Health Consultation

Former Western Minerals Denver Plant

111 South Navajo Street
Denver, Denver County, Colorado

EPA Facility Identification Number: CO0010165136

September 9, 2003

Prepared by:
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Department of Health Assessment & Consultation

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 U.S. 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.

Background

The Western Minerals Denver Plant site is located at 111 South Navajo Street, near Interstate 25 in Denver, Colorado. The site location is shown in Figure 1. The immediate surroundings of the site are mainly light industrial, with a community ball field located diagonal to the site and residences located several blocks (about ¼ of a mile) away. There were more residences in the area before 1965, but a major flood in that year destroyed many houses.

It is not known when the facility was originally constructed. The facility was originally operated as a glass plant. Sometime before 1967, the facility began processing vermiculite that was obtained primarily from the vermiculite mine located in Libby, Montana. The facility expanded, or exfoliated, the vermiculite ore to produce a lightweight substance used in insulation and other products. In 1967, this site as well as the Libby mine were purchased by the W.R. Grace Company. There was a fire at the facility in 1971, and part of the processing building was rebuilt. The facility continued to process vermiculite until 1990. At that time, the buildings and land were purchased by Liquid Sugars, a corn syrup processing company. Ownership was transferred to Minnesota Corn Processors, the current owners, in 1996, and the facility is still being used to process corn syrup.

The site was one of the highest volume vermiculite processors in the nation. Between 1967 and 1989, the plant processed over 100,000 total tons of vermiculite ore. Over time, it became known that the vermiculite mined from Libby was contaminated with naturally occurring asbestos fibers. Vermiculite from Libby was found to contain several types of asbestos fibers including the amphibole asbestos varieties tremolite and actinolite and the related fibrous asbestiform minerals winchite, richterite, and ferro-edenite [1]. In this report we will use the term **Libby asbestos** to refer to the characteristic composition of asbestos contaminating the Libby vermiculite. It is difficult to measure all the different mineral fibers in Libby asbestos specifically. In this document, soil sample results are reported as “tremolite-actinolite” asbestos to indicate the presence of Libby asbestos.

Scientific studies throughout the 1980s and information that received media attention in 1999 indicated that Libby mine workers had high rates of asbestos-related respiratory diseases [2,3,4,5,6]. This site is being investigated further because of the large volume of Libby vermiculite ore processed here and because the process used here—exfoliation—can release more asbestos fibers than other types of processing [7].

In 2001, the US Environmental Protection Agency (EPA) collected soil samples at and around the site [8]. Grains of asbestos in raw vermiculite were seen in soil at some locations on the property and along the railroad lines serving the property. Microscopic analysis of the samples showed tremolite-actinolite asbestos at levels greater than 5%.

Vermiculite Processing

Vermiculite is a non-fibrous, platy mineral similar in form to mica and used in many commercial and consumer applications. Raw vermiculite ore is used in gypsum wallboard, cinder blocks, and

many other products, and exfoliated vermiculite is used as loose fill insulation, as a fertilizer carrier, and as an aggregate for concrete. Exfoliated vermiculite is formed by heating the ore to approximately 2,000 degrees Fahrenheit (^{o}F), which explosively vaporizes the water in the mineral structure and causes the vermiculite to expand by a factor of 10 to 15 [9]. The facility at this site produced expanded vermiculite and Monokote, a fireproofing material that contained vermiculite and was typically sprayed on steel beams. In earlier operations, the plant also produced perlite insulation, a material not known to be contaminated with asbestos.

EPA interviewed several people who worked at the facility in the 1970s and 1980s [10]. The following information on the plant processes comes mainly from those interviews. According to the former workers, vermiculite ore was delivered to the facility in covered railcars on a railroad spur leading to the west door of the facility. The vermiculite was emptied from the bottom of the railroad cars into pits, and then transferred automatically by conveyor belt or auger to storage silos. The vermiculite was then fed into a furnace for exfoliation. The stoner rock (waste material) was dampened and channeled into a portable dumpster, which was double-lined with plastic material, and labeled as hazardous material. Stoner rock has been shown to contain up to 10% tremolite-actinolite asbestos (personal communication, James Kelly, Minnesota Department of Health, August 12, 2002). At the end of each day, the stoner rock was bagged and put into another dumpster for disposal by a contracted disposal company. Monokote was made in a large mixer. Workers reported that bags of vermiculite were hung over the mixer and untied to allow the vermiculite to empty into the mixer.

ATSDR and its partners in the National Asbestos Exposure Review have learned other information about past processing methods that could apply to this site. Before ore and waste handling was automated, workers at many vermiculite processing sites used shovels or forklifts to handle ore. Reportedly, types of asbestos other than Libby asbestos, particularly chrysotile, were added in the Monokote mixing process.

Former workers at the site described the exfoliation process as dusty to very dusty at times. Representatives from the Occupational Safety and Health Administration (OSHA) and W.R. Grace took air samples at various process locations during operations in the 1970s and 1980s (unpublished information from EPA database of W.R. Grace documents). Workers said that they wore disposable cotton masks and that respirators and disposable suits were available. By the 1970s, the plant had installed one or two baghouses to capture dust from some plant operations. No reports of community complaints about dust from the facility were found.

