Public Health Assessment for

SDMS Document ID
2009600

OU4: Screening Plant, Export Plant, Town of Libby,
and Affected Libby Valley Residential and Commercial Properties

LIBBY ASBESTOS NPL SITE

LIBBY, LINCOLN COUNTY, MONTANA

EPA FACILITY ID: MT0009083840

SEPTEMBER 30, 2002

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DEPARTMENT OF HEALTH & HUMAN SERVICES
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THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

Section 104 (i) (7) (A) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, states "...the term 'health assessment' shall include preliminary assessments of potential risks to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure (including ground or surface water contamination, air emissions, and food chain contamination), the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure. The Administrator of ATSDR shall use appropriate data, risk assessments, risk evaluations and studies available from the Administrator of EPA."

In accordance with the CERCLA section cited, ATSDR has conducted this preliminary health assessment on the data in the site summary form. Additional public health assessments may be conducted for this site as more information becomes available to ATSDR.

The conclusions and recommendations presented in this public health assessment are the results of site-specific analyses and are not to be cited or quoted in other evaluations or public health assessments.

Use of trade names is for identification only and does not constitute endorsement by the Public Health Service or the U.S. Department of Health and Human Services.

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Prepared by:

Superfund Site Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. (The legal definition of a health assessment is included on the inside front cover.) If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, fullscale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state and federal agencies, the companies responsible for cleaning up the site, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When informed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E60), Atlanta, GA 30333.

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Summary

Libby is the county seat of Lincoln County in northwest Montana. Vermiculite was mined from "Zonolite Mountain" near Libby from the early 1920s until 1990 and was processed for export in and around the town of Libby. The vermiculite mined in Libby is contaminated with amphibole asbestos fibers (Libby asbestos, LA). Mining and processing operations, as well as home use of Libby vermiculite products, resulted in the spreading of LA throughout the town. Unusually high numbers of people in Libby have been diagnosed with asbestos-related respiratory disease, and deaths from asbestos-related respiratory diseases are also elevated. The Environmental Protection Agency's (EPA's) Emergency Response Branch has been conducting sampling and removals to address the most highly contaminated areas in the Libby valley since 1999. Since the proposal of the Libby Asbestos site to the National Priorities List (NPL), these activities are transitioning over to the Superfund Branch for long-term cleanup.

People were exposed to LA by many different exposure pathways in the past, and the possibility for further exposure exists as long as source materials are present. However, many of the most highly contaminated areas are being cleaned up. Characterization of contamination in homes and businesses in Libby in order to prioritize cleanups is occurring as of summer 2002 through the EPA Superfund program.

Based on the available information, the Agency for Toxic Substances and Disease Registry (ATSDR) has concluded that:

- People in the Libby area were exposed to hazardous levels of asbestos in the past.
- People in the Libby area have elevated levels of disease, and death, associated with exposure to asbestos.
- People may still be exposed to hazardous levels of asbestos near current source areas. These levels may be especially hazardous to sensitive populations, including people who have been exposed for many years already, smokers, and young children.
- The exact level of risk associated with low level exposure to asbestos cannot be determined due to uncertainties in the analysis and toxicology of Libby asbestos. However, continuing exposures to Libby asbestos pose an unacceptable risk to residents and workers who have already been exposed for many years.
- The cleanup actions undertaken by EPA are protective of public health.

ATSDR makes the following recommendations:

- EPA should continue to investigate and clean up the site to reduce or remove continuing sources of Libby asbestos.
- Conduct toxicological investigation of the risks associated with low level exposure to asbestos, specifically with the chemical makeup and fiber size of Libby asbestos. This investigation is necessary to assure that site cleanup levels remain protective.
- Conduct health education for the community, especially concerning smoking and asbestos.
- Create a registry to track former workers, their household contacts, and residents exposed to Libby asbestos.
- Continue to provide information to the community about the hazards of Libby asbestos.
- Continue to provide information on how to diagnose and treat asbestos-related diseases to the local medical community.

Purpose and Health Issues

Libby Asbestos was proposed for the National Priorities List (NPL) on February 26, 2002. The Agency for Toxic Substances and Disease Registry (ATSDR) is required by Congress to conduct public health assessments (PHAs) on all sites proposed for the NPL. In this PHA, ATSDR evaluates the public health significance of the Libby Asbestos site based on available environmental data, potential exposure scenarios, community health concerns, and health outcome data. This document also recommends actions to prevent, reduce, or further identify the possibility for site-related adverse health effects.

Background

The background, site description, and site operational history comes from Environmental Protection Agency (EPA) and ATSDR documents [1,2,3,4,5].

Libby is the county seat of Lincoln County in northwest Montana. Vermiculite, a type of platy weathered mica minerals, was discovered by gold prospectors on a mountain ("Zonolite Mountain") 7 miles northeast of Libby in 1881. It was mined from the early 1920s until 1990 for use in a variety of products. 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 (°F), which explosively vaporizes the water contained within the mineral structure and causes the vermiculite to expand by a factor of 10 to 15. Direct export and exfoliation (expansion) prior to shipping was performed in locations in and around the town of Libby.

The vermiculite mined from Zonolite Mountain is contaminated with asbestos fibers, including the varieties tremolite and actinolite, as well as the related fibrous asbestiform minerals winchite, richterite, and ferro-edenite [6]. Collectively, the asbestiform minerals contaminating the vermiculite are referred to herein as Libby asbestos (LA). Mining and processing operations, as well as home use of waste rock and products from the mine, resulted in the spreading of LA throughout the town. Hundreds of people in Libby, including former mine workers, their families, and other residents, have exhibited signs and symptoms of asbestos-related disease. In response to reports of widespread disease among Libby residents, since 1999 EPA's Region 8 Emergency Response Branch has been conducting sampling and removals to address the most highly contaminated areas in the Libby valley. These activities are transitioning to EPA's Superfund Branch for long-term cleanup since the Libby area was proposed for the NPL in February 2002.

Site Description

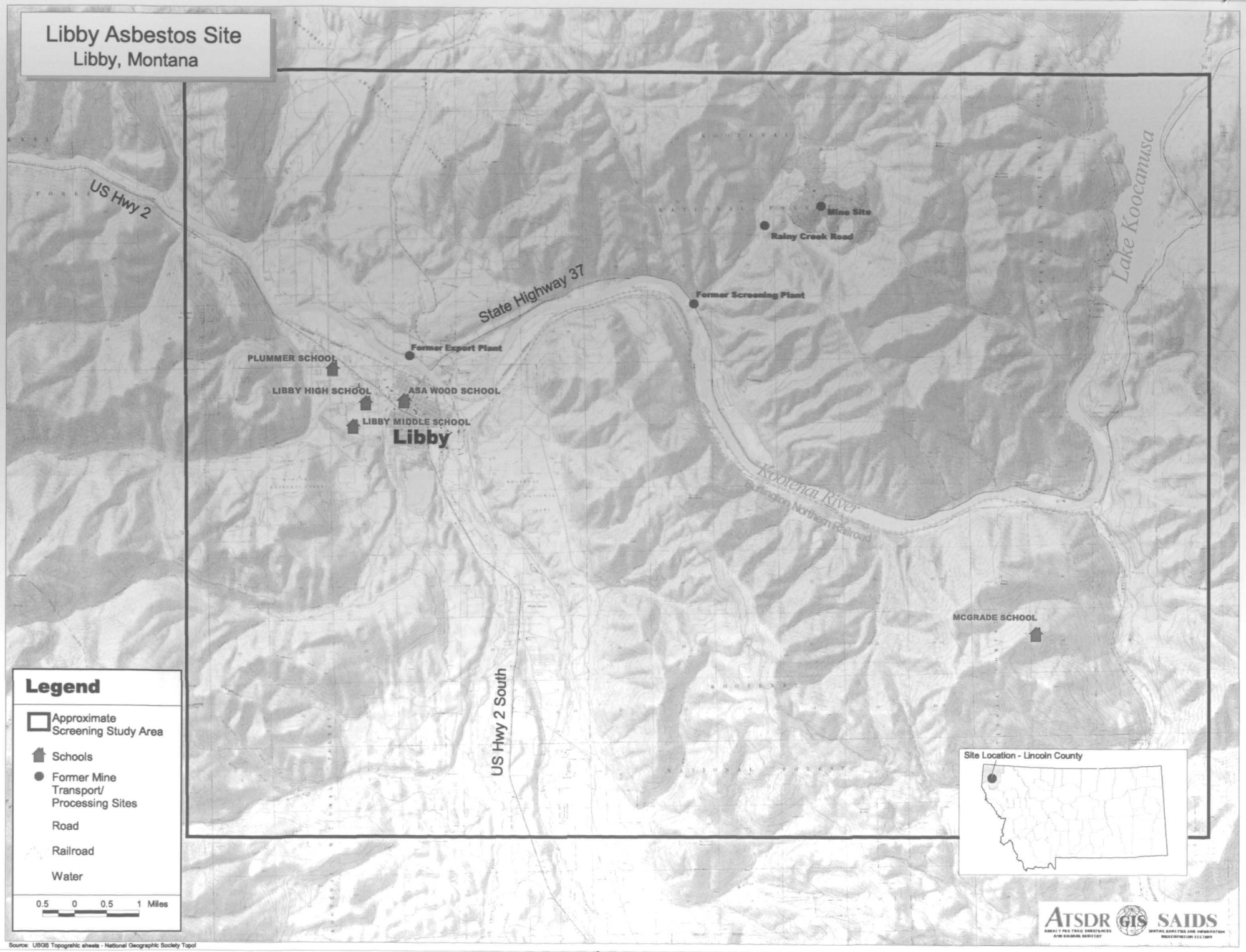
The Libby Asbestos site (the site) is located in Libby, Montana. Figure 1 shows the site location and features. Libby lies in the northwest corner of Montana in Lincoln County approximately 35 miles east of the Idaho border and 65 miles south of the Canadian border. Libby is bounded to the north by the Kootenai River and surrounded to the south by the Cabinet Mountains and the Cabinet Mountain Wilderness area. The site lies within Sections 3 and 10, T30N, R31W of the Libby Quadrangle in Lincoln County, Montana.

