Respir Dis 129:952-958.

Peipins L, Lewin M, Campolucci S, Lybarger JA, Miller A, Middleton D, Weis C, Spence M, Black B, Kapil V. 2003 [cited 2003 July 2]. Radiographic abnormalities and exposure to asbestos-contaminated vermiculite in the community of Libby, Montana. *Environ Health Perspect*: doi:10.1289/ehp.6346. Available at URL: http://dx.doi.org/.

U.S. Geological Survey. May 2002 [cited 2002 July 31]. Bulletin 2192. Reconnaissance study of the geology of US vermiculite deposits—are asbestos minerals common constituents? Denver: US Department of the Interior. Available at URL: http://geology.cr.usgs.gov/pub/bulletins/b2192/

Wright RS, Abraham JL, Harber P, Burnett BR, Morris P, and West P. 2002. Fatal asbestosis 50 years after brief high intensity exposure in a vermiculite expansion plant. Am J Respir and Crit Care Med 165:1145–49.

Figures 2 - 5

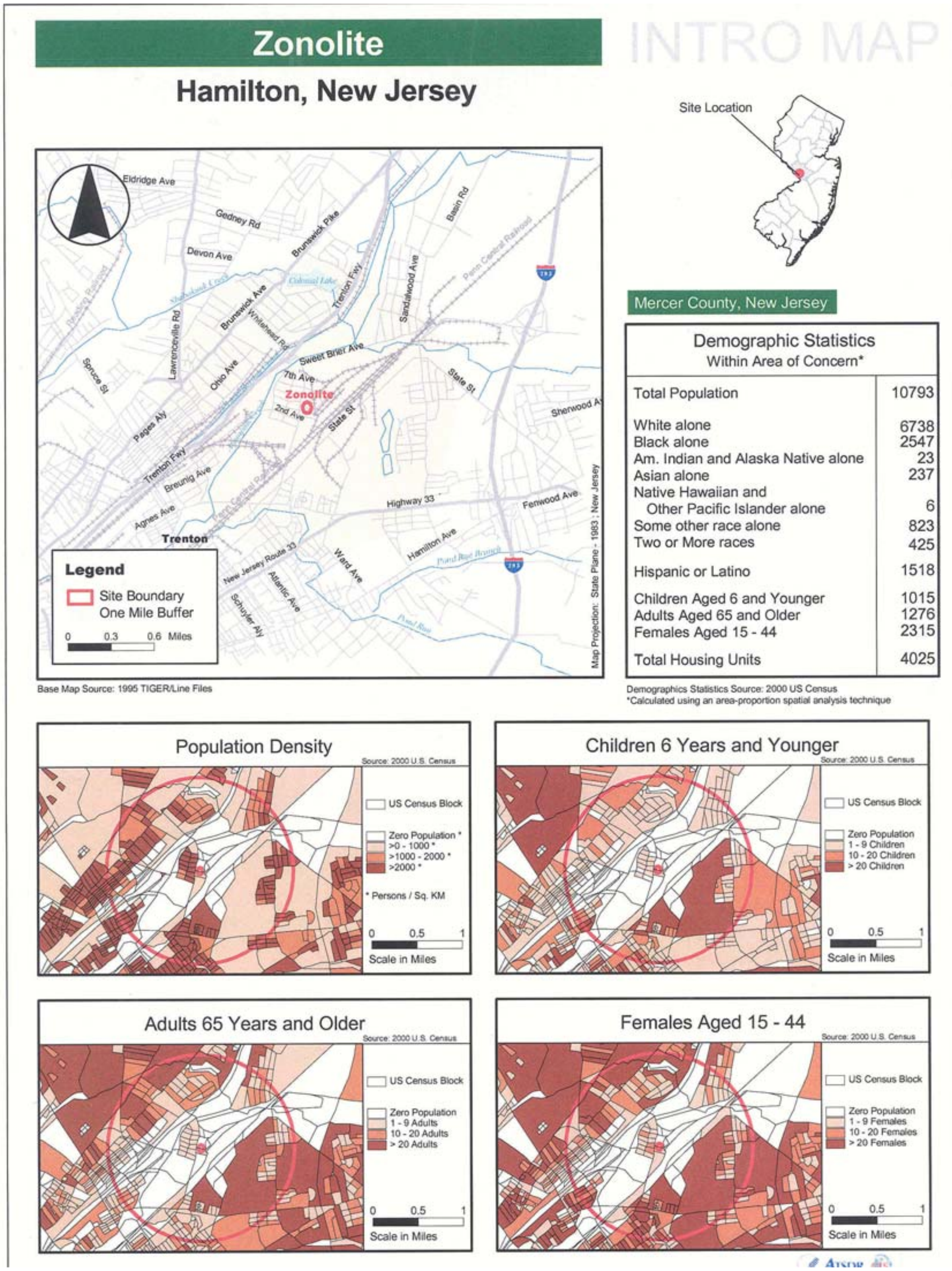

Figure 2. Demographic statistics within area of concern at the Zonolite site based on 2000 U.S. Census data

