Health Consultation

GERMAIN'S SEED COMPANY

4820 E. 50TH STREET

VERNON, LOS ANGELES COUNTY, CALIFORNIA

EPA FACILITY ID: CAD008289548

MAY 11, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

California Department of Health Services
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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Foreword

Libby vermiculite was distributed to and processed by facilities located throughout the United States. Because human exposure to asbestos has possibly occurred in communities near these facilities, the Division of Health Studies of the federal Agency for Toxic Substances and Disease Registry (ATSDR) initiated a nationwide follow-up effort. This project is designed to screen for similar impacts on the health of populations living near facilities that received shipments of Libby vermiculite. As part of that effort, the Environmental Health Investigation Branch of the California Department of Health Services (CDHS) received funding to conduct health statistics reviews on communities located near facilities that received Libby vermiculite.

This health consultation presents the results of the health statistics review for the population living near Germain's in Vernon, California. The objectives of the health statistics review are:

1. to identify the residential area at highest risk of exposure to hazardous levels of asbestos from the exfoliation and processing of Libby vermiculite at Germain's;

2. to determine whether the population living in this area had higher incidence rates of asbestos-related cancers than the U.S. population;

3. to determine whether the population residing in this area had higher mortality rates from asbestos-related disease than the U.S. population.

Asbestos and Asbestos-related Disease

Asbestos is the name of a group of minerals that occur naturally in the environment. Asbestos minerals have long, thin, and separable fibers. Asbestos fibers do not evaporate into air or dissolve in water, and they are resistant to heat, fire, and chemical and biological degradation (1). Asbestos fibers in vermiculite entered the air when Libby vermiculite was handled, processed, or disturbed after processing at Germain's (3). Small diameter fibers and fiber-containing particles may remain in the air for a long time and may be carried long distances by wind or water currents before settling to the ground (1).

Asbestos fibers can enter the body when inhaled (breathed in) or ingested (eaten or drunk). When asbestos fibers are inhaled, some of the fibers can become lodged in the lungs. Because asbestos fibers are very durable, they remain in lung tissue throughout life. Asbestos fibers can accumulate in lung tissue and cause scarring and inflammation. Repeated scarring and inflammation can affect breathing and lead to disease.

Exposure to asbestos does not cause disease immediately; instead, disease develops many years later. The time period between when someone is first exposed to asbestos and when they develop disease is called the latency period.

Background

In 1881, miners searching for gold unearthed a mica-like material from an area 7 miles northeast of the town of Libby, Montana. It was not until 1919 that a local businessman discovered the unique properties of this mineral: while he was walking through an abandoned mine, his torch contacted the surface of the mine, resulting in an expansion or "popping" of the vermiculite. The newly formed Zonolite Company opened a mine at this location during the following year. Since then, vermiculite has been marketed for many uses, such as loose-fill insulation, fireproofing, a fertilizer carrier, a soil conditioner, and an aggregate in many construction products.

WR Grace and Company purchased the vermiculite mine from the Zonolite Company in 1963 and expanded operations. Between the 1960s and 1980s, as much as 80% of the vermiculite used worldwide came from the WR Grace and Company mine near Libby (6). (Vermiculite from the WR Grace and Company mine near Libby will be referred to as Libby vermiculite in this document.) Libby vermiculite was shipped to over 200 locations in 30 states in this country for processing or packaging. Twenty of these facilities were located in California, including the Germain's Seed Company facility in Vernon, California. (This facility will be referred to as Germain's in this document.) Libby vermiculite was shipped to Germain's between the years 1967 and 1969 (3). WR Grace and Company mining operations in Libby, Montana closed in 1990, and the last shipments of Libby vermiculite occurred in 1992 (7).

All vermiculite contains a range of other minerals that were formed along with the vermiculite in the rock. The vermiculite found near Libby contains 21% to 26% asbestos (8), a mineral toxic to humans when inhaled (breathed in). Inhalation of asbestos is known to cause asbestosis (a non cancerous scarring of the lungs), lung cancer, and mesothelioma (cancer of the tissues lining the lung and abdomen). (The asbestos contained in Libby vermiculite will be referred to as Libby asbestos in this document.)