Some vermiculite processing facilities in the United States allowed or encouraged workers and nearby community members to take stoner rock, vermiculite ore, or other process materials for personal use [11]. On the basis of EPA interviews with former workers and residents from the surrounding neighborhood, it does not appear that this was a common practice at this site. However, official documentation of the waste disposal practices at the facility was not available. The only personal uses identified in the interviews were occasional use of vermiculite for tire traction and use of expanded vermiculite as a potting soil amendment. These uses, however, did not appear to be widespread.

In 1990, the facility was sold. Before the sale, employees of W.R. Grace dismantled equipment for disposal and pressure washed the building inside and out. Post-clearance sampling showed the building to be free of asbestos [12]. According to one of the workers of the company that took over the facility, the building was "squeaky clean" when they moved in.

Soil Contamination at the Western Minerals Denver Plant and Surrounding Areas

A few areas around the site have visible Libby asbestos-contaminated vermiculite. Figure 2 is a photograph that shows grains of Libby asbestos in vermiculite in a former parking area on the south edge of the plant's parking lot. Vermiculite contaminated with Libby asbestos was also observed along the railroad spur, especially where the spur joined the main line. Areas where asbestos is visible in vermiculite have been documented by EPA.

In the summer of 2001, EPA representatives collected soil samples at the site. Composite samples were collected at the surface (0-2 inches) and subsurface (2-6 inches and 6-12 inches) at more than 120 locations to characterize asbestos levels at the facility, neighboring businesses, the community ball field, and the railroad line and spur. The soil samples were analyzed by polarized light microscopy for tremolite-actinolite asbestos to indicate the presence of Libby asbestos. Results indicate that several samples had detectable levels of tremolite-actinolite asbestos (see Figure 3) [8]. The highest measurements correspond with the areas of visible asbestos-containing vermiculite discussed above. Tremolite-actinolite asbestos was also detected in the area where the railroad cars were unloaded and along the railroad line in general (not just next to the facility). Core samples taken from underneath the asphalt parking lot also showed high levels of tremolite-actinolite. The community ball field and the adjacent property north of the facility were essentially free of contamination. Subsurface samples generally showed the same trends as the surface samples [8].

Along with the soil sampling, EPA conducted air sampling in the former exfoliation facility building and in the building across the street from the facility. According to EPA officials, asbestos was not detected in any of the samples (personal communication, Joyce Ackerman, US Environmental Protection Agency, October 2002). Detailed information on the sampling and analysis of these samples was not available as of the writing of this report.

Site Visit

ATSDR staff visited the site with an EPA representative in August of 2002. Site access was granted by the current facility operator. The group conducted a walk-through of the former exfoliation facility (now occupied by a corn syrup manufacturer), the area immediately adjacent to the facility, and surrounding streets where EPA had conducted soil sampling. They also drove around the neighborhood to determine the distances between the site and residences in the area. The following observations were made:

- Vermiculite which contained grains of asbestos was observed in the unpaved area adjacent to the facility parking lot. This area was previously sampled by EPA and found to be high in asbestos. Workers had previously parked their cars there; however, under advisement from EPA, they stopped parking there and covered the area with tarps. At the time of the site visit, the tarps had been blown around by the wind or otherwise disturbed

and were not covering the soil surface adequately.

- The current operators of the facility had installed a truck scale in the parking lot area and also had done some work on the sewers. The asphalt in the parking lot appeared aged and was cracked in several places.
- The inside of the building appeared clean. The current operator reported that the building had been cleaned very well by W.R. Grace before they moved in (in approximately 1990). No significant dust was observed inside the building.
- The areas where EPA sampling had detected asbestos were mainly along the railroad line, especially where the spur broke away from the main track, and in the former parking area.
- The areas of the site with high levels of asbestos did not appear to be places that would attract children. The nearest homes were about a quarter mile away. The baseball field diagonally across from the site was extensively sampled by EPA and found to be free of asbestos contamination. The other adjacent properties are used for industrial purposes.

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 [13].

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 that includes tremolite, actinolite, richterite, and winchite; this characteristic material will be referred to as Libby asbestos. The raw ore was estimated to contain up to 26% Libby asbestos [14]. For most of the mine's operation, Libby asbestos was considered a byproduct of little value and was not used commercially. The mined vermiculite ore was processed to remove unwanted materials and sorted into various grades or sizes. The ore was 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) [14].

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

There are a number of different analytical methods 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 longer than 5 μm and with an aspect ratio (length: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 thinner than 0.25 μm in diameter and the inability to distinguish between asbestos and nonasbestos fibers [13].

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) of 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 and 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 it is difficult to determine asbestos concentration in soils and other bulk materials [13].

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 (μg/m3)/(f/cc) was adopted as a conversion factor, but this value is highly uncertain since it represents an average of conversions ranging from 5 to 150 (μg/m3)/(f/cc) [15]. 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 [15]. Generally, a combination of PCM and TEM is used to describe the fiber population in a particular 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, US Environmental Protection Agency, 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 lining of the lung (pleura) and other internal organs. This cancer can spread to tissues surrounding the lungs or other organs. The vast majority of mesothelioma cases are attributable to asbestos exposure [13].