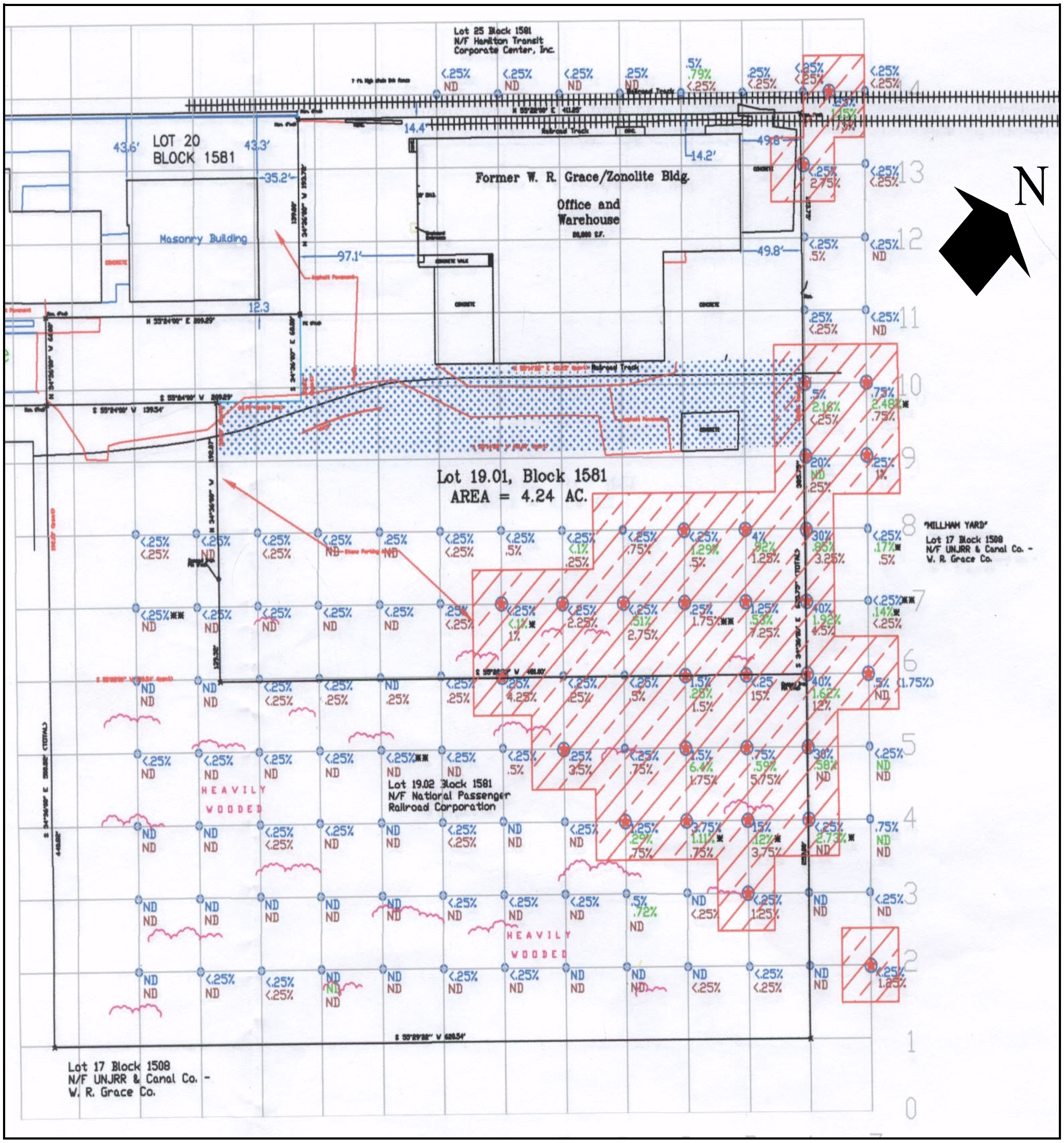

Figure 3. Proposed excavation areas are shaded in red (asbestos levels ≥1%). Results at grid locations represent tremolite and/or actinolite unless otherwise noted. Grid spacing 50' x 50'. (Source: EPA W.R. Grace/Zonolite Asbestos Investigation, August 2001; original drawing by Princeton Junction Engineering, P.C.)

Figure 4. Zonolite/W.R. Grace site. Aerial photograph taken in 1970 showing windblown deposits of vermiculite