In 1999, a series of Seattle Post-Intelligencer articles about high rates of asbestos-related disease brought national attention to the WR Grace and Company vermiculite mine in Libby, Montana. ATSDR, in cooperation with the Montana Department of Public Health and Human Services, analyzed mortality statistics (information on causes of death obtained from death certificates) for the Libby community for a 20-year period (1979-1998). This review found that death due to asbestosis was 40 times more common in the Libby population than in the rest of the state of Montana, and 80 times more common than in the rest of the U.S. population. Death due to lung cancer was 20% to 30% (1.2 to 1.3 times) higher than expected. Although rates of mesothelioma were elevated, it was not possible to quantify by how much. Still, these elevations were high enough that they were considered unlikely to have been due to natural fluctuations in the occurrence of these diseases (9). Findings from the review of mortality statistics led to several follow-up activities to address the health impacts to those who lived and worked in Libby (10, 11).

Health statistics reviews are statistical analyses of information from cancer registry and death certificate records that investigate whether people in a particular community have developed cancer or have died from a particular disease more often than another comparison population. The health statistics reviews are being conducted in communities located near facilities that

received Libby vermiculite, regardless of whether that community was in fact exposed to hazardous levels of asbestos from the vermiculite. (Usually, reviews of health information are conducted only when exposure to a harmful chemical is known to have occurred.) Communities are being screened because, given the experience in the Libby community, it is not unrealistic to think that exposure to levels of asbestos high enough to have caused disease might have occurred in these communities.

Finding an excess of asbestos-related cancers or disease in a community would alert ATSDR and CDHS to the possibility that workers or community members might have been exposed to hazardous levels of asbestos as a result of the facility's handling or processing of Libby vermiculite. If, however, the health statistics review does not find an excess of asbestos-related disease, this does not prove that the community was not exposed to Libby asbestos.

Germain's Operations and Worker and Community Exposure to Asbestos

Germain's was located at 4820 E. 50th Street in Vernon. The area immediately surrounding the Germain's site is industrial (12). Germain's no longer processes vermiculite and is no longer in business. The current company at the former Germain's site, PEYK International, Inc., is an importer and buyer of textiles, drapery fabrics, and upholstery. This company does not process any vermiculite. The site building itself is concrete and metal-framed. The west side of the building has three garage doors for shipping and receiving. On the south side of building there is a railroad spur. On the east side of the building there is a parking lot. About 200 yards south of the former Germain's site, there is a residential neighborhood. In addition, five schools are located within one mile of the facility.

From 1967 through 1969, the facility received approximately 44 tons of Libby vermiculite. Germain's received shipments of ground vermiculite, expanded vermiculite, and expanded ground vermiculite from WR Grace and Company.* It is likely that Germain's used vermiculite to perform a seed enhancement process called seed pelleting. A general description of this process is described in California Zonolite Company's records (13). In seed pelleting, seeds are coated with vermiculite and other materials to alter the shape and size of the seed. This process converts seeds that are naturally too small or oddly shaped for use in mechanized planting equipment into more uniformly round shapes. In addition, the vermiculite can also improve the seed's germination and growth.

According to the current personnel, Germain's Seed Company facility in Vernon closed in 1989 (Personal communication with Judy Dennis, January 2007). After the closure, various divisions of Germain's Seed Company were sold to other companies. The division charged with seed pelleting was sold to a company based in Great Britain. It is now called Germain's Technology Group and based in Gilroy (Personal communication with Cathy Farr, January 2007). This

* WR Grace and Company had a division called California Zonolite Company in Newark, California, which received and processed crude vermiculite. One way that California Zonolite Company processed vermiculite was to grind vermiculite for use in a seed enhancement process. California Zonolite Company shipped ground vermiculite to Germain's.

division currently uses new methods to perform seed pelleting that do not involve vermiculite. The company now bearing the Germain's Seed Company name is a seed distributor located in Fresno and does not perform seed pelleting (Personal communication with Judy Dennis, January 2007). Both Germain's Technology Group and the current Germain's Seed Company do not have any records about historical methods of seed pelleting utilizing vermiculite at the original Germain's Seed Company. In addition, Germain's Technology Group and the current Germain's Seed Company do not have contact information for former workers of the Vernon facility.