Color Map(s)

The following pages contain color that does not appear in the scanned images.

To view the actual images, please contact the Superfund Records Center at (303) 312-6473.

Figure 1: Site Location and Features



The site includes the vermiculite mine on Zonolite Mountain, the former screening plant and the former export plant (two former vermiculite processing centers), the road between the former screening plant and the mine site (Rainy Creek Road), and homes and other businesses which may have become contaminated with LA fibers as a result of the mining and processing operations in and around Libby. For long-term management purposes, EPA has divided the site into two operable units (OUs). OU3 includes the mine site and Rainy Creek Road, and OU4 includes the remainder of the Libby valley [1].

Because OU4 includes homes and other areas where continuing exposure to asbestos fibers is likely, and because EPA is focusing its current remedial investigation (RI) activities on this unit, this PHA will consider only OU4. The mine and road in OU3 are of less concern at present since access is limited by a barricade at the lower entrance to Rainy Creek Road. OU3 will be considered at a later date.

Site Operational History

Initial mining operations began on the vermiculite ore body 7 miles northeast of Libby in the early 1920s. Full-scale operation began later that decade under the name of Universal Zonolite Insulation Company (Zonolite). The vermiculite ore was strip mined using conventional mining equipment. The ore was processed onsite in a dry mill to remove waste rock and overburden material and then transported to the former screening plant at the foot of Zonolite Mountain, where is was sorted into size fractions. After the sorting process, the material was shipped all over the United States, either for direct use in products or for expansion prior to use in products. Two sites of expansion were also located in Libby: the former export plant located immediately west of Highway 37 where it crosses the Kootenai River and the former expansion plant located at the end of Lincoln Road, near 5th Street (shut down in the early 1950s, exact location not yet determined).

In 1963, W.R. Grace purchased Zonolite and continued operating the mine in the same manner. In 1975, a wet milling process was added which operated in tandem with the dry mill until the dry mill was shut down in 1985. Expansion operations at the export plant ceased sometime before 1981, although the area was still used to bag and export milled ore until mining operations stopped in 1990. In the years of operation, the Libby mine produced millions of tons and provided about 80% of the world's supply of vermiculite.

Demographics

According to U.S. Census 2000 information, 10,362 persons live within the zip code area including Libby, Montana (59923) [7]. Figure 2 shows the demographic profile of the population residing in the area around Libby selected for asbestos screening by EPA, a population of 8,668. The population is mostly (95%) white. About 1.5% of the population is Native American, less than 1% is Black, Asian, Native Hawaiian or other Pacific Islanders or other, and about 2% of the population is from two or more races.

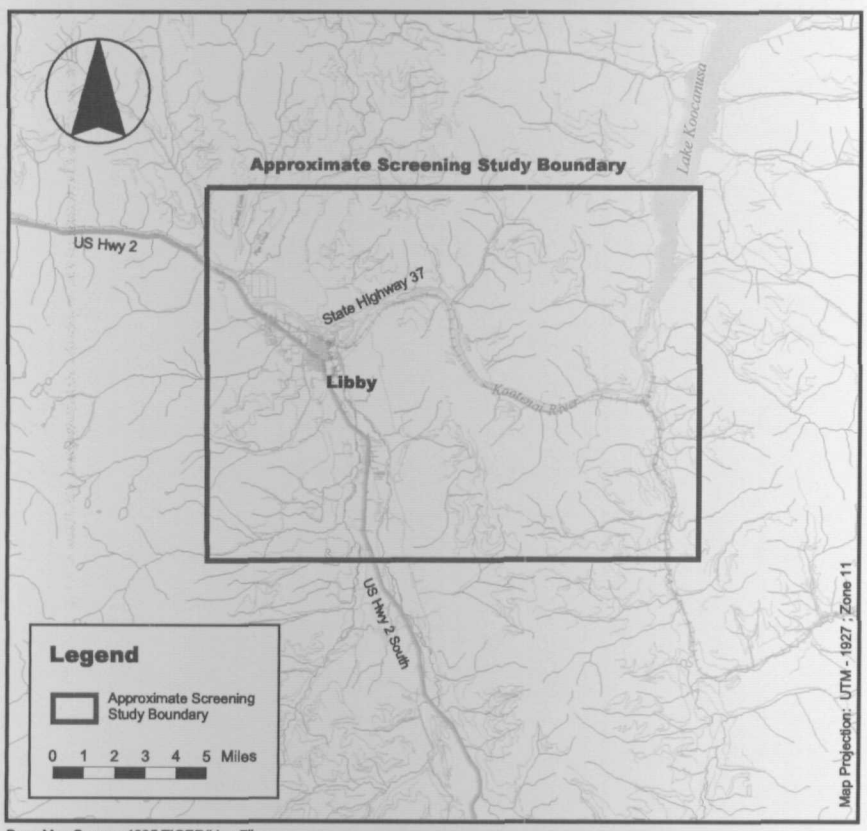
It should be noted that some mine workers resided in the smaller towns of Troy and Eureka, Montana. Also, some mine workers moved to the town of Elko, Nevada, after the Libby mine