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 [13].

Noncancer 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 (lining of the lung); *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 [13].

There is not enough evidence to conclude whether inhalation of asbestos increases the risk of cancers at sites other than the lungs, pleura, and abdominal cavity [13].

Ingestion of asbestos causes little or no risk of noncancer effects. However, there is some evidence 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 [13].

ATSDR considers the inhalation route of exposure to be the most significant in the current evaluation of sites that received Libby vermiculite. Actions taken to limit inhalation exposures will also minimize risk from dermal and oral exposures.

There is general acceptance in the scientific community of correlations of asbestos toxicity with fiber length as well as fiber mineralogy. Fiber length may play an important role in clearance 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 in December 2002 to review fiber size and its role in fiber toxicity [16]. The panel concluded that fiber length plays an important role in toxicity. Fibers with lengths less than 5 μm are essentially nontoxic when considering a role in mesothelioma or lung cancer promotion. However, fibers less than 5 μm in length may play a role in asbestosis when exposure duration is long and fiber concentrations are high. More information is needed to definitively make this conclusion.

It has been suggested that amphibole asbestos is more toxic than chrysotile asbestos, mainly due to physical characteristics which allow chrysotile to be broken down and cleared from the lung, whereas amphibole is not removed and builds up to high levels in lung tissue [17]. 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 [17]. However, OSHA continues to regulate chrysotile and amphibole asbestos as one substance, as both types increase the risk of disease [18]. EPA's Integrated Risk Information System assessment of asbestos also treats mineralogy and fiber length as equipotent [15].

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 to the observed variation in risk as does the fiber type itself [19].

Counting fibers using the regulatory definitions (see below) does not adequately describe risk of health effects, as fiber size, shape, and composition contribute collectively to risks in ways that are still being elucidated. For example, shorter fibers appear to preferentially deposit in the deep lung, but longer fibers might disproportionately increase the risk of mesothelioma [13,19]. 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 to 5 μm are considered above the upper limit of respirability (that is, too large to inhale) and do not contribute significantly to risk [13,19]. Methods are being developed to assess the risks posed by varying types of asbestos and are currently awaiting peer review [19].

Current Standards, Regulations, and Recommendations for Asbestos

In industrial applications, asbestos-containing materials are defined as any material with greater than 1% bulk concentration of asbestos [20]. 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 soils containing less than 1% amphibole asbestos can suspend fibers at levels of health concern [21].

Friable asbestos (asbestos which is crumbly and can be broken down to suspendable fibers) is listed as a Hazardous Air Pollutant on EPA's Toxic Release Inventory [22]. This requires companies that release friable asbestos at concentrations greater than 0.1% to report the release under Section 313 of the Emergency Planning and Community Right-to Know Act.

OSHA has set a permissible exposure limit (PEL) of 0.1 f/cc for asbestos fibers longer than 5 μm and with an aspect ratio (length:width) greater than 3:1, as determined by PCM [18]. 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 [18]. 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 based upon 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 community member exposure, as the PEL is based on an unacceptable risk level.

In response to the World Trade Center disaster in 2001 and an immediate concern about asbestos levels in homes 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, US Environmental Protection Agency, National Institute of Occupational Safety and Health, CDC National Center for Environmental Health, Occupational Safety and Health Administration, New York City Department of Health and Mental Hygiene, the New York State Department of Health, and other state, local, and private entities. The workgroup set a re-occupation level of 0.01 f/cc after cleanup. Continued monitoring was also recommended to limit long-term exposure to this level [24].

The National Institute of Occupational Safety and Health (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 [24]. The American Conference of Government Industrial Hygienists (ACGIH) has also adopted a TWA of 0.1 f/cc as its threshold limit value [25].

EPA has set a maximum contaminant level (MCL) for asbestos fibers in water of 7,000,000 fibers longer than 10 μm per liter, based on an increased risk of developing benign intestinal polyps [26]. Many states, including Colorado, use the same value as a human health water quality standard for surface water and groundwater [27].

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 [15]. 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, since above this concentration the slope factor might differ from that stated [15]. 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 current assessment and the knowledge gained since it was implemented in 1986.

Discussion

The vermiculite processed at this 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 [30,31]. The findings at Libby provided the impetus for investigating this site, as well as other sites across the nation that received asbestos-contaminated vermiculite from the Libby mine. It is important to recognize, however, that the asbestos exposures documented in the Libby community are in many ways unique and will not collectively be present at other sites that processed or handled Libby vermiculite. The site investigation at the Western Minerals Denver Plant is part of a national effort to identify and evaluate potential asbestos exposures that may be expected at these other sites.

Exposure Assessment and Toxicological 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. Site-specific exposure pathway information is also limited or unavailable.

- There is limited information on past concentrations of Libby asbestos in air in and around the plant. Also, as described in the preceding section, significant uncertainties and conflicts in the methods used to analyze asbestos exist. This makes it hard to estimate the levels of Libby asbestos people may have been exposed to.
- There is not enough information known about how and how often people came in contact with the Libby asbestos from the plant, because most exposures happened so long ago. This information is necessary to estimate accurate exposure doses.
- There is not enough information available about how some vermiculite materials, such as waste rock, were handled or disposed. This makes it difficult to identify and assess potential current exposures.