Discussion

Asbestos fibers in the Libby vermiculite could have been released to the air during the handling and processing of vermiculite. People who worked at Germain's between 1967 and 1969 may have been exposed to hazardous levels of asbestos. However, Germain's received 44 tons of Libby vermiculite, which is a relatively small quantity compared to other facilities receiving Libby vermiculite. People who lived with former workers could have been also exposed to hazardous levels of asbestos from fibers carried home on workers' hair and clothing. There is not enough information to determine whether people who lived near Germain's between 1967 and 1969 were exposed to hazardous levels of asbestos from Libby vermiculite.

Germain's no longer processes vermiculite and is no longer in business. Furthermore, PEYK International, Inc., the current company occupying this site, does not use vermiculite. However, if there is asbestos contamination inside the former Germain's building or in soil outside the building, people who currently work at PEYK International, Inc. could be exposed to hazardous levels of asbestos. Current operations at PEYK International, Inc. are not causing community exposure to asbestos from Libby vermiculite.

Vermiculite Use and Handling in Seed Pelleting

Former workers could not be contacted because the current companies originating from the original Germain's do not have any personnel records from that time period. In addition, the original seed pelleting plant is no longer operating. Therefore, an understanding of the seed pelleting process was gained through reading descriptions in the technical literature.

A general outline of the process includes (14):

1. First, seeds are put into a coating drum or pan that is similar to a cement mixer.

2. Seeds are sprayed with water while the drum rotates the seeds. In another technique, seeds may also be sprayed with an adhesive such as ethyl cellulose (15, 16).

3. Next, a mixture of dry fillers, such as clays, limestone, calcium carbonate, talc, and vermiculite, are added to the wet seeds as they are rotated. Because the seeds are wet with water or covered with adhesive, they attract dry filler to their surface. As the rotation time lengthens, the amount of dry filler coating the seed increases and the wet seed grows in size. In another technique, adhesives and the mixture of dry fillers are alternately applied until a pellet of sufficient size has been built around the seed (15).

4. Finally, binders, such as gum arabic, polyvinyl alcohol, methylcellulose, polyoxylethylene glycol-based waxes, or gelatin, are added to harden the outer layer of the seed pellet.

5. After the pelleting process is complete, the pelleted seeds are dried and handled like unpelleted seeds.

The technical literature also showed diagrams of what seed treatment machinery used at Germain's may have looked like (15). Seeds and dry fillers are fed into the revolving drum via a tube, which may have a slight incline. While the drum mixer turns, water or liquid adhesive are sprayed onto the seeds and dry filler via small tubes. There is also a discharge tube in which treated seed could exit the revolving drum and be collected.

The revolving drum portion of the machine may or not be an enclosed system (Personal communication with Cathy Farr, January 2007). Sometimes, this portion of the machine is not covered to allow workers to observe the formation of the pellet around the original seed. If necessary, workers could then add more dry filler or adhesive.

Based on the general seed pelleting process, it seems that dust from the vermiculite may become airborne within the facility at several stages in the manufacturing process, including:

- When the raw material first arrives at the facility, depending on the way it is packaged and handled.
- When vermiculite is introduced into the rotating drum machinery and added to a mixture of seeds with water or adhesive. Seeds and dry fillers such vermiculite could be unloaded into the tube via individual bags by hand or via forklift and other automated machinery.
- When any spilled or released vermiculite or mixture of dry filler ingredients is cleaned up.
- If the revolving drum was not an enclosed system, dust from the revolving vermiculite could be easily released. In addition, any vermiculite that does not adhere to the seed and become part of the coating could exit through the discharge tube. It is also unknown how much dust collection equipment was located around the seed treatment machines or how much dust protection was used by workers at Germain's.
- During maintenance of the ventilation system, dust collector, or other equipment in the facility where dry material is present. In addition, airborne dust may escape from the facility itself through openings to the outdoor air, such as shipping or receiving doors.

Current Exposure to Asbestos from Commercial Products Made with Libby Vermiculite

Much of the vermiculite from the WR Grace mine in Libby was used to produce attic insulation products, often sold under the brand name Zonolite. Vermiculite was commonly sold in gardening and hardware stores. It was used as a soil amendment (a conditioner to improve soil quality), fertilizer carrier, and as an ingredient in many potting soil mixes. Vermiculite was also used in fireproofing materials, gypsum wallboard, and as a lightweight aggregate in construction materials (17).