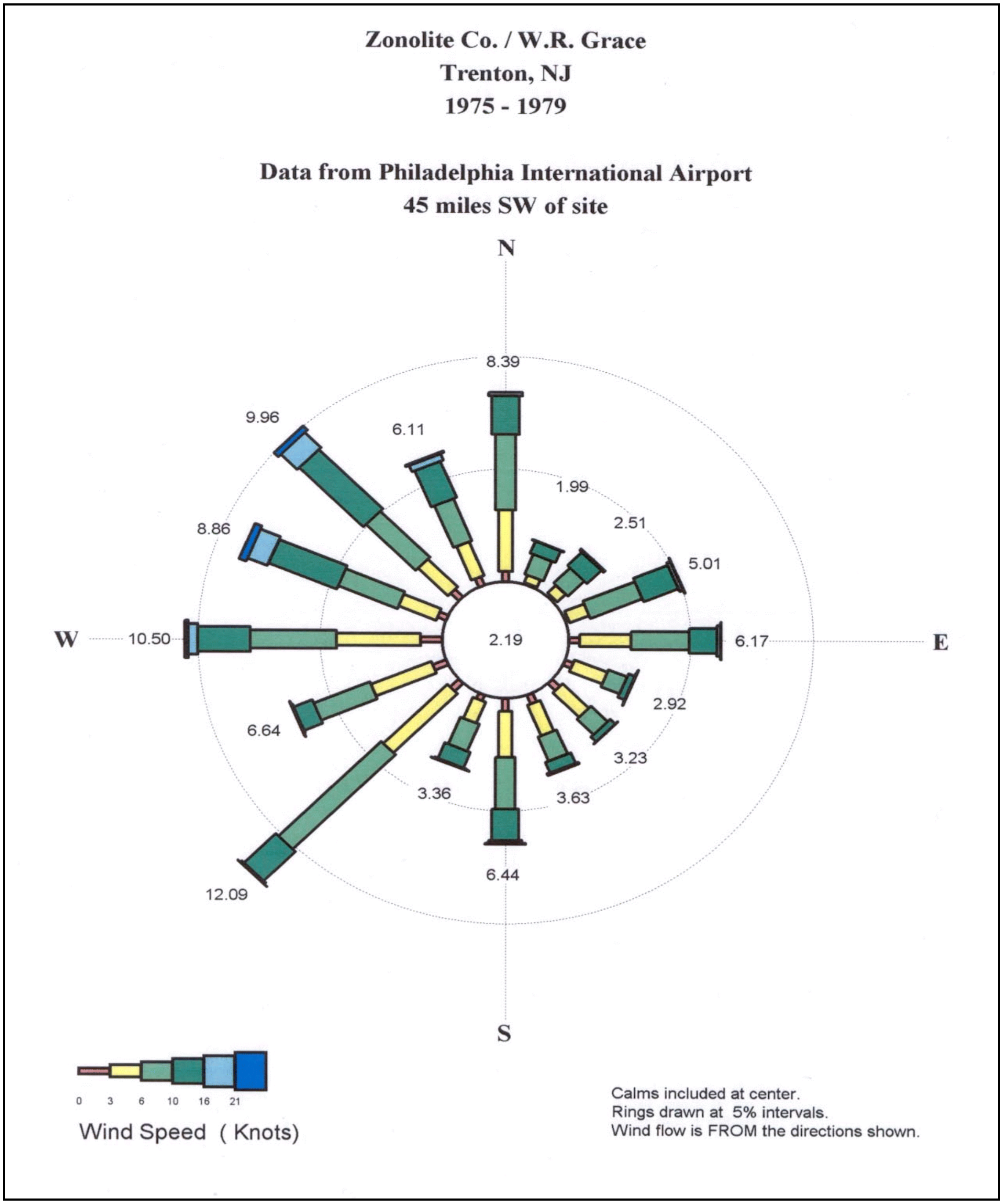

Figure 5. Prevailing wind map at the Philadelphia International Airport. The Airport is 45 miles southwest of the Zonolite/W.R. Grace site

Photographs 1 - 4

Photograph 1. Former Zonolite/W.R.Grace building, Hamilton Township, Mercer County, New Jersey.

Photograph 2. Libby vermiculite mixed with top soil at the former Zonolite/W.R. Grace site.

Photograph 3. More Libby vermiculite mixed with top soil at the former Zonolite/W.R. Grace site.

Photograph 4. Libby vermiculite mixed with understory plant growth at the former Zonolite/W.R. Grace site.

APPENDIX A

Asbestos Overview

Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers in a parallel arrangement. Asbestos minerals fall into two classes, serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers; this class includes chrysotile, the predominant type of asbestos used commercially. 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 [1].

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.

The vermiculite mined at Libby contains amphibole asbestos, with a characteristic composition including tremolite, actinolite, richterite, and winchite; this material will be referred to as Libby asbestos. The raw vermiculite ore was estimated to contain up to 26% Libby asbestos as it was mined [2]. For most of the mine’s operation, Libby asbestos was considered a by-product of little value and was not used commercially. The mined vermiculite ore was processed to remove unwanted materials and then sorted into various grades or sizes of vermiculite that were then shipped to sites across the nation for expansion (exfoliation) or use as a raw material in manufactured products. Samples of the various grades of unexpanded vermiculite shipped from the Libby mine contained 0.3%–7% fibrous tremolite-actinolite (by mass) [2].

The following sections provide an overview of several concepts relevant to the evaluation of asbestos exposure, including analytical techniques, toxicity and health effects, and the current regulations concerning asbestos in the environment. A more detailed discussion of these topics will also be provided in ATSDR’s upcoming summary report for the national review of vermiculite sites.

Methods for Measuring Asbestos Content

A number of different analytical methods are used to evaluate asbestos content in air, soil, and other bulk materials. Each method varies in its ability to measure fiber characteristics such as length, width, and mineral type. For air samples, fiber quantification is traditionally done through phase contrast microscopy (PCM) by counting fibers with lengths greater than 5 micrometers (>5 µm) and with an aspect ratio (length to width) greater than 3:1. This is the standard method by which regulatory limits were developed. Disadvantages of this method include the inability to detect fibers less than 0.25 (<0.25) µm in diameter and the inability to distinguish between asbestos and nonasbestos fibers [1].