Libby Asbestos Site

Libby, Montana

EPA Facility ID MT0009083840

FIGURE 2. Demographic Map

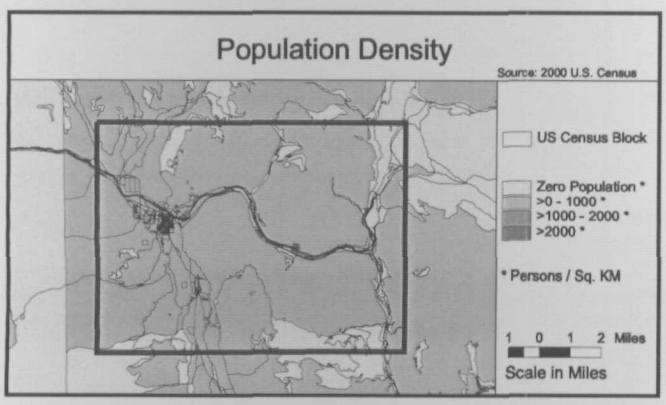


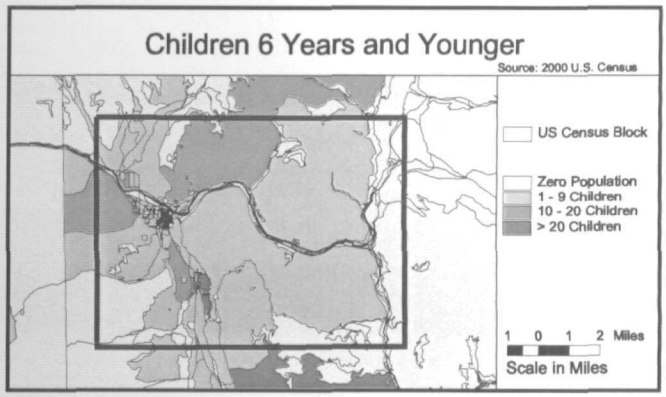
Base Map Source: 1995 TIGER/Line Files

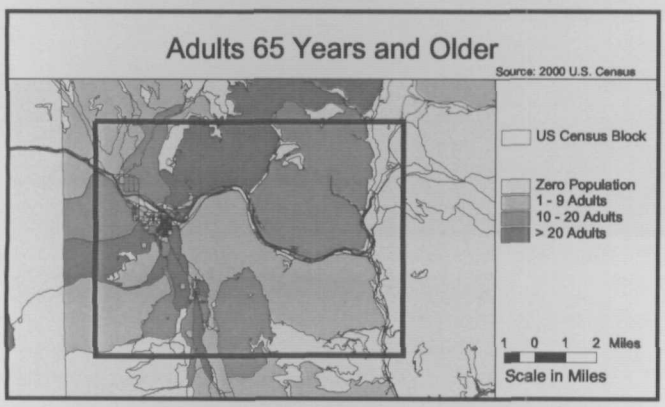
Lincoln County, Montana

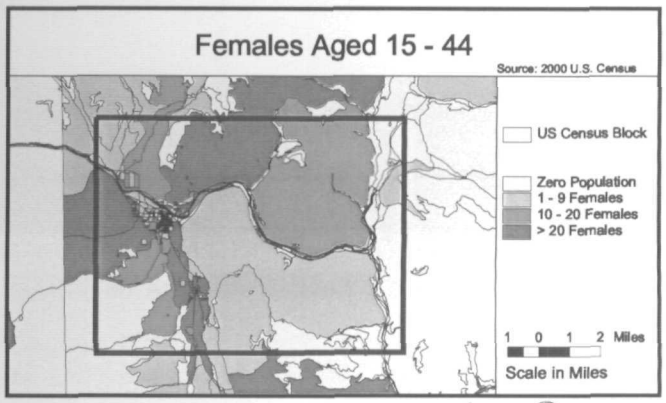
Demographic Statistics Within site boundary*	
Total Population	8668
White alone	8286
Black alone	8
Am. Indian and Alaska Native alone	122
Asian alone	33
Native Hawaiian and Other Pacific Islander alone	2
Some other race alone	39
Two or More races	180
Hispanic or Latino	121
Children Aged 6 and Younger	652
Adults Aged 65 and Older	1369
Females Aged 15 - 44	1566
Total Housing Units	3954

Demographics Statistics Source: 2000 US Census
*Calculated using an area-proportion spatial analysis technique









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shut down. The demographics of people affected in these communities are expected to be similar to that of Libby.

Land and Natural Resource Use

Located in the far northwestern corner of Montana, Libby lies in a valley carved by the Kootenai River on the northeastern edge of the Cabinet Mountain Range. Libby sits at an elevation of 2,066 feet and is surrounded by the Kootenai National Forest. The Libby Dam confines the Kootenai River about 17 miles north of town to create the 90 mile long Lake Koocanusa that extends north into Canada. Montana Highway 37 parallels the Kootenai River and Lake Koocanusa and connects Libby to U.S. Highway 93 to the north. U.S. Highway 2 runs through Libby and connects Libby to the nearest towns of Kalispell 90 miles to the southeast and Troy 18 miles to the northwest. The Burlington Northern Railroad maintains the railroad that runs through Libby connecting Libby to Whitefish, Montana and Spokane, Washington. Freight service runs daily and Amtrak service is available 4 days a week. Libby also has a small airport with a 5,000 foot runway [8].

Libby contains neighborhoods, commercial, and industrial areas in relative proximity to each other. Outside of town the terrain quickly becomes mountainous, forested, and rural. Population is sparse away from two main roads. Major industries include forestry, forest products, and tourism.

People in Libby engage in typical residential activities as well as activities related to work at commercial and industrial facilities in town. The areas outside of town are used for hiking, fishing, hunting, and other recreational activities. Logging also takes place in the forested areas.

Drinking water for the city of Libby comes from the Flower Creek reservoir, which is located approximately 3 miles southwest of town. [1] People in the area surrounding Libby may use groundwater wells for their drinking water.[1]

The Libby valley has a vertical relief as high as 4,000 feet in some areas and is subject to severe temperature inversions during many times of the year. These physical characteristics may result in the trapping of particulates and other air pollutants in the Libby valley [3].

Previous Reports and Studies

This PHA builds on the many previous studies and reports already in existence regarding Libby asbestos and the impact it has had on health in Libby and the surrounding area. The information in the following documents was used as background for this report:

- Articles began appearing in the scientific literature in the late 1970s and 1980s reporting elevated levels of asbestos-related diseases in workers of the Libby vermiculite mine [9,10,11,12]. Concern for the workers as well as their families and residents of Libby was brought to the public's attention in the media in 1999 [13]. ATSDR became involved with Libby at this time.

[1] Based on conversations with Jim Christiansen, EPA Remedial Project Manager.

- Throughout its involvement, ATSDR has cooperated with EPA, the Montana Department of Public Health and Human Services (MDPHHS), the Lincoln County Environmental Health Department, and the Montana Department of Environmental Quality in the Libby Community Environmental Health Project to address public health concerns regarding asbestos exposure in Libby.
- In December 1999, ATSDR published a health consultation regarding EPA Region 8's proposal to use an asbestos sampling protocol developed by EPA Region 1 to assess levels of contamination in Libby [2]. ATSDR concurred with the use of this protocol.
- In May 2000, ATSDR published a health consultation regarding the health hazards associated with asbestos contamination at the former screening plant and at the former export plant [4]. ATSDR concluded that the contamination posed a public health hazard and that time critical removals by EPA were warranted.
- In November 2000, ATSDR published a health consultation in which it evaluated proposed plans for the removal of asbestos contamination at the former screening plant and the former export plant [5]. ATSDR found that the plans were protective of public health. ATSDR also made recommendations to minimize the chances of asbestos exposure to workers or the community during the removal.
- In August 2001, ATSDR and cooperative partners in the Libby Community Environmental Health Project released a report on the results of the first round of medical testing of Libby residents and former residents for asbestos-related health effects [14]. The testing program was undertaken in cooperation with other agencies to identify the asbestos-related health effects of participants exposed to asbestos and to refer these individuals for additional medical evaluation as needed. In the first round of testing, conducted in the summer of 2000, pleural abnormalities were observed in 18% of the people tested; 48% of those who were former mine workers exhibited abnormalities. Another report combining results from the first round of testing with a second round, performed in the summer of 2001, is expected shortly.
- In September 2001, ATSDR released a chemical-specific health consultation on tremolite asbestos and other related types of asbestos [15]. This consultation served as an addendum to ATSDR's toxicological profile on asbestos and was produced to address public health concerns regarding the fibrous amphibole that occurred in vermiculite from Libby.
- In conjunction with the medical testing performed in 2000 and 2001, ATSDR conducted a study on the usefulness of computed tomography (CT) scans in identifying lung problems associated with asbestos exposure for people whose chest x-rays were indeterminate. The results of this study are expected shortly.
- In December 2001, an EPA toxicologist published a memorandum to the Libby on-scene coordinator which included a discussion of potential risks from exposure to LA in residential type settings [16]. The memo concluded that "amphibole mineral fibers in source materials in residential and commercial areas of Libby pose an imminent and substantial endangerment to public health."
- In May 2002, EPA published a sampling and analysis plan for their contaminant screening study, part of the RI activities for OU4 [1]. This report outlines EPA's plan for screening each property in the Libby valley for potential sources of LA. ATSDR was given the opportunity to comment on a draft of this document and agreed that the proposed plan was reasonable.