Current and future exposure to asbestos from use of products made with Libby vermiculite is possible, though the extent of this risk depends on which product and how the product is being used or disturbed. ATSDR has created a fact sheet on products containing Libby vermiculite and how to protect against exposure to asbestos from these products. This fact sheet has been distributed to the local county health department.

Toxicology of Asbestos

Asbestos and Cancer

Asbestos has been classified by U.S. and international health agencies as a substance that is known to cause cancer in humans. Numerous studies of occupational exposure to asbestos (exposure to asbestos during work) have shown that exposure to asbestos can cause two types of cancer: mesothelioma and lung cancer. Other studies have suggested that asbestos exposure might also increase the risk of some gastrointestinal and digestive cancers.

- Mesothelioma is the uncontrolled growth of abnormal cells in the tissue that lines the lungs and abdomen. Mesothelioma is relatively rare in the general population (approximately two out of one million people will get mesothelioma), but does occur more frequently in populations of workers in industries that use asbestos. About 5% of people who are exposed to asbestos develop mesothelioma (18). Mesothelioma has a latency period of 30 to 40 years (19).

- Lung cancer is the uncontrolled growth of abnormal cells in one or both of the lungs. While normal lung tissue cells reproduce and develop into healthy lung tissue, these abnormal cells reproduce rapidly and never grow into normal lung tissue. Lumps of cancer cells (tumors) then form and disrupt lung function (20). Studies have shown that people who were exposed to asbestos at work are five times more likely to develop lung cancer than workers who are not exposed to asbestos. In addition, people exposed to asbestos at work who also smoke are 50 to 90 times more likely to develop lung cancer than workers who do not smoke and who were not exposed to asbestos. The latency period for asbestos-caused lung cancer is 20 to 30 years (19).

- A number of studies suggest that asbestos exposure may increase the risk of some gastrointestinal (digestive organ) cancers. Some studies have observed slightly higher rates of death from gastrointestinal cancer among workers exposed to asbestos. This is presumed to be due to the transfer of inhaled fibers from the lung to the gastrointestinal tract. However, these studies were not able to determine whether the excess death from gastrointestinal cancer was due to asbestos or to other factors (e.g., exposure to other chemicals, misdiagnosis, dietary factors, alcohol intake) (1). Currently, there is no conclusive evidence that exposure to asbestos does or does not cause gastrointestinal cancer.

Asbestos and Respiratory Illness

Exposure to asbestos can also lead to several non-cancer respiratory illnesses, including asbestosis and abnormalities in the pleura (the lining of the lungs).

- Asbestosis is a serious, chronic, respiratory illness that occurs when asbestos fibers lodged in lung tissue cause scarring. Scarred lung tissue does not expand and contract like normal lung tissue and so breathing becomes difficult. Oxygen and carbon dioxide do not pass through the lungs as easily and blood flow to the lungs may also be decreased, which can cause the heart to enlarge (1). Asbestosis can lead to heart failure. The latency period for asbestosis is typically 10 to 20 years (21).

- Pleural abnormalities are changes in the lining of the lung (called the pleura). The most common change is the formation of thick, fibrous areas called plaques. Other effects of asbestos exposure include diffuse (wide-spread) thickening of the pleura, fibrosis (the formation of fibrous, scar-like tissue), and areas of pleural effusions (an abnormal collection of fluid between the pleura and the wall of the chest cavity). Small areas of pleural plaques are not thought to be of significant health concern. However, diffuse thickening of the pleura and large areas of pleural plaques or pleural effusions can impair respiratory function (1). Pleural abnormalities are not likely to be identified as a cause of death.

Health Outcome Data Analysis

The analysis of incidence rates of asbestos-related cancers will be referred to as the "cancer statistics review" and the analysis of mortality rates of asbestos-related disease will be referred to as the "mortality statistics review."

Diseases Evaluated in the Health Statistics Review

The ATSDR Division of Health Studies selected a variety of diseases for evaluation in order to 1) assess the full burden of disease and death that exposure to asbestos could have had on a population, and 2) confirm information obtained from cancer registries and vital statistics records for this review as consistent and therefore comparable.

A **cancer registry** is a center that collects, organizes and analyzes information on cancer cases that have been diagnosed or treated in a geographic area (for example, California).