Asbestos content in soil and bulk material samples is commonly determined using polarized light microscopy (PLM), a method which uses polarized light to compare refractive indices of minerals and can distinguish between asbestos and nonasbestos fibers and between different types of asbestos. The PLM method can detect fibers with lengths greater than ~1 µm, widths greater than ~0.25 µm, and aspect ratios (length to width ratios) greater than 3. Detection limits for PLM methods are typically 0.25%–1% asbestos.

Scanning electron microscopy (SEM) and, more commonly, transmission electron microscopy (TEM) are more sensitive methods that can detect smaller fibers than light microscopic techniques. TEM allows the use of electron diffraction and energy-dispersive x-ray methods, which give information on crystal structure and elemental composition, respectively. This information can be used to determine the elemental composition of the visualized fibers. SEM does not allow measurement of electron diffraction patterns. One disadvantage of electron microscopic methods is that determining asbestos concentration in soil and other bulk material is difficult [1].

For risk assessment purposes, TEM measurements are sometimes multiplied by conversion factors to give PCM equivalent fiber concentrations. The correlation between PCM fiber counts and TEM mass measurements is very poor. A conversion between TEM mass and PCM fiber count of 30 micrograms per cubic meter per fiber per cubic centimeter ($\mu g/m^3$)/(f/cc) was adopted as a conversion factor, but this value is highly uncertain because it represents an average of conversions ranging from 5 to 150 ($\mu g/m^{3)}$/(f/cc) [3]. The correlation between PCM fiber counts and TEM fiber counts is also very uncertain, and no generally applicable conversion factor exists for these two measurements [3]. Generally, a combination of PCM and TEM is used to describe the fiber population in a particular air sample.

EPA is currently working with several contract laboratories and other organizations to develop, refine, and test a number of methods for screening bulk soil samples. The methods under investigation include PLM, infrared (IR), and SEM (personal communication, Jim Christiansen, EPA, November 2002).

Asbestos Health Effects and Toxicity

Breathing any type of asbestos increases the risk of the following health effects:

> *Malignant mesothelioma*—cancer of the membrane (pleura) that encases the lungs and lines the chest cavity. This cancer can spread to tissues surrounding the lungs or other organs. The great majority of mesothelioma cases are attributable to asbestos exposure [1].
>
> *Lung cancer*—cancer of the lung tissue, also known as bronchogenic carcinoma. The exact mechanism relating asbestos exposure with lung cancer is not completely understood. The combination of tobacco smoking and asbestos exposure greatly increases the risk of developing lung cancer [1].
>
> *Noncancer health effects*—these include asbestosis, scarring, and reduced lung function caused by asbestos fibers lodged in the lung; pleural plaques, localized or diffuse areas of thickening of the pleura; pleural thickening, extensive thickening of the pleura which may restrict breathing; 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 the chest cavity [1].

Not enough evidence is available to determine whether inhalation of asbestos increases the risk of cancer at sites other than the lungs, pleura, and abdominal cavity [1].

Ingestion of asbestos causes little or no risk of noncancer effects. However, some evidence indicates that acute oral exposure might induce precursor lesions of colon cancer and that chronic oral exposure might lead to an increased risk of gastrointestinal tumors [1].

ATSDR considers the inhalation route of exposure to be the most significant in the current evaluation of sites that received Libby vermiculite. Exposure scenarios that are protective of the inhalation route of exposure should be protective of dermal and oral exposures.

The scientific community generally accepts the correlations of asbestos toxicity with fiber length as well as fiber mineralogy. Fiber length may play an important role in clearing the materials from the body, and mineralogy may affect both biopersistence and surface chemistry.

ATSDR, responding to concerns about asbestos fiber toxicity from the World Trade Center disaster, held an expert panel meeting to review fiber size and its role in fiber toxicity in December 2002 [4]. The panel concluded that fiber length plays an important role in toxicity. Fibers with lengths <5 µm are essentially nontoxic in terms of association with mesothelioma or lung cancer promotion. However, fibers with lengths <5 µm may play a role in asbestosis when exposure duration is long and fiber concentrations are high. More information is needed to definitively reach this conclusion.