- In August 2002, ATSDR published a health consultation updating results of a December 2000 analysis of Libby area mortality statistics [17,3]. This review was conducted to generate an accurate representation of mortality potentially associated with historical asbestos exposure in the Libby area. For the period reviewed in the report (1979-1998), mortality in Libby resulting from asbestosis was 40 to 80 times higher than expected, and lung cancer was 20% to 30% higher than expected. Mesothelioma mortality was also elevated, but it could not be quantified. State and national statistics on this disease are not routinely published, but because the disease is so rare, any cases are viewed as an elevation. Most of the asbestosis and mesothelomia deaths were among former workers of the vermiculite mine and processing operations.

Discussion

Data Used

The preparation of this report involved the review and summary of numerous previous studies and data summaries. Generally, the conclusions reached herein are based on three types of data:

1. Analytical data – reported in several documents available in EPA's administrative record (AR) for the site [18].
2. Community concerns – collected by ATSDR representatives in Libby. Also, some community concerns were obtained from EPA's draft community involvement plan [8].
3. Health outcome data – as reported in ATSDR's mortality statistics review and in the ATSDR report on the community medical testing program [3,17,14].

All the above data were considered in determining conclusions and recommendations for the site.

Contaminant of Concern

The Libby vermiculite contains a characteristic profile of asbestiform minerals, including tremolite, actinolite, winchite, richterite, and ferro-edenite. The contaminant of concern, comprising the various types of asbestiform minerals detected in vermiculite from the Libby mine, is referred to herein as Libby Asbestos (LA). The following sections give more information about asbestos in general and the materials making up LA specifically.

This document is atypical compared to most PHAs in that only one contaminant is considered. If in the course of the RI activities for this site, other contaminants are identified that could contribute significantly to health risks in the community, they will be evaluated in an addendum to this document.

Asbestos Overview

This description comes mostly from ATSDR's toxicological profile for asbestos [15]. Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers in a parallel arrangement. Different criteria are used to identify asbestos fibers, depending on the context. In general, the Occupational Safety and Health Administration (OSHA) regulates as fibers those particles of the regulated mineral classes (see below) longer than 5 μm in length,

with aspect ratios (length: width) of at least 3:1, and which are not "cleavage fragments," crystalline particles exempt from regulation [6].

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, may exhibit fibrous asbestiform properties.

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 characteristic material will be referred to herein as Libby asbestos (LA). The raw ore was estimated to contain up to 26% LA [19]. For most of the mine's operation, LA was considered a byproduct of little or no value and was not used commercially. However, the mining and processing of LA-contaminated vermiculite resulted in the contamination of many areas in and around Libby with LA.

Asbestos Health Effects

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 may spread to tissues surrounding the lungs or other organs. Virtually all mesothelioma cases are attributable to asbestos exposure [15]. It has been suggested that amphibole asbestos is a more potent inducer of mesothelioma than chrysotile asbestos, but uncertainties and confounding evidence have prevented a complete consensus in the scientific community from being reached [20].

Lung cancer – Cancer of the lung tissue. 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 [15].

Noncancer effects – these include *asbestosis*, where asbestos fibers lodged in the lung cause scarring and reduce lung function; *pleural plaques*, localized or diffuse areas of thickening of the pleura (lining of the lung); *pleural thickening*, extensive thickening of the pleura which restricts 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 [15].

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 [15].

There is some evidence which suggests that the different types of asbestos fibers vary in carcinogenic potency relative to one another and site specificity [21]. This evidence is limited by

the lack of information on fiber exposure by mineral type [21]. Other data indicate that differences in fiber size distribution and other process differences may contribute at least as much to the observed variation in risk as does the fiber type itself [21].

Ingestion of asbestos causes little or no risk of noncancer effects [15]. However, there is some evidence that acute oral exposure may induce precursor lesions of colon cancer, and that chronic oral exposure may lead to an increased risk of gastrointestinal tumors [15]. ATSDR found no increase in the number of deaths from gastrointestinal cancers in the Libby area [17].

Asbestos, Immunological Changes, and Autoimmune Disease

There were concerns expressed by community members about autoimmune diseases, such as rheumatoid arthritis, lupus, or fibromyalgia, being caused by asbestos exposure. ATSDR's toxicological profile for asbestos reviews information in the literature about possible immunological effects of exposure to asbestos. The toxicological profile summarizes its findings in the following excerpted passage [15]:

> Studies of workers suffering from asbestos-related diseases such as asbestosis or mesothelioma indicate that the cellular immune system in such patients can be depressed. This is an effect of particular interest and concern since impaired immune surveillance may contribute to the increased incidence of cancer in asbestos-exposed people. Moreover, variation in immune system functional capability might be an important determinant of why some people develop cancer or asbestosis while others, with approximately equal exposures, do not. However, it is very difficult to distinguish whether the alterations in immune function noted in such studies are the cause or the result of asbestos-induced disease. The frequency of impaired cellular immunity in exposed workers without clinically-apparent disease is generally low, although some studies have noted alterations in lymphocyte distribution and impairment of natural killer (NK) cells. This could mean that the immunological changes do not occur until the disease develops (i.e., the changes are the result of the disease). Alternatively, it could mean that workers with immune systems that are not impaired by asbestos do not get serious disease, while workers whose immune systems are injured by asbestos do tend to develop disease (i.e., effects on the immune system are the cause of the disease). Available data do not allow a firm distinction between these alternatives at present, but the possible immunotoxic effects of asbestos are of clear concern. Results from animal studies provide supporting evidence of direct and indirect effects of asbestos on the immune system, although the specific roles of these effects in the etiology of asbestos-induced pulmonary diseases are not well understood and are under current investigation. For example, experiments with mice indicate that asbestos exposure decreases the number and cytotoxic activity of interstitial pulmonary NK cells and that genetically impaired cell-mediated immunity may be a predisposing factor in asbestos fibrosis.

Also, according to the toxicological profile, "concentrations of autoantibodies (rheumatoid factor, antinuclear antibodies) tend to be abnormally high in asbestos-exposed workers.... In some cases, increased autoantibodies can lead to rheumatoid arthritis (Caplan's Syndrome), although this is more common in coal miners and workers with other pneumoconioses than in workers with asbestosis.... Immunological abnormalities are usually mild or absent in asbestos-exposed workers who have not developed clinical signs of asbestosis...." [Note secondary references have been omitted for brevity, further information and secondary references is given in the toxicological profile, which is available on-line at:

http://www.atsdr.cdc.gov/toxprofiles/tp61.html .]

In summary, there is not enough evidence to say whether asbestos exposure, or resulting asbestos-related disease, may increase a person's likelihood of experiencing autoimmune disease. However, the associations that have been discovered between immunological changes and asbestos exposure indicate that this question deserves further research.

Methods for Measuring Asbestos Content

Measuring asbestos content in air samples and in bulk materials that may become airborne involves both quantification of fibers and determination of mineral content of the fibers to identify whether they are asbestiform. 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 [15]. Disadvantages of this method include the inability to detect fibers smaller than 0.25 μm in diameter and the inability to distinguish between asbestos and nonasbestos fibers [15].

Asbestos content in bulk samples is 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. Fibers are quantified through PCM, and then mineral species are determined using polarizing elements added to the light path. The PLM method is also limited by resolution; fibers finer than about 1 μm in diameter cannot be identified by PLM.

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 [15]. 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 bulk asbestos concentration [15].

To compare SEM and TEM measurements with regulatory limits, they are 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 (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) [21]. 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 [21]. Generally, a combination of PCM and TEM is used to describe the fiber population in a particular sample.

Counting fibers using the regulatory definitions does not adequately describe risk of health effects, as fiber size, shape, and composition may 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 may disproportionately increase the risk of mesothelioma [15,22]. Some of the unregulated amphibole minerals may exhibit asbestiform characteristics and contribute to

risk. Fiber diameters greater than 2 μm are considered above the upper limit of respirability and do not contribute significantly to risk [22]. Methods are being developed to assess the risks posed by varying types of asbestos and are currently awaiting peer review [22].