A **death certificate** is an official legal record of a death. They include information on the cause of death (determined by a physician) and demographic characteristics of the deceased.

Incidence rate is a measure of the occurrence of disease in a population. It is the number of people in a population who get a disease in a specific time period, per (divided by) the number of people in that population during the time period. For example, the incidence rate of lung cancer in California for the year 1997 was 60.1 per 100,000 people (4).

Mortality rate is a measure of the occurrence of death from a disease in a population. It is the number of people in a population who die from a disease in a specific time period, divided by the number of people in that population during the time period. For example, the mortality rate for lung cancer in California for the year 1997 was 41.8 per 100,000 people (5).

Exposure to asbestos is known to cause lung cancer, mesothelioma, and asbestosis. Some studies suggest that exposure to asbestos might also increase the risk of certain digestive organ cancers. It is also possible that exposure to asbestos might worsen and cause premature death from certain diseases of the pulmonary and circulatory system.

One factor complicating the study of asbestos-related diseases is that physicians often misdiagnose these diseases, particularly when establishing a cause of death. This review also evaluated the number of people getting or dying from certain diseases because these people might have had an asbestos-related disease that was misdiagnosed.

Incidence rates of eight types of cancers or cancer groups were evaluated in the cancer statistics review (see list at right). Lung and bronchus cancer, mesothelioma, and digestive organ cancers were studied because of their known or suspected association with asbestos exposure. Cancer of the peritoneum, retroperitoneum and pleura, and cancer of the respiratory system and intrathoracic organs were evaluated because people with these diagnoses might actually have had an asbestos-related cancer instead.

The cancer statistics review evaluated the following types of cancer:

- Lung and bronchus
- Mesothelioma
- Digestive organs
- Peritoneum, retroperitoneum, and pleura
- Respiratory system and intrathoracic organs
- All types of cancer
- Female breast
- Prostate

The mortality statistics review evaluated death from the following diseases:

- Lung and bronchus cancer
- Cancer of the peritoneum, retroperitoneum, and pleura (including mesothelioma)
- Asbestosis
- Digestive organ cancers
- Respiratory system and intrathoracic organ cancers
- Cancer (no specification of site)
- Pneumoconioses
- Chronic obstructive pulmonary disease
- Diseases of pulmonary circulation
- Other diseases of respiratory system
- All types of cancer
- Female breast cancer
- Prostate cancer

Lastly, all types of cancer, female breast cancer, and prostate cancer were evaluated to determine whether cancer was underreported to the cancer registries that provided information for this review.

Mortality rates from 13 types of diseases or disease groups were evaluated as part of the mortality statistics review (see list, at right). Lung and bronchus cancer, cancer of the peritoneum, retroperitoneum and pleura (including mesothelioma), asbestosis, and digestive organ cancers were evaluated because of their known or suspected association with asbestos exposure.

Respiratory system and intrathoracic organ cancers, cancer (no specification of site), pneumoconioses, and chronic obstructive pulmonary disease were evaluated because these deaths might have included people with misdiagnosed asbestos-related diseases. Chronic obstructive pulmonary disease, disease of the pulmonary circulation, and other diseases of the respiratory system were evaluated because asbestos-exposure might have worsened these conditions and led to premature death. Lastly, all types of cancer, female breast cancer, and prostate cancer were evaluated to determine whether causes of death were underreported to the registries that provided information for the mortality statistics review.

Evaluating Mesothelioma

During the years that were evaluated in this review, cancer and causes of death were coded in cancer registries and on death certificates according to two classification systems: International Classification of Diseases, Oncology Codes, Revision 2 (ICD-O-2) (used by cancer registries), and International Classification of Diseases, Injury, and Causes of Death Codes, Revision 9 (ICD-9) (used for death certificates).

The ICD-O-2 system has a specific code for mesothelioma, which makes it possible to evaluate the incidence rate of this cancer in the Vernon community. In contrast, the ICD-9 system does not have a specific code for mesothelioma. Therefore, it is not possible to analyze mortality rates for mesothelioma alone; only a larger group of diseases (cancer of the peritoneum, retroperitoneum, and pleura, including mesothelioma) can be evaluated. Nearly all of the deaths in this cancer group are, in fact, deaths from mesothelioma (W. Kaye, ATSDR, personal communication, 2004). Therefore, evaluating mortality from this group of cancers reflects, with relative accuracy, the occurrence of death from mesothelioma.