In accordance with these concepts, it has been suggested that amphibole asbestos is more toxic than chrysotile asbestos, mainly because physical differences allow chrysotile to break down and to be cleared from the lung, whereas amphibole is not removed and builds up to high levels in lung tissue [5]. Some researchers believe the resulting increased duration of exposure to amphibole asbestos significantly increases the risk of mesothelioma and, to a lesser extent, asbestosis and lung cancer [5]. However, OSHA continues to regulate chrysotile and amphibole asbestos as one substance, as both types increase the risk of disease [6]. EPA's Integrated Risk Information System (IRIS) assessment of asbestos also treats mineralogy (and fiber length) as equipotent.

Evidence suggesting that the different types of asbestos fibers vary in carcinogenic potency and site specificity is limited by the lack of information on fiber exposure by mineral type. Other data indicate that differences in fiber size distribution and other process differences can contribute at least as much as fiber type to the observed variation in risk [7].

Counting fibers using the regulatory definitions (see below) does not adequately describe risk of health effects. Fiber size, shape, and composition contribute collectively to risk in ways that are still being elucidated. For example, shorter fibers appear to deposit preferentially in the deep lung, but longer fibers may disproportionately increase the risk of mesothelioma [1,7]. Some of the unregulated amphibole minerals, such as the winchite present in Libby asbestos, can exhibit asbestiform characteristics and contribute to risk. Fiber diameters greater than 2 µm–5 µm are considered above the upper limit of respirability (that is, too large to inhale), and thus do not contribute significantly to risk. Methods to assess the risks posed by varying types of asbestos are being developed and are currently awaiting peer review [7].

Current Standards, Regulations, and Recommendations for Asbestos

In industrial applications, asbestos-containing materials are defined as any material with >1% bulk concentration of asbestos [8]. It is important to note that 1% is not a health-based level, but instead represents the practical detection limit in the 1970s when OSHA regulations were created. Studies have shown that disturbing soil containing <1% amphibole asbestos, however, can suspend fibers at levels of health concern [9].

Friable asbestos (asbestos which is crumbly and can be broken down to suspendible fibers) is listed as a hazardous air pollutant on EPA's Toxic Release Inventory [10]. This classification requires companies that release friable asbestos at concentrations >0.1% to report the release under Section 313 of the Emergency Planning and Community Right-to-Know Act.

OSHA's permissible exposure limit (PEL) is 0.1 f/cc for asbestos fibers with lengths >5 µm and with an aspect ratio (length:width) >3:1, as determined by PCM [6]. This value represents a time-weighted average (TWA) exposure level based on 8 hours per day for a 40-hour work week. In addition, OSHA has defined an "excursion limit," which stipulates that no worker should be exposed in excess of 1 f/cc as averaged over a sampling period of 30 minutes [6]. Historically, the OSHA PEL has steadily decreased from an initial standard of 12 f/cc established in 1971. The PEL levels prior to 1983 were determined on the basis of empirical worker health observations, while the levels set from 1983 forward employed some form of quantitative risk assessment. ATSDR has used the current OSHA PEL of 0.1 f/cc as a reference point for evaluating asbestos inhalation exposure for past workers. ATSDR does not, however, support using the PEL for evaluating exposure for community members, because the PEL is based on an unacceptable health risk level.