EPA is currently developing an infrared (IR) method for screening bulk soil samples, which will produce results much more quickly than microscopic methods. This method is based on characteristic spectral reflectances of specific chemical bonds. The method will be calibrated to detect LA specifically.[2]

Current Standards, Regulations, and Recommendations for Asbestos

For industrial applications, OSHA has defined as asbestos-containing materials any material with greater than 1% bulk concentration of asbestos. It is important to note that 1% is not a health-based level, but instead represents the practical detection limit in the 1970s when the regulations were made.

OSHA has set a permissible exposure limit (PEL) of 0.1 fibers per cubic centimeter (f/cc) for asbestos fibers greater than 5 μm in length and with an aspect ratio (length:width) greater than 3:1, as determined by PCM. This value represents a time-weighted average (TWA) exposure level based on 8 hours a day for a 40-hour work week. In addition, OSHA has defined an excursion limit in which no worker should be exposed in excess of 1 f/cc as averaged over a sampling period of 30 minutes [23].

The National Institute of Occupational Safety and Health (NIOSH) set a recommended exposure limit (REL) of 0.1 f/cc for asbestos fibers greater than 5 μm in length. This REL is a TWA for up to a 10-hour workday in a 40-hour work week [23]. The American Conference of Government Industrial Hygienists (ACGIH) has also adopted a TWA of 0.1 f/cc as its threshold limit value [24].

EPA has set a maximum contaminant level (MCL) for asbestos fibers in water as 7,000,000 fibers longer than 10 μm in length per liter, based on an increased risk of developing benign intestinal polyps [25]. The state of Montana, along with several other states, uses the same value as a human health water quality standard for surface water and groundwater [26].

Asbestos is a known human carcinogen. EPA has calculated an inhalation unit risk for cancer (cancer slope factor) of 0.23 per f/cc of asbestos. 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. Using this value, one can calculate average lifetime asbestos fiber air concentrations corresponding to specified risk levels. The concentration resulting in an increased risk of 1 in 10,000 is 0.0004 f/cc, and the concentration resulting in an increased risk of 1 in 1,000,000 is 0.000004 f/cc. The unit risks were based on measurements with phase contract microscopy and should not be applied directly to measurements made with other analytical techniques. Also, the unit risk should not be used if the air concentration exceeds 0.04 f/cc, since above this concentration the slope factor may differ from that stated [21].

[2] Based on conversations with Jim Christiansen, EPA Remedial Project Manager.

Exposure Pathways

An exposure pathway is the process by which an individual is exposed to contaminants originating from a contamination source. An 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. The following sections describe the exposure pathways identified at the site.

The highest risk at the site, both now and in the past, is from inhalation of asbestos fibers. Several inhalation exposure pathways were identified, and they are discussed briefly in the next section.

Present Inhalation Exposure Pathways

Residential indoor – Residents may inhale LA-contaminated household dust, LA-contaminated Zonolite insulation disturbed during renovations, or deteriorating LA-contaminated insulation falling into living areas.

Residential outdoor – Residents may inhale LA while gardening in soil amended with LA-contaminated vermiculite, driving over LA-contaminated fill in driveways, and/or playing in LA-contaminated soil.

Occupational – Cleanup workers may be exposed to LA through disturbing LA-contaminated vermiculite, soil, and insulation during remedial activities.

EPA has documented in a memorandum the potential for the above types of activities to result in inhalation exposure to LA fibers at levels of concern (i.e., above OSHA or risk-based standards) [16]. The calculations in this memorandum were for screening purposes only. However, given the uncertainties involved in the risk assumptions, measurement techniques, and toxicology of LA fibers, ATSDR feels that this analysis is adequate for demonstrating that a risk exists.

Potential present exposure pathways include breathing ambient air in the Libby area and breathing around undisturbed insulation. For these pathways, exposures are not expected to be high enough to cause significant additional health risks in combination with the other known exposure pathways.

Past Inhalation Exposure Pathways

Occupational – Workers were exposed to high levels of LA in the air at the mine, during transport and handling operations, and during processing operations such as exfoliation. Levels of asbestos in the air at the mine were measured as high as 100 f/cc [16]. Anecdotal information indicates that workers did not often wear personal protective equipment such as respirators.

Household contact – Relatives of workers were exposed to LA from dirty clothing and cars of workers returning from the mine.

Vermiculite piles – Children played in open piles of LA-contaminated vermiculite, such as those near the ball fields and export plant.

Residential outdoor – Residents inhaled LA while gardening in soil amended with LA-contaminated vermiculite, driving over LA-contaminated fill in driveways, and/or playing in contaminated soil. This pathway includes inhalation of LA-contaminated fill used at local schools, since residents may have been exposed there.

Residential indoor – Residents inhaled LA-contaminated household dust, LA-contaminated Zonolite insulation being sprayed into attics and walls or disturbed during past renovations, or deteriorating LA-contaminated insulation falling into living areas.

Ambient air – Historical levels of asbestos in the ambient air in Libby were higher than the current OSHA standard of 0.1 f/cc [16]. These historical results are uncertain due to the scarcity of sampling, a lack of differentiation between asbestos and nonasbestos fibers, and the low sensitivity of the analytical method used. However, the results indicate a potentially higher risk of health effects, especially for residents, who were exposed continuously and through multiple pathways.

The limited information on historical concentrations of LA in air and appropriate exposure assumptions to make for activities that happened long ago make it even more difficult to determine quantitative risk for the past exposure pathways. However, it is known that past levels of LA were much higher while the mine and processing facilities were in operation, and as described below, health outcome data shows that people exposed to LA have higher rates of asbestos-related disease. Therefore, no calculations are necessary to conclude that the risk of health effects was unusually high for the past exposures in Libby.

Pathways Eliminated From Consideration

Ingestion of Drinking Water

There is a ban on private wells in the city of Libby due to groundwater contamination from a source unrelated to asbestos. The city of Libby's drinking water is taken from Flower Creek Reservoir. This reservoir is located southwest and upstream of town, and it is not close to or downstream from Zonolite Mountain or the processing facilities associated with the vermiculite mine. No asbestos fibers were detected in sampling of water at the influent and effluent of the water treatment plant in 2000 [18]. In the areas outside of Libby, some people drink groundwater from private wells. Based on conversations with EPA officials, private wells in and around Libby have not been tested for asbestos[3]. Because asbestos fibers are not readily transported through soil, it is unlikely that contamination from waste piles, processing operations, or vermiculite in soil would reach the groundwater to contaminate it. Therefore, because site-related asbestos contamination is unlikely, and because the inhalation pathways described above are the major contributors to risk, the drinking water pathway was eliminated from consideration in this PHA.

[3] Based on information from Jim Christiansen, EPA RPM for Libby Asbestos, on July 10, 2002.

Soil and Waste Incidental Ingestion

Incidental ingestion of LA-contaminated soils and/or vermiculite, and/or wastes was not considered, because the health risk from this pathway is minor in comparison to the inhalation pathways described above. This assumption is supported by the results of ATSDR's mortality review, which found deaths from lung diseases (related to inhalation) elevated, while no increase in gastrointestinal cancers (related to ingestion) was found.

Dermal Exposure Pathways

No dermal exposure (skin contact) pathways were considered. The health risks associated with this route of exposure are minor in comparison to the inhalation pathways described above.

Health Outcome Data

The Superfund law requires that health outcome data be considered in a public health assessment. Health outcome data may include mortality information (e.g., the number of people dying from a certain disease) or morbidity information (e.g., the number of people in an area getting a certain disease or illness). The Libby Asbestos site meets the four criteria necessary to perform a thorough evaluation of health outcome data. The necessary items are:

(1) A completed human exposure pathway – as described previously, several completed human exposure pathways exist at the site, specifically those related to inhalation of asbestos fibers.
(2) Contaminant levels high enough to result in measurable health effects – many reports of measured health effects caused by exposure to asbestos exist and will be detailed below.
(3) Enough people in the completed pathway for the health effect to be measured – Workers, their families, and residents in the Libby area were and are potential receptors for the asbestos inhalation pathway.
(4) A health outcome database in which disease rates for populations of concern can be identified – information used includes death certificate data and results of medical testing conducted by ATSDR and other agencies.