Populations Evaluated

As mentioned above, whether people who lived near Germain's between 1967 and 1969 were exposed to hazardous levels of asbestos from Libby vermiculite, and if so, which areas of Vernon experienced such exposure, is currently unknown (3).

Therefore, the first step of the health statistics review was to determine which area near Germain's was most likely to have experienced an increased burden of asbestos-related disease (assuming that Germain's did pollute the surrounding air with hazardous levels of asbestos). CDHS concluded that the population living within ½ mile of Germain's was most likely to have been exposed to levels of asbestos high enough to cause a detectable excess burden of asbestos-related disease. This distance was selected based on information presented in this health consultation, as well as on information from health studies of lung cancer and mesothelioma rates in communities near asbestos industries (22-25).

Figure 1 shows the location of the Vernon Plant and the area of Vernon that is located within ¼ mile of the facility. The health statistics review would ideally evaluate the incidence and mortality rates of asbestos-related disease in the population residing in this area. But the smallest geographic area on which cancer statistics are publicly available is the census tract (providing information on a smaller geographic area could make it possible to identify a cancer patient, and thus would violate their right to privacy). For similar reasons pertaining to privacy, the smallest geographic area on which mortality statistics are publicly available is the ZIP Code.

> Census tracts are small geographic areas defined by the U.S. Census Bureau. Census tracts usually have 2,500 to 8,000 residents with similar population characteristics, economic status, and living conditions.

Therefore, for the cancer statistics review, CDHS studied the population living in census tract 5334. For the mortality statistics review, CDHS studied the population residing in ZIP Code 90270. Figure 2 shows the location of Germain's, the area that CDHS determined was most likely to experience an excess of asbestos-related disease, and census tract 5334. Figure 3 shows the location of Germain's, the area that CDHS determined was most likely to experience an excess of asbestos-related disease, and ZIP Code 90270.

Figure 1: Area of Vernon that is most likely to have been exposed to levels of asbestos high enough to cause a detectable excess burden of asbestos-related disease, assuming that Germain's Seed Company, Vernon, California, polluted the outside air with hazardous levels of asbestos.

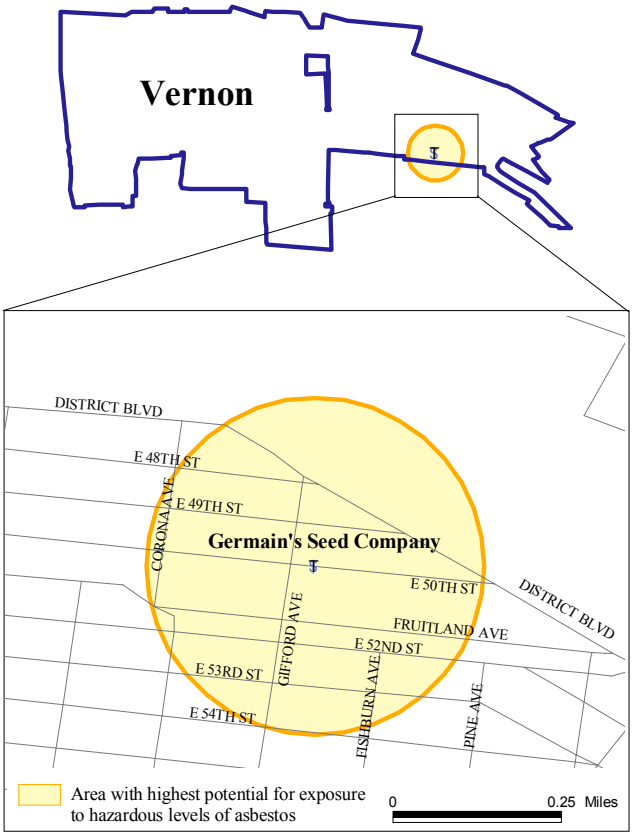


Figure 2: Map of Census Tract 5334 in Relationship to the Area Located Within ¼ Mile of Germain's Seed Company, Vernon, California.