In response to the World Trade Center disaster in 2001 and an immediate concern about asbestos levels in buildings in the area, the Department of Health and Human Services, EPA, and the Department of Labor formed the Environmental Assessment Working Group. This work group was made up of ATSDR, EPA, CDC's National Center for Environmental Health, the National Institute of Occupational Safety and Health (NIOSH), the New York City Department of Health and Mental Hygiene, the New York State Department of Health, OSHA, and other state, local, and private entities. The work group set a re-occupation level of 0.01 f/cc after cleanup. Continued monitoring was also recommended to limit long-term exposure at this level [11]. In 2002, a multiagency task force headed by EPA was formed specifically to evaluate indoor environments for the presence of contaminants that might pose long-term health risks to residents in Lower Manhattan. The task force, which included staff from ATSDR, developed a health-based benchmark of 0.0009 f/cc for indoor air. This benchmark was developed to be protective under long-term exposure scenarios, and it is based on risk-based criteria that include conservative exposure assumptions and the current EPA cancer slope factor. The 0.0009 f/cc benchmark for indoor air was formulated on the basis of chrysotile fibers and is therefore most appropriately applied to airborne chrysotile fibers [12].

NIOSH set a recommended exposure limit of 0.1 f/cc for asbestos fibers longer than 5 µm. This limit is a TWA for up to a 10-hour workday in a 40-hour work week [13]. The American Conference of Government Industrial Hygienists has also adopted a TWA of 0.1 f/cc as its threshold limit value [14].

EPA has set a maximum contaminant level (MCL) for asbestos fibers in water of 7,000,000 fibers longer than 10 µm per liter, on the basis of an increased risk of developing benign intestinal polyps [15]. Many states use the same value as a human health water quality standard for surface water and groundwater.

Asbestos is a known human carcinogen. Historically, EPA has calculated an inhalation unit risk for cancer (cancer slope factor) of 0.23 per f/cc of asbestos [3]. This value estimates additive risk of lung cancer and mesothelioma using a relative risk model for lung cancer and an absolute risk model for mesothelioma.

This quantitative risk model has significant limitations. First, the unit risks were based on measurements with phase contrast microscopy and therefore cannot be applied directly to measurements made with other analytical techniques. Second, the unit risk should not be used if the air concentration exceeds 0.04 f/cc because the slope factor above this concentration might differ from that stated [3]. Perhaps the most significant limitation is that the model does not consider mineralogy, fiber-size distribution, or other physical aspects of asbestos toxicity. EPA is in the process of updating their asbestos quantitative risk methodology given the limitations of the method currently used and the knowledge gained since it was implemented in 1986.

References

1. Agency for Toxic Substances and Disease Registry. Toxicological profile for asbestos (update). Atlanta: U.S. Department of Health and Human Services; September 2001.
2. Midwest Research Institute. Collection, analysis, and characterization of vermiculite samples for fiber content and asbestos contamination. Kansas City: report prepared for the U.S. Environmental Protection Agency Office of Pesticides and Toxic Substances; September 1982.
3. U.S. Environmental Protection Agency. Integrated risk information system (for asbestos). Accessed on July 31, 2002, at: http://www.epa.gov/iris/subst/0371.htm.
4. Agency for Toxic Substances and Disease Registry. Report on the expert panel on health effects of asbestos and synthetic vitreous fibers: the influence of fiber length. Atlanta: U.S. Department of Health and Human Services; 2003. Available at: (http://www.atsdr.cdc.gov/HAC/asbestospanel/index.html).
5. Churg A. Asbestos-related disease in the workplace and the environment: controversial issues. In: Churg A, Katzenstein AA. The lung: current concepts (Monographs in pathology, no. 36). Philadelphia: Lippincott, Williams, and Wilkins; 1993. p. 54-77.
6. Occupational Safety and Health Administration. Federal Register 59:40964-41162, Aug 10, 1994; Federal Register 60:33973-34002, June 29, 1995.
7. Berman DW, Crump K. Methodology for conducting risk assessments at asbestos Superfund sites. Part 2: Technical background document (interim version). Prepared for the U.S. Environmental Protection Agency Region 9. San Francisco: February 15, 1999.
8. U.S. Environmental Protection Agency. Guidelines for conducting the AHERA TEM clearance test to determine completion of an asbestos abatement project. Washington: U.S. Environmental Protection Agency, Office of Toxic Substances, NTIS No. PB90-171778. 1989.
9. Weis CP (EPA). Memorandum to P. Peronard of U.S. Environmental Protection Agency, Amphibole mineral fibers in source materials in residential and commercial areas of Libby pose an imminent and substantial endangerment to public health. Denver: U.S. Environmental Protection Agency; December 20, 2001.
10. U.S. Environmental Protection Agency. Toxic air pollutants Web site. Accessed on October 29, 2002, at: http://www.epa.gov/air/toxicair/newtoxics.html.
11. Agency for Toxic Substances and Disease Registry. World Trade Center response activities. Close-out report. September 11, 2001–April 30, 2003. Atlanta: U.S. Dept. of Health and Human Services; May 16, 2003.
12. U.S. Environmental Protection Agency. World Trade Center indoor environment assessment: selecting contaminants of potential concern and setting health-based benchmarks. New York: EPA Region 2; May 2003.
13. National Institute of Occupational Safety and Health (NIOSH). Online NIOSH pocket guide to chemical hazards. Accessed on July 16, 2002, at: http://www.cdc.gov/niosh/npg/npgd0000.html.
14. American Conference of Government Industrial Hygienists. 2000 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati; 2000.
15. U.S. Environmental Protection Agency. National primary drinking water regulations. Accessed on July 16, 2002, at: http://www.epa.gov/safewater/mcl.html.