Both morbidity and mortality information have been evaluated in other ATSDR reports [14,17,3]. The conclusions of these reviews are summarized below.

Morbidity Information – Medical Testing Results

In response to the reports of asbestos-related illness in the Libby community, ATSDR developed a community-based medical testing program. The testing was a part of the Libby Community Environmental Health Project and was carried out with the cooperation of the Department of Health and Human Services Region 8 office, EPA, MDPHHS, the Lincoln County Environmental Health Department, and the Lincoln County Public Health Officer.

People eligible for participation in the program included former workers and contractors of the vermiculite mine, household contacts of former workers, and people who had been in the Libby area for a 6-month period prior to December 31, 1990. The testing included a questionnaire, chest x-rays for adult participants, and lung function tests. There were two rounds of testing offered; the first round was in summer 2000 and tested 6,149 people. A second round of testing

was offered in summer 2001 to test people who had missed the first round; 1,158 people were tested in this round.

A report summarizing results of the year 2000 testing was published in August 2001 [14]. 18% of the participants had pleural abnormalities reported by at least 2 out of 3 certified B-readers who analyzed the x-rays. Of former mine workers, 48% showed pleural abnormalities. The factors most strongly related to having pleural abnormalities were being a former mine worker, being male, and being a female household contact of a former mine worker. Exposure to asbestos via multiple exposure pathways also increased the chances of finding pleural abnormalities. Pulmonary function testing showed a much lower rate of restrictive changes in the participants than pleural changes appearing on x-ray. The strongest risk factors for restrictive changes in pulmonary function included current cigarette smoking, being a former mine worker, chest surgery, having a high body mass index, and age.

Combined results from the two testing rounds have not been published as of the writing of this report. We will update this summary once those results are released.

Mortality Information – Death Certificate Review

As part of its response to reports of asbestos-related illnesses in Libby, ATSDR reviewed mortality statistics from the Libby area for the years 1979-1998. Death certificates were reviewed, and mortality rates and standard mortality ratios were determined for underlying causes of death associated with asbestos exposure. These included nonmalignant respiratory diseases, lung cancer, mesothelioma, digestive cancer, and diseases of pulmonary circulation. The initial findings were released in a health consultation in December 2000 [3]. Asbestosis mortality in the area were 40 to 60 times higher than expected, and mesothelioma cases were also elevated. The degree to which mesothelioma was elevated could not be quantitatively determined, because state and national statistics on this rare disease are not routinely available. Other causes of death, including lung cancer, digestive cancer, and diseases of pulmonary circulation, were not significantly elevated over the time period studied.

Recently, it was discovered that several death certificates were inadvertently omitted from the initial review, due to differences in reporting procedures in certificates from before 1980. Therefore, ATSDR reanalyzed the statistics from 1979 to 1998, including the newly identified certificates. The updated health consultation was released in August 2002 [17]. The updated analysis showed that the elevation of asbestosis was even greater than previously found, with mortality in Libby 40 to 80 times higher than expected. In addition, lung cancer was found to be 20% to 30% higher than expected. Again, mesothelioma was elevated, but difficult to quantify. Other causes of death, including digestive cancer and diseases of pulmonary circulation, were not significantly elevated.

The updated mortality review included a comparison of death certificate data with employment information obtained from employee records from the mining and milling facilities in Libby. This analysis showed that 92% (11/12) of the asbestosis deaths, 17% (21/124) of the lung cancer deaths, and two out of three mesothelioma deaths were former employees of the vermiculite facility.

Evaluation

Determining a quantitative risk of health effects to Libby community members from exposure to LA is difficult for two reasons: 1) there are significant uncertainties and conflicts in the methods used to analyze asbestos, and 2) the exact level of health concern for different sizes and types of asbestos is controversial due to limitations in toxicological information currently available. Analytical techniques and toxicology issues specifically related to the LA from the Libby vermiculite mine are areas deserving significant further research.

Despite these uncertainties, based on the health outcome data presented above, it is likely that continuing exposure to LA increases the risk of malignant and nonmalignant respiratory disease.

The mortality review showed that almost all the deaths from asbestos-related disease occurred in former workers of the vermiculite facility or their household contacts. It is not surprising that the workers would show the highest mortality, as they were exposed to the highest concentrations of asbestos for the longest period of time. The greater level of exposure combined with the long duration of exposure (average length of employment was close to 20 years) would increase the risk of disease and effectively reduce the latency period before onset of disease.

People who had lower exposures and/or shorter durations of exposure may exhibit longer latency periods before the onset of disease. For example, a recent case report described a patient who had a brief but high intensity exposure to LA. The patient showed pleural abnormalities on chest x-rays about 30 years later, but had no symptoms of asbestos-related disease for another 10 years, when fatal asbestosis quickly set in [27]. No direct causal relationship between pleural abnormalities and asbestos-related diseases has ever been demonstrated. However, both conditions are associated with asbestos exposure, and it is reasonable to assume that people who exhibit pleural abnormalities may be at higher risk for asbestos-related diseases, including asbestosis as well as lung cancers. The elevated number of pleural abnormalities, in both former workers and other residents around Libby, suggests that additional cases of asbestos-related disease can be expected in coming years.

Summary of Removal and Remedial Actions Completed and Proposed

Because risk is based on exposure level and duration, the risk of asbestos-related health effects can be effectively reduced by interrupting continuing exposures to LA. EPA has been and continues to perform emergency removal and remedial activities to interrupt major sources of LA and LA-contaminated materials in and around Libby. This section reviews these activities with respect to their effectiveness in protecting public health.

Mine Site – Because the mine site is in a remote area, it is unlikely that people will have large, continuing exposure to asbestos there. To minimize the chance of exposure, EPA has paved a portion of Rainy Creek Road, closed the entrance to Rainy Creek Road, and placed warning signs at the road entrance and around the mine. Although further investigation and cleanup of the mine site is expected, at this time these actions will be protective of public health.

Screening Plant / Export Plant – EPA provided ATSDR with plans for removal of contamination at these facilities. ATSDR reviewed the plans and determined that they would be protective of public health [5]. Remediation of both of these sites is ongoing [28].

Schools – Cleanup of school grounds has occurred. Cleanup of school tracks is planned to be complete by the fall of 2002 [28].

Residential and Commercial Properties – The EPA has published a Sampling and Analysis Plan for prioritizing residential and commercial properties for cleanup. ATSDR reviewed this plan and found it would be protective of public health. To assure proper disposal of waste materials from the residential cleanup activities, EPA is constructing a special cell in the county landfill.

The contaminant screening study is underway. At the time of this report, 1,000 properties (about 1/3 of the total) have been screened. Of the screened properties, approximately 20% have vermiculite attic insulation and about 40% have visible vermiculite in gardens or yards. Fifty to 60 property owners denied EPA access for screening [28].

ATSDR Child Health Initiative

ATSDR recognizes that infants and children may be 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 the site as part of the ATSDR Child Health Initiative.

The effects of asbestos on children are thought to be similar to adults. However, children may be especially vulnerable to asbestos exposures due to the following factors:

- Children are more likely to disturb fiber-laden soils or indoor dust while playing.
- Children are closer to the ground and thus more likely to breathe contaminated soils or dust.
- Children have faster breathing rates that may increase the level of exposure to asbestos.
- Children may be more at risk than people exposed later in life because of the long latency period between exposure and onset of asbestos-related respiratory disease.

Because many of the most highly contaminated areas have been addressed through emergency removals, children today have a lower risk of health effects than children in the past.

Community Health Concerns

Community concerns about the health effects of asbestos exposure have been identified through ATSDR's activities in Libby. Concerns have been expressed during Community Advisory Group (CAG) meetings and other interactions with community members. A number of concerns were documented in EPA's community involvement plan [8]. ATSDR has also maintained a presence in Libby at EPA's Information Center and encouraged people to share concerns.

ATSDR plans to hold a public availability session to give community members another chance to share any health-related concerns about the site. This is tentatively planned for the last week in

September, 2002, shortly after the agency presents final results of the combined medical testing, updated mortality information as documented in this report, and results from the CT scan study.