Given these difficulties, the public health implications of past operations at this site can only be evaluated qualitatively. The following sections describe the various types of evidence we used to evaluate exposure pathways and reach conclusions about the site.

Exposure Pathway Analysis

An exposure pathway is the way in which an individual is exposed to contaminants originating from a contamination source. Every exposure pathway consists of the following five elements: 1) a *source* of contamination; 2) a *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 potential 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 potential 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 at a later point in time. An eliminated pathway was a potential or completed pathway in the past, but has had one or more of the pathway elements removed to prevent present and future exposures.

After reviewing information from Libby, Montana and from facilities that processed vermiculite ore from Libby, the National Asbestos Exposure Review team has identified possible likely exposure pathways for vermiculite processing facilities. 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.

The pathways that will be considered for each site are listed in the following table. More detail on the pathways is included in Appendix A. Not every pathway identified will be an important source of exposure for a particular site. An evaluation of the pathways for this site is presented in the following paragraphs.

Table 1. Summary of Inhalation Pathways Considered for Western Minerals Denver Plant

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	Not applicable	Eliminated	Eliminated
Household Contact	Household contacts exposed to airborne Libby asbestos brought home on workers' clothing	Complete	Eliminated	Eliminated
Waste Piles	Community members (particularly children) playing in or otherwise disturbing onsite piles of contaminated vermiculite or waste rock	Potential	Eliminated	Eliminated
Ambient Air	Community members or nearby workers exposed to airborne fibers from plant emissions during handling and processing of contaminated vermiculite	Potential	Eliminated	Eliminated
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 fibers from plant emissions or residential outdoor waste	Potential	Potential	Potential
Onsite Soils	Current onsite workers, contractors, or community members disturbing contaminated onsite soils (residual contamination, buried waste)	Not applicable	Potential	Potential
Consumer Products	Community members, contractors, and repairmen disturbing consumer products containing contaminated vermiculite	Potential	Potential	Potential

Occupational (past and present) – Grace records indicate that workers were exposed to high levels of Libby asbestos in the air at the plant. Time-weighted averages (TWAs) for employees from the years 1975 to 1981 (found from Grace internal records) showed TWAs ranging from 0.02 f/cc to 2.37 f/cc. Most of the TWAs are higher than the current OSHA limit of 0.1 f/cc (although it should be noted that OSHA limits were higher at the time of sampling). In addition, records exist of very high fiber counts (>30 f/cc) in the furnace feed room, a room workers had to pass through on their way to work or to the locker rooms. The records available were generally from the time period after pollution control equipment and other dust suppression measures had been installed (in the early 1970s). It is assumed that workers were exposed to even higher fiber concentrations in previous years. Because anecdotal information indicates that use of personal protective equipment such as respirators by workers was not universal, the past occupational pathway is considered the most significant exposure pathway for the site.

The facility building was reportedly cleaned very well, and EPA reported that recent sampling of the air inside the building showed no Libby asbestos contamination. Therefore, it is unlikely that workers inside the facilities operating since 1990 (including present operations) were exposed to hazardous levels of Libby asbestos. However, high levels of contamination were detected in core

samples from under the parking lot, and workers who did sewer work and installed truck scales in the lot would have been exposed to Libby asbestos during those activities. Those exposures, however, were of short duration and much less likely to lead to health effects than the long-term, high-level exposures experienced by workers in the vermiculite processing plant. Because the building where current operations take place has been shown to be clean, there is no risk from the corn syrup product produced there today.

Household contact (past and present) – In the past, persons living with the workers could have inhaled Libby asbestos coming off of dirty clothing or hair of workers returning home from work. Information from former workers of the site indicated that the plant operations were dusty, disposable suits were not generally worn, and workers did not shower or change clothes before going home. This pathway was therefore likely to be important for the site.

Because the present occupational pathway is not expected to result in any Libby asbestos exposure to workers, the present household contact pathway is considered incomplete and eliminated from further consideration.

Waste piles (past and present) – Available anecdotal information indicated that the waste from the processing operations was kept bagged in dumpsters and disposed of by a contractor. No information was found that workers or neighborhood residents took substantial amounts of vermiculite or wastes for personal use. No waste or vermiculite piles were observed on the August 2002 site visit. Assuming the past waste was disposed of in a landfill, it is not likely that waste piles would be an important past pathway of exposure. Because no piles exist now, the present waste piles pathway is eliminated from further consideration .