APPENDIX B

Exposure pathways for Zonolite/W.R. Grace site which received asbestos contaminated vermiculite from Libby, Montana

PATHWAY	ENVIRONMENTAL MEDIA & TRANSPORT MECHANISMS	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSURE POPULATION	TIME
Occupational	Suspension of asbestos fibers into air during materials transport, handling and processing operations	Onsite	Inhalation	Former and/or current workers	Past, present and future
Household Contact	Suspension of asbestos fibers into air from dirty clothing of workers after work	Workers' homes	Inhalation	Former and/or current workers' families and other household contacts	Past, present and future
Waste Piles	Suspension of asbestos fibers into air by playing in or otherwise disturbing piles of vermiculite or waste rock	Onsite at waste piles	Inhalation	Neighborhood children and adult workers	Past
Residential Outdoor	Suspension of asbestos fibers into air by disturbing contaminated vermiculite brought offsite for personal uses (gardening, traction, fill)	Residential yards or driveways	Inhalation	Neighborhood residents, workers' families and household contacts	Past, present and future
Residential Indoor	Suspension of household dust containing asbestos fibers from plant emissions or worker clothing into air	Residences	Inhalation	Neighborhood residents, workers' families and household contacts	Past, present and future
Ambient Air	Stack emissions and fugitive dust from plant operations into neighborhood air	Neighbor-hood around site	Inhalation	Neighborhood residents	Past
Onsite	Suspension of asbestos fibers into air from disturbing contaminated vermiculite, waste, or soil remaining on site	At areas of remaining contamination at or around the site	Inhalation	Cleanup workers, neighborhood residents, current workers and trespassers	Past, present and future
Consumer Products	Suspension of asbestos fibers into air from using or disturbing insulation or other consumer products containing Libby vermiculite	At homes where LA-contaminated products were/are present	Inhalation	Household residents and contractors	Past, present and future

APPENDIX C

Summary of ATSDR Conclusion Categories

Category	Definition
Urgent Public Health Hazard	Applies to sites that have certain physical hazards or evidence of short-term (less than 1 year), site-related exposure to hazardous substances that could result in adverse health effects and require quick intervention to stop people from being exposed.
Public Health Hazard	Applies to sites that have certain physical hazards or evidence of chronic, site-related exposure to hazardous substances that could result in adverse health effects.
Indeterminate Public Health Hazard	Applies to sites where critical information is lacking (missing or has not yet been gathered) to support a judgment regarding the level of public health hazard.
No Apparent Public Health Hazard	Applies to sites where exposure to site-related chemicals might have occurred in the past or is still occurring, but the exposures are not at levels expected to cause adverse health effects.
No Public Health Hazard	Applies to sites where no exposure to site-related hazardous substances exists.