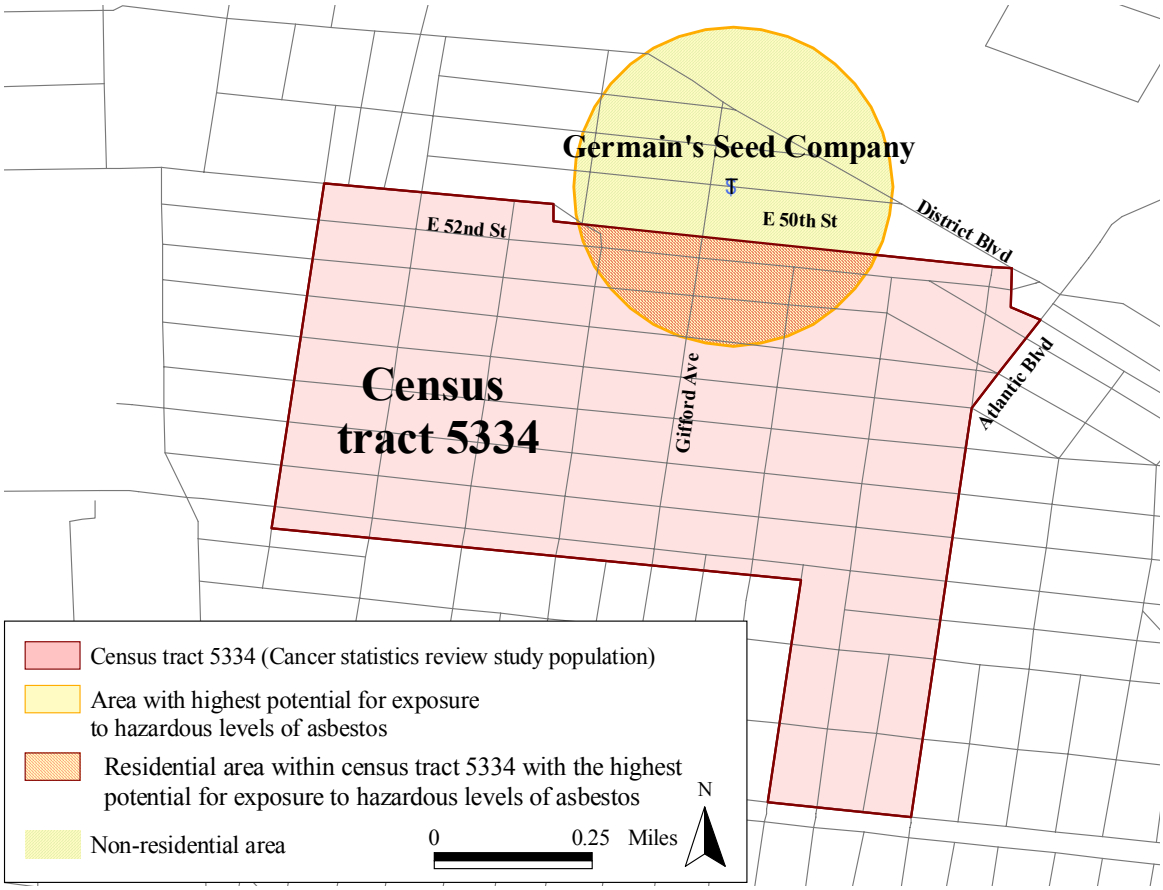
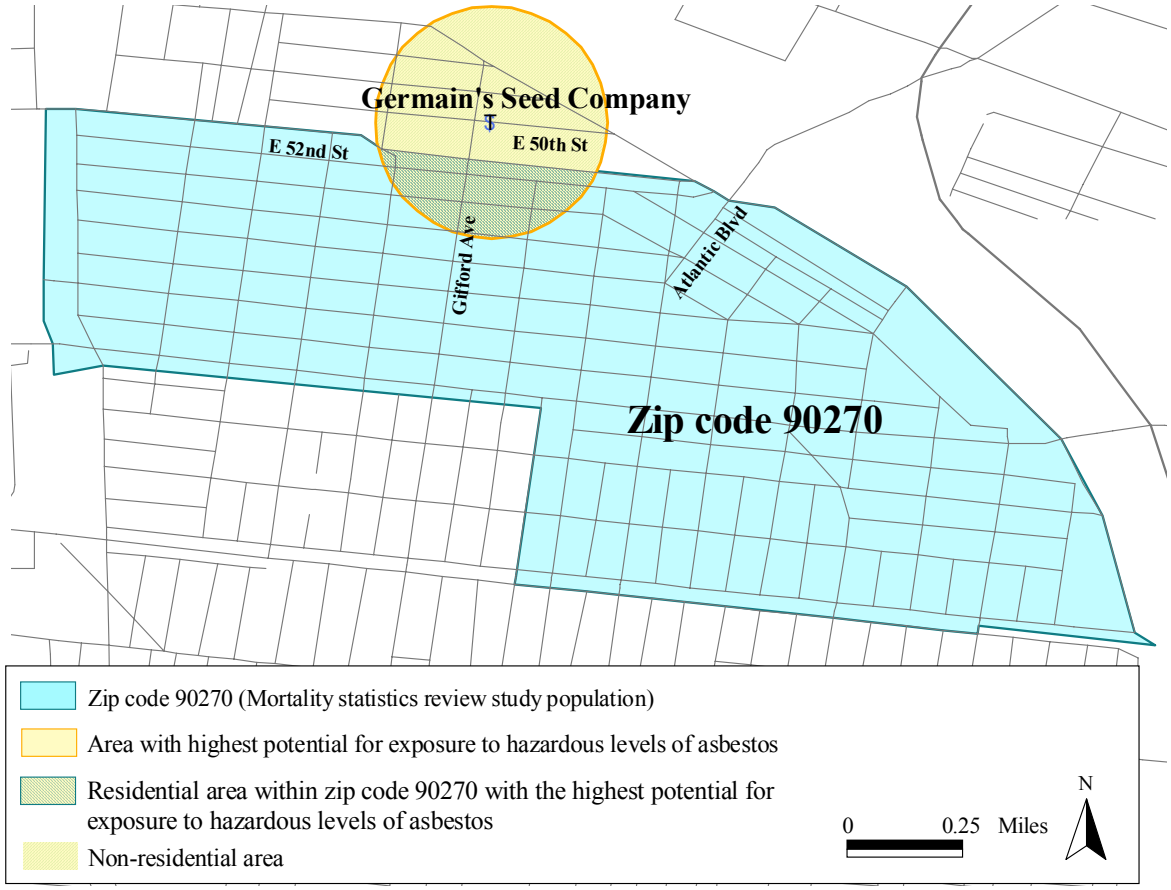