Ambient air (past) – Community members or workers at nearby businesses could have been exposed in the past to Libby asbestos fibers released into the ambient air from fugitive dusts or the furnace stack while the plant was running. Available wind rose data from a monitoring station several miles from the site, shown in Figure 4, suggest that winds in the late 1970s were predominantly from the south and southwest, generally away from the residences and most of the businesses observed during the site visit. However, some winds could have blown towards these buildings, and there may have been a greater number of residences or businesses near the plant in the past. No estimate of risk from this potential exposure can be made. It is unlikely that sufficiently detailed plant-specific emission information will ever be available, and if it was, it would still be difficult to construct past exposures given limited information on population in the area. The Minnesota Department of Health developed an air dispersion model for an expansion plant in Minneapolis, Minnesota, which suggested that elevated fiber levels in air dropped off rapidly with distance from the facility, decreasing by an order of magnitude within a few hundred meters [28]. Site-specific emissions characteristics and meteorological conditions could affect results greatly, however. For this site, there is insufficient information to evaluate the significance of this exposure pathway. However, due to dispersion and changing wind patterns, the level of exposure from the ambient air pathway would be much lower than the high-level exposure experienced by former plant workers and thus less likely to lead to adverse health effects.

Residential outdoor (past and present) – Available information indicates that people living in the community around the plant face minimal risk of asbestos exposure from soils in their yards, either in the past or currently. The area immediately around the plant is industrial, and soil sampling showed asbestos contamination to be concentrated in specific locations around the processing buildings and railroad spur, not widespread throughout the neighborhood. No indication that people ever hauled materials contaminated with Libby asbestos away for personal use was found, so it is doubtful that people could be currently exposed to contaminated vermiculite in residential soil. In light of this information, this exposure pathway is considered to be insignificant compared to the other pathways evaluated.

Residential indoor (past and present) – Residents could have inhaled LA fibers from household dust, either from plant emissions that infiltrated into homes or from dust brought inside from waste products brought home for personal use. There is no information on past levels of contamination in ambient air; however, it appears unlikely that past ambient air emissions would have been high enough to infiltrate significantly into houses about a quarter of a mile away. No information has been gathered about community members using waste materials in their yards. There is not enough information to evaluate whether this exposure pathway is likely to be significant for the site.

Onsite (present) – Cleanup workers, trespassers, or neighborhood residents can be exposed to Libby asbestos through disturbing contaminated vermiculite or soil remaining on or around the site. Although the building was reportedly cleaned well when the property changed ownership in 1990 and EPA reported that sampling showed no contamination remaining inside the building, there are small amounts of residual Libby asbestos-contaminated vermiculite present in the soil around the plant. It has been shown that disturbing soils with even trace amounts of Libby asbestos can result in airborne Libby asbestos at levels of concern [21]. Of specific concern is vermiculite present in an unpaved former parking area on the south property boundary. This area is currently covered, but the cover is in poor condition and anyone disturbing the material could be exposed. Disturbing vermiculite along the railroad track and spur could also result in exposure, although the likelihood of anyone accessing those areas is smaller. This pathway is considered an insignificant exposure pathway at the present time because people rarely contact with the contaminated areas, if at all, but a potential future hazard exists as long as the contamination remains in place.

Consumer products – People who purchased and used vermiculite products may be exposed to asbestos fibers from using those products in and around their homes. At this time, determining the public health implication of commercial or consumer use of vermiculite products (such as home insulation or gardening products) is beyond the scope of this evaluation. However, studies have shown that disturbing or using these products can result in airborne asbestos fiber levels higher than occupational safety limits [21,29]. Additional information for consumers of vermiculite products has been developed by EPA, ATSDR, and NIOSH and provided to the public (see www.epa.gov/asbestos/insulation.html).

Future Pathways – All of the present exposure pathways are expected to continue into the future unless appropriate cleanup actions are taken, and additional pathways might be created in the future. Of specific concern at this site is the Libby asbestos contamination under the asphalt parking lot. If future construction activities disturb the asphalt or underlying soils, workers, and

possibly other passersby in the area, could be exposed to Libby asbestos fibers. Those exposures, however, would be of short duration and much less likely to lead to adverse health effects than the long-term, high-level exposures experienced by plant workers.

Health Outcome Data

Health outcome data can be used to give a more thorough evaluation of the public health implications of a given exposure. Health outcome data can include mortality information (for example, the number of people who have died from a certain disease) or morbidity information (for example, the number of people in an area who have a certain disease or illness).

Workers at the site were exposed to levels of contamination consistent with the development of adverse health effects. No information is available about past levels of contamination around the plant or the number of people affected in the neighborhood. The Colorado Department of Public Health and the Environment is performing a review of health outcome data to determine if any of the areas in the state near facilities that processed Libby vermiculite are associated with higher disease rates. Because the plant employed few workers and because few people lived very close to the plant, the small number of potentially affected people could make it difficult to detect community-level health effects. Preliminary site-specific results of the health statistics review for this site are included in Appendix B. The ATSDR Division of Health Studies will release annual reports summarizing health statistics review findings for all sites for which data have been received. The first annual report is slated to be released in summer 2003.

In Libby, Montana, the number of recorded deaths associated with asbestos-related diseases was significantly elevated (as compared with the state or the nation as a whole), especially among former workers of the vermiculite mine and their household contacts [30]. Former workers and their household contacts also showed higher rates than expected of pleural (lung lining) abnormalities, indicating higher exposure and a higher risk for developing asbestos-related disease [31]. Limited past data indicates that fiber levels in the processing areas of Libby and Western Minerals were similar, suggesting that worker exposures might have also been similar. Therefore, it is likely that former workers at the Western Minerals Denver Plant and their household contacts have an increased risk of developing asbestos-related disease.