The health-related concerns expressed to date are listed and addressed below:

Concern: *Does asbestos cause autoimmune disorders such as lupus, rheumatoid arthritis, and fibromyalgia?*

Response: There is not enough information at this time to determine whether asbestos causes autoimmune diseases. A number of studies have shown that the illness asbestosis is associated with immunological changes that could theoretically make a person more susceptible to autoimmune disorders. According to a recent allergy textbook, "immunologic abnormalities in animal models and patients with asbestosis include abnormal lymphocyte accumulation in the lower respiratory tract, abnormal T-lymphocyte subsets in BAL [bronchoalveolar lavage] fluid, evidence of decreased cell-mediated immunity, and diminished suppressor T cell function". The text continues, however, "Correlation of these abnormalities (systemic or local) with the clinical features of asbestosis ... has not been clearly demonstrated" [29]. In other words, it is not known at this time whether the changes are causally linked to the asbestosis or exposure to asbestos. It is also possible that people who have autoimmune abnormalities may be more likely to develop asbestos-related disease. Please see page 11 of this document for a more detailed treatment of this subject.

Concern: *What is the risk to residents, children, and visitors from vermiculite insulation dust potentially sifting into living spaces?*

Response: If the insulation does not contain asbestos, it poses no risk of asbestos-related illnesses. In addition, undisturbed insulation is not considered to pose a significant risk. However, if the insulation contains asbestos and is creating dust, the dust may contain microscopic asbestos fibers which increase the risk of asbestos-related health effects when breathed in. (Conservatively, it should be assumed that all insulation made with Libby vermiculite contains asbestos.) The exact level of risk depends on how many fibers were breathed in and how long the exposure lasted. In addition, a person's response to exposure differs and may be based upon genetic makeup and certain lifestyle activities, particularly smoking. People who suspect they have been exposed to asbestos fibers, especially if the exposure was long-term, should consult a physician experienced in occupational and environmental medicine or pulmonary medicine.

Public Health Hazard Category

Based on the known past exposures and resulting disease rates, to protect public health it is prudent to reduce known continuing exposures to LA. ATSDR concludes that locations where LA-contaminated vermiculite has the potential to become airborne during people's normal activities pose a *current public health hazard* to the people of Libby.

ATSDR has also evaluated the cleanup actions and plans for cleanup taken by EPA. These actions, provided confirmation testing indicates effective reduction of LA levels, have been and

will be protective of public health by reducing continuing LA exposures. Areas that have been cleaned up as described are not likely to pose a hazard. Although very small amounts of asbestos may still be present, the potential for significant exposure is expected to be very small. Therefore, ATSDR characterizes these areas as *no apparent public health hazard.*

Based on historical information and current health outcome data, ATSDR concludes that the site was a *past public health hazard.* Workers at the mine, their household contacts, and people not occupationally exposed at the mine were exposed to airborne LA at unsafe levels. This exposure has resulted in significantly elevated levels of asbestos-related disease in the area.

Conclusions

- People in the Libby area were exposed to hazardous levels of asbestos in the past.
- People in the Libby area have elevated levels of disease, and death, associated with exposure to asbestos.
- People may still be exposed to hazardous levels of asbestos near current source areas. These levels may be especially hazardous to sensitive populations, including people who have been exposed for many years already, smokers, and young children.
- The exact level of risk associated with low level exposure to asbestos cannot be determined due to uncertainties in the analysis and toxicology of Libby asbestos. However, continuing exposures to Libby asbestos pose an unacceptable risk to residents and workers who have already been exposed for many years.
- The cleanup actions undertaken by EPA are protective of public health.

Recommendations

- EPA should continue to investigate and clean up the site to reduce or remove continuing sources of Libby asbestos.
- Conduct toxicological investigation of the risks associated with low level exposure to asbestos, specifically with the chemical makeup and fiber size of Libby asbestos. This investigation is necessary to assure that site cleanup levels remain protective.
- Conduct health education for the community, especially concerning smoking and asbestos.
- Create a registry to track former workers, their household contacts, and residents exposed to Libby asbestos.
- Continue to provide information to the community about the hazards of Libby asbestos.
- Continue to provide information on how to diagnose and treat asbestos-related diseases to the local medical community.

Public Health Action Plan

The Public Health Action Plan for the site contains a description of actions have been or will be taken by ATSDR and/or other government agencies at the site. The purpose of the Public Health Action Plan is to ensure that this public health assessment not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a

commitment on the part of ATSDR to follow up on this plan to ensure its implementation. The public health actions that have been completed are as follows:

- ATSDR published four health consultations evaluating public health implications related to Libby asbestos.
- ATSDR implemented two rounds of medical testing for signs of asbestos-related disease.
- ATSDR conducted a site visit to verify site conditions and gather pertinent information and data for the site.
- ATSDR and EPA maintained personnel in an information center in Libby to inform the community about site-related health and environmental activities.
- EPA conducted emergency removals of many contaminated areas in and around Libby.

The public health actions to be implemented follow:

- ATSDR will hold a public availability session to gather health concerns from the Libby community. These concerns will be addressed in the public comment release of this document.
- ATSDR will present results of the combined two rounds of medical testing performed in 2000 and 2001, the updated mortality review, and the computed tomography (CT) study to the Libby community. MDPHHS will provide ongoing medical testing in Libby to qualified individuals, with funding and technical assistance provided by ATSDR.
- ATSDR will work with MDPHHS to develop a registry to track former workers of the vermiculite mine and their household contacts. ATSDR will assess the feasibility of including other populations in the registry.
- EPA will continue investigating and cleaning up the site as needed.
- ATSDR will produce an addendum to this PHA evaluating the public health impact of the mine site (OU3). This addendum will be produced during EPA's RI activities for OU3.

ATSDR will reevaluate and expand this plan when needed. New environmental, toxicological, or health outcome data or the results of implementing the above proposed actions may determine the need for additional actions at this site.

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Appendix A. ATSDR Plain Language Glossary of Environmental Health Terms

Absorption How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect A change in body function or the structures of cells that can lead to disease or health problems.

Amphibole A large group of silicate minerals with more than 40-50 members. The molecular structure of all amphiboles consists of two chains of SiO_4 molecules that are linked together at the oxygen atoms. In the earth's crust, amphibole minerals are mostly nonasbestiform; asbestiform amphiboles are relatively rare. See definitions of asbestiform, mineral, and mineral habit.

Antagonistic Effect A response to a mixture of chemicals or combination of substances that is **less** than might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Asbestiform A habit of crystal aggregates displaying the characteristics of asbestos: groups of separable, long, thin, strong, and flexible fibers often arranged in parallel in a column or in matted masses. See definitions of mineral and mineral habit. Mineralogists call asbestiform amphibole minerals by their mineral name followed by "asbestos". Thus, asbestiform tremolite is called tremolite asbestos.

Asbestos A group of highly fibrous minerals with separable, long, thin fibers often arranged in parallel in a column or in matted masses. Separated asbestos fibers are generally strong enough and flexible enough to be spun and woven, are heat resistant, and are chemically inert. See definitions of fibrous and mineral. Currently, U.S. regulatory agencies recognize six asbestos minerals: the serpentine mineral, chrysotile; and five asbestiform amphibole minerals, actinolite asbestos, tremolite asbestos, anthophyllite asbestos, amosite asbestos (also known as asbestiform cummingtonite-grunerite), and crocidolite asbestos(also known as asbestiform riebeckite). Proposals have been made to update asbestos

regulations to include other asbestiform amphibole minerals such as winchite asbestos and richterite asbestos.

Asbestosis Interstitial fibrosis of the pulmonary parenchymal tissue in which asbestos bodies (fibers coated with protein and iron) or uncoated fibers can be detected. Pulmonary fibrosis refers to a scar-like tissue in the lung which does not expand and contract like normal tissue. This makes breathing difficult. Blood flow to the lung may also be decreased, and this causes the heart to enlarge. People with asbestosis have shortness of breath, often accompanied by a persistent cough. Asbestosis is a slow-developing disease that can eventually lead to disability or death in people who have been exposed to high amounts of asbestos over a long period. Asbestosis is not usually of concern to people exposed to low levels of asbestos.

ATSDR The Agency for Toxic Substances and Disease Registry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.

Bioavailability See **Relative Bioavailability**.

Biota Used in public health, things that humans would eat – including animals, fish and plants.

Cancer A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control

Cancer Slope Factor (CSF) The slope of the dose-response curve for cancer. Multiplying the CSF by the dose gives a prediction of excess cancer risk for a contaminant.

Carcinogen Any substance shown to cause tumors or cancer in experimental studies.

Chronic Exposure A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Cleavage Fragment Microscopic particles formed when large pieces of nonasbestiform amphiboles are crushed, as may occur in mining and milling of ores. Within a population of nonasbestiform amphibole cleavage fragments, a fraction of the particles may fit the definition of a fiber adopted for

	counting purposes. Populations of asbestos fibers can be readily distinguished from populations of nonasbestiform cleavage fragments, but sometimes it can be difficult to distinguish an isolated nonasbestiform cleavage fragment from an isolated asbestos fiber. See definitions of asbestiform, fiber, fibrous, and mineral habit.
Completed Exposure Pathway	See **Exposure Pathway**.
Community Assistance Panel (CAP)	A group of people from the community and health and environmental agencies who work together on issues and problems at hazardous waste sites.
Comparison Value (CV)	Concentrations of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	**CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.
Concentration	How much or the amount of a substance present in a certain amount of soil, water, air, or food.
Contaminant	See **Environmental Contaminant**.
Delayed Health Effect	A disease or injury that happens as a result of exposures that may have occurred far in the past.
Dermal Contact	A chemical getting onto your skin (see **Route of Exposure**).
Dose	The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".
Dose / Response	The relationship between the amount of exposure (dose) and the change in body function or health that results.
Duration	The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.

Environmental Media Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

US Environmental Protection Agency (EPA) The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Epidemiology The study of the different factors that determine how often, in how many people, and in which people will disease occur.

Exposure Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:
1. Source of Contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Fiber Any slender, elongated mineral structure or particle. For the purposes of counting asbestos fibers in air samples, regulatory agencies commonly count particles that have lengths ≥ 5 μm and length:width ratios $\geq 3:1$ as fibers. For detecting asbestos fibers in bulk building materials, particles with length:width ratios $\geq 5:1$ are counted as fibers.

Fiber-year/mL	A cumulative exposure measure calculated by multiplying a worker's duration of exposure (measured in years) by the average air concentration during the period of exposure (measured in number of fibers/mL of air). Epidemiologic studies of groups of asbestos-exposed workers commonly express exposure in these units.
Fibrous	A mineral habit with crystals that look like fibers. A mineral with a fibrous habit is not asbestiform if the fibers are not separable and are not long, thin, strong, and flexible.
Frequency	How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.
Hazardous Waste	Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.
Health Effect	ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).
Indeterminate Public Health Hazard	The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.
Ingestion	Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (see **Route of Exposure**).
Inhalation	Breathing. It is a way a chemical can enter your body (see **Route of Exposure**).
Interstitial	A term used as an adjective relating to spaces within a tissue or organ. Pulmonary interstitial fibrosis refers to fibrosis (scarring) occurring within lung tissue.
LOAEL	Lowest Observed Adverse Effect Level. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.
Malignancy	See **Cancer**.
Mesothelioma	Cancer of the thin lining surrounding the lung (the pleura) or the abdominal cavity (the peritoneum). Mesotheliomas are rare cancers in the general population.
Mineral	Any naturally occurring, inorganic substance with a crystal structure.

Naturally occurring, inorganic substances without a crystal structure (such as amorphous silica) are called mineraloids.

Mineral Habit The shape or morphology that single crystals or crystal aggregates take during crystal formation. Mineral habit is influenced by the environment during crystal formation. Habits of single crystals include prismatic, acicular, platy, and fiber. Habits of crystal aggregates include asbestiform, fibrous, lamellar, and columnar.

MRL Minimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL No **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may 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 The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

Parenchyma The functional cells or tissue of a gland or organ; for example, the lung parenchyma. The major lung parenchymal abnormality associated with exposure to asbestos is the development of scar-like tissue referred to as pulmonary interstitial fibrosis or asbestosis.

PHA Public **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Pleura A thin lining or membrane around the lungs or chest cavity. This lining can become thickened or calcified in asbestos-related disease.

Pleural	Having to do with or involving the pleura.
Pleural abnormalities	Abnormal or diseased changes occurring in the pleura. Pleural abnormalities associated with exposure to asbestos include pleural plaques, pleural thickening or calcifications, and pleural effusion.
Pleural calcification	As a result of chronic inflammation and scarring, pleura becomes thickened and can calcify. White calcified areas can be seen on the pleura by X-ray.
Pleural cavity	The cavity, defined by a thin membrane (the pleural membrane or pleura), which contains the lungs.
Pleural effusion	Cells (fluid) can ooze or weep from the lung tissue into the space between the lungs and the chest cavity (pleural space) causing a pleural effusion. The effusion fluid may be clear or bloody. Pleural effusions may be an early sign of asbestos exposure or mesothelioma and should be evaluated.
Pleural plaques	Localized or diffuse areas of thickening of the pleura (lining of the lungs) or chest cavity. Pleural plaques are detected by chest x-ray, and appear as opaque, shiny, and rounded lesions.
Pleural thickening	Thickening or scarring of the pleura may be associated with asbestos exposure. In severe cases, the normally thin pleura can become thickened like an orange peel and restrict breathing.
Plume	A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds and streams).
Point of Exposure	The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, or the backyard area where someone might breathe contaminated air.
Population	A group of people living in a certain area; or the number of people in a certain area.
PRP	Potentially Responsible Party. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

Public Health Assessment(s)	See **PHA**.
Public Health Hazard	The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.
Public Health Hazard Criteria	PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are: – Urgent Public Health Hazard – Public Health Hazard – Indeterminate Public Health Hazard – No Apparent Public Health Hazard – No Public Health Hazard
Pulmonary interstitial fibrosis	Scar-like tissue that develops in the lung parenchymal tissue in response to inhalation of dusts of certain types of substances such as asbestos.
Receptor Population	People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathway**).
Reference Dose (RfD)	An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.
Relative Bioavailability	The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.
Route of Exposure	The way a chemical can get into a person's body. There are three exposure routes: – breathing (also called inhalation), – eating or drinking (also called ingestion), and – getting something on the skin (also called dermal contact).
Safety Factor	Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is <u>not</u> likely to cause harm to people.

SARA	The Superfund Amendments and Reauthorization Act in 1986 amended CERCLA (see **CERCLA**) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting from chemical exposures at hazardous waste sites.
Sample Size	The number of people that are needed for a health study.
Sample	A small number of people chosen from a larger population (see **Population**).
Serpentinite	Igneous or metamorphic rock chiefly composed of serpentine minerals such as chrysotile or lizardite. Chrysotile, when found, can occur in localities with serpentinite rock.
Source (of Contamination)	The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.
Special Populations	People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.
Statistics	A branch of the math process of collecting, looking at, and summarizing data or information.
Superfund Site	See **NPL**.
Survey	A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.
Synergistic Effect	A health effect from an exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together are greater than the effects of the chemicals acting by themselves.
Toxic	Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.
Toxicology	The study of the harmful effects of chemicals on humans or animals.

Tremolite asbestos A special form of the amphibole mineral, tremolite, that displays separable, long, thin fibers often arranged in parallel in a column or in matted masses. The fibers are generally strong enough and flexible enough to be spun and woven, are heat resistant, and are chemically inert.

Tumor Abnormal growth of tissue or cells that have formed a lump or mass.

Ultramafic rock Igneous rock composed chiefly of dark-colored ferromagnesian silicate minerals. Asbestiform amphiboles, when found, can occur in localities with ultramafic rock.

Uncertainty Factor See **Safety Factor**.

Urgent Public Health Hazard This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

Vermiculite A mineral belonging to the mica group of silicate minerals. Vermiculite has water molecules located between the silicate layers in the crystal structure. When heated, vermiculite expands to form a light-weight material that has been used for home and building insulation, as a soil amendment, and as a packing material. The process of heating and expanding vermiculite is called exfoliation or "popping". Raw vermiculite ore is processed to produce vermiculite concentrate, which is shipped to exfoliating plants to produce the finished vermiculite product.