Summary of Removal and Remedial Actions Completed and Proposed

- There has been no cleanup action taken yet at the site. The most likely source of Libby asbestos fiber exposure is the former parking area on the south property border. Under advisement from EPA, the area is reportedly no longer used for supplemental parking for the facility. This reduces the potential for current exposure. However, the area is not effectively covered, and people who might be there are not protected from exposure to Libby asbestos.
- EPA is planning removal of soil from locations around the site which have trace levels of tremolite-actinolite asbestos or higher (personal communication, Joyce Ackerman, US Environmental Protection Agency, August 2002). This action will be protective of public health for current and future exposures.

- To our knowledge, there are no plans to clean up soils beneath the existing parking lot. Public health in the area will be protected, however, as long as the surface of the parking lot remains undisturbed.

Child Health Considerations

ATSDR recognizes that infants and children might be more vulnerable than adults to exposure 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 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 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, children who are exposed could be more at risk of actually developing asbestos-related disease than people exposed later in life because of the long latency period between exposure and onset of asbestos-related respiratory disease.

The most at-risk children are those who were household contacts of workers at the time the plant was operating. The plant is no longer operating, the ball field was shown to be free of contamination, and contamination is localized in areas where children would not likely play. Therefore, it is unlikely that children today are exposed to vermiculite contaminated with Libby asbestos.

Conclusions

- Workers at the Western Minerals Denver Plant were exposed to hazardous levels of Libby asbestos in the past. Members of workers' households are likely to have been exposed to hazardous levels of Libby asbestos through household contact in the past. The occupational and household contacts pathways represent a past public health hazard.
- Not enough information is available to determine the extent to which people living in the neighborhood of the plant were exposed to Libby asbestos in the past through ambient air or residential indoor pathways. These past pathways represent an indeterminate public health hazard. However, the risk of adverse health effects from these past pathways is probably low, especially compared to the past occupational and household contacts pathways.
- Localized areas of Libby asbestos contamination remain around the plant and could pose a public health hazard since regular contact could lead to adverse health effects. Currently, however, adverse health effects are unlikely because most areas are free of contamination and people are not frequently in the areas that are contaminated.
- Other pathways (past and present exposure to waste piles, past and present outdoor residential soils, present occupational, present household contacts, and present ambient air) are unlikely to be significant exposure pathways at this site and therefore pose no apparent public health hazard.

- Future exposure is possible if construction or other activities disturb the asphalt in the parking lot. Such exposure would be much less likely to lead to adverse health effects than past plant worker exposures, but still could pose a future public health hazard.

Recommendations

- Identify former workers and their families or other household contacts for possible evaluation of health effects associated with Libby asbestos exposure.
- Clean up areas of contaminated vermiculite remaining around the site to avoid future exposure.
- Develop a plan to prevent future exposure pathways that might be created if soil underneath the parking lot is disturbed.
- Contact former workers and request more detailed information about waste disposal and operating practices at the facility to assist in exposure analysis.

Public Health Action Plan

The purpose of the public health action plan is to ensure that public health hazards are not only identified, but also addressed. The public health action plan for this site describes actions that ATSDR and/or other government agencies plan to take at the site to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. ATSDR will also follow up on the plan to ensure implementation of the following public health actions:.

- ATSDR will work with EPA as they continue investigating and cleaning up the site.
- ATSDR, its state partners, or both will study the feasibility of conducting worker and household contact follow-up activities.
- ATSDR will combine the findings from this health consultation with findings from other health consultations on sites that processed vermiculite from Libby and develop a national summary report of the overall conclusions and strategies for addressing the public health implications, as needed.
- ATSDR will provide educational materials and references, upon request, to community members concerned about products containing vermiculite.
- ATSDR will review information that becomes available to determine appropriate site-specific public health actions.
- ATSDR will publish annual reports summarizing results of health statistics reviews for the vermiculite processing sites.

Author
Jill J. Dyken, Ph.D., P.E.
Environmental Health Scientist
Superfund Site Assessment Branch (SSAB), DHAC, ATSDR

Regional Representative
Susan Muza
Regional Representative
Office of Regional Operations, Region 8

Reviewers
John Wheeler, Ph.D., DABT
Senior Toxicologist
Exposure Investigations and Consultation Branch (EICB), DHAC, ATSDR

Susan Moore, M.S.
Chief, Consultations Section
Exposure Investigations and Consultation Branch (EICB), DHAC, ATSDR

John E. Abraham, Ph.D., MPH
Branch Chief
Exposure Investigations and Consultation Branch (EICB), DHAC, ATSDR

Richard Gillig, MCP
Branch Chief
Superfund Site Assessment Branch (SSAB), DHAC, ATSDR

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Figure 1. Western Minerals Denver Plant Site Location

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Figure 2. Tremolite Grains in Western Minerals Former Parking Area

22

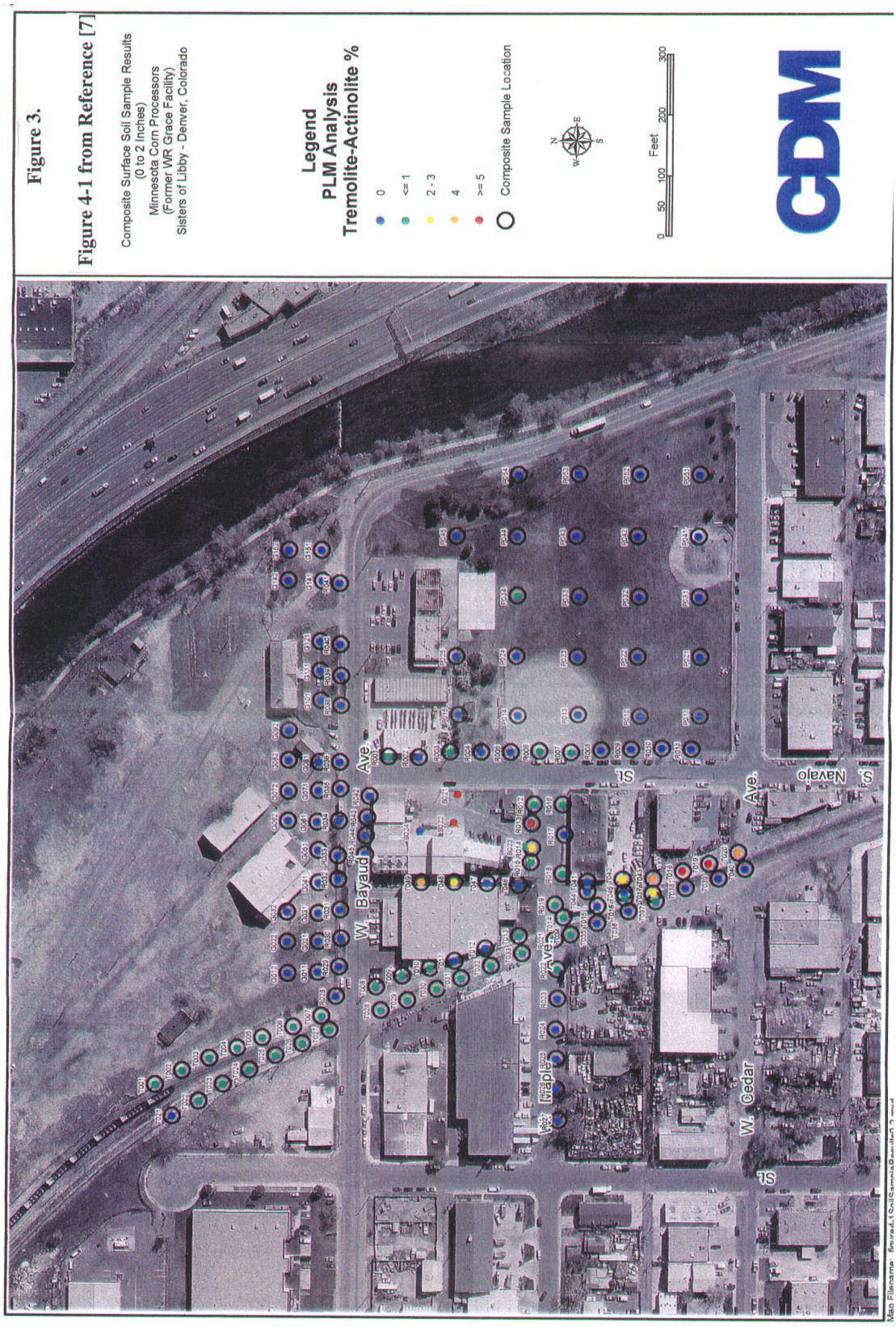
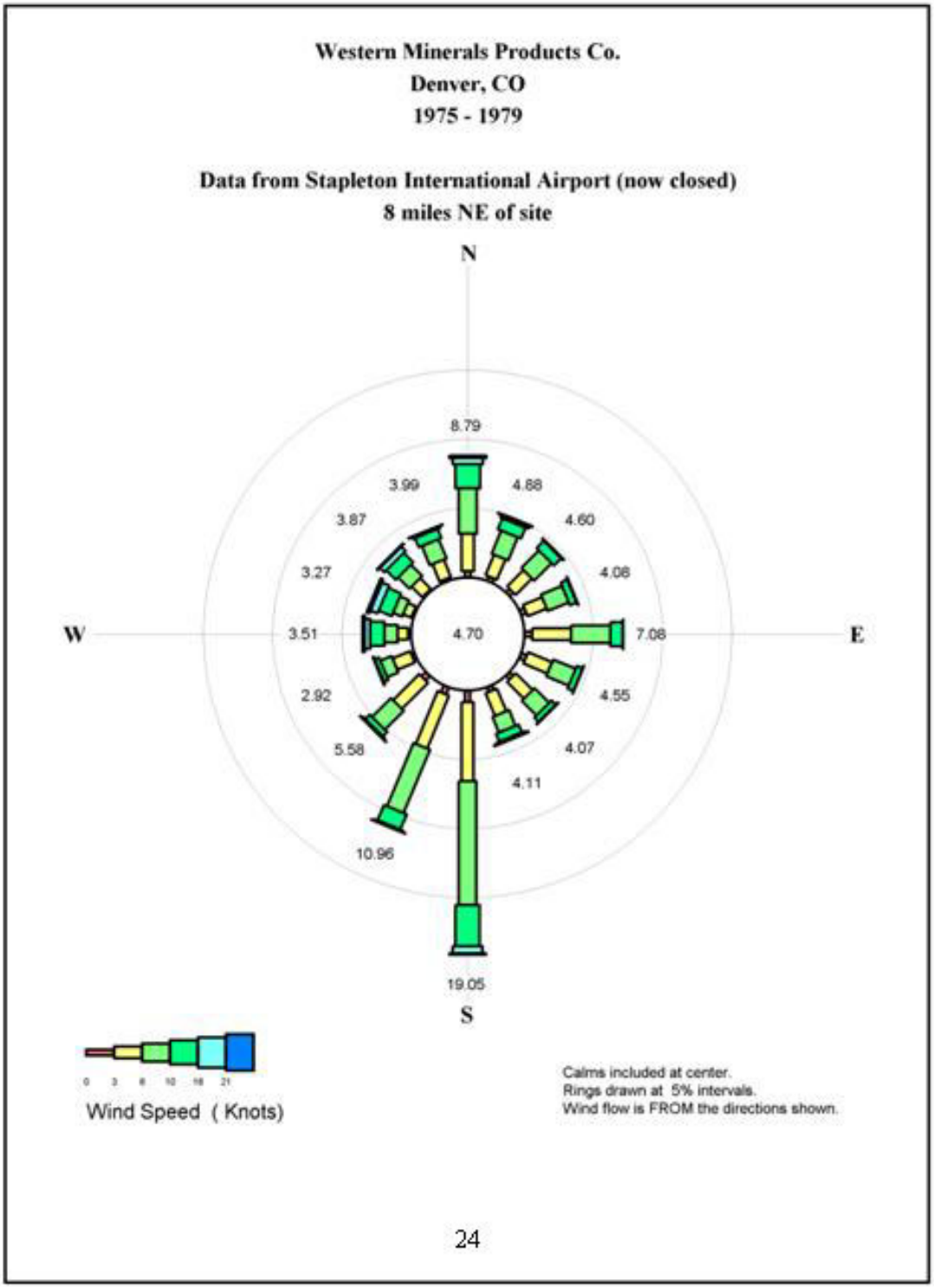


Figure 3.
Figure 4-1 from Reference [7]
Composite Surface Soil Sample Results
(0 to 2 Inches)
Minnesota Corn Processors
(Former WR Grace Facility)
Sisters of Libby - Denver, Colorado
Legend
PLM Analysis
Tremolite-Actinolite %
0
<= 1
2 - 3
4
>= 5
Composite Sample Location
N
W
E
S
0
50
100
200
300
Feet
CDM
W. Bayaud Ave.
W. Cedar Ave.
W. Maple Ave.
S. Navajo St.
S. Navajo St.

Figure 4. Wind Rose Data



APPENDIX A. EXPOSURE PATHWAYS- VERMICULITE PROCESSING FACILITIES

SOURCE FOR ALL PATHWAYS: Libby Asbestos-contaminated Vermiculite from Libby, Montana

PATHWAY NAME	ENVIRONMENTAL MEDIA & TRANSPORT MECHANISMS	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSURE POPULATION	TIME
Occupational	Suspension of Libby asbestos fibers or contaminated dust into air during materials transport and handling operations or during processing operations	Onsite	Inhalation	Former workers	Past
	Suspension of Libby asbestos fibers into air from residual contamination inside former processing buildings	Inside former processing buildings	Inhalation	Current workers	Present, future
Household Contact	Suspension of Libby 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, future
Waste Piles	Suspension of Libby asbestos fibers into air by playing in or otherwise disturbing piles of vermiculite or waste rock	Onsite, at waste piles	Inhalation	Community members, particularly children	Past, present, future
Residential Outdoor	Suspension of Libby asbestos fibers into air by disturbing contaminated vermiculite brought offsite for personal uses (gardening, paving driveways, traction, fill)	Residential yards or driveways	Inhalation	Community members	Past, present, future
Residential Indoor	Suspension of household dust containing Libby asbestos fibers from plant emissions or residential outdoor waste	Residences	Inhalation	Community members	Past, present, future
Ambient Air	Stack emissions and fugitive dust from plant operations into neighborhood air	Neighborhood around site	Inhalation	Community members, nearby workers	Past
Onsite Soils	Suspension of Libby asbestos fibers into air from disturbing contaminated material remaining in onsite soils (residual soil contamination, buried waste)	Areas of remaining contamination at or around the site	Inhalation	Current onsite workers, contractors, community members	Present, future
Consumer Products	Suspension of Libby asbestos fibers into air from using or disturbing insulation or other consumer products containing Libby vermiculite.	Homes where LA-contaminated products were/are present	Inhalation	Community members, contractors and repairmen	Past, present, future