Figure 3: Map of ZIP Code 90270 in Relationship to the Area Located Within ¼ Mile of Germain's Seed Company, Vernon, California.



Time Periods of Health Statistics Review

The cancer statistics review studied the period from January 1, 1986, through December 31, 1995, and the mortality statistics review studied the period January 1, 1989, through December 31, 1998. ATSDR selected these periods for two reasons: 1) they come closest to corresponding to the time of exposure and the latency period of asbestos-related disease; and 2) a 10-year period provides the minimum amount of data required for informative statistical analysis (26).

Demographic Information on the Study Populations

In 1990, there were 12,381 people residing in census tract 5334 and 27,888 people residing in ZIP Code 90270 (see Table 1). Compared to the U.S. population, both study populations had more males than females and were primarily Hispanic other ethnicity and Hispanic white. The study populations also had fewer people age 65 and older and had a lower socioeconomic status, as measured by educational attainment, the percentage of people in the labor force, employment status, and poverty status.

Statistical Analysis

CDHS followed a health statistics review protocol developed by the ATSDR Division of Health Studies (26). The statistical analysis was designed to screen for an excess of asbestos-related disease in communities with facilities that received Libby vermiculite. Specifically, the following questions are explored:

1. Is the number of people who were diagnosed with an asbestos-related cancer while residing in census tract 5334 from 1986-1995 higher than what we would

Table 1: Demographic Characteristics of the Populations Living in Census Tract 5334, ZIP Code 90270 and in the United States (2). Germain's Seed Company, Vernon, California.

	Census Tract 5334	ZIP Code 90270	U.S.
Total population	12,381	27,888	
Sex			
Males	51%	51%	49%
Females	49%	49%	51%
Race/Ethnicity			
Non-Hispanic			
White	6%	5%	76%
Other	1%	1%	16%
Hispanic			
White	25%	26%	5%
Other	67%	67%	4%
Age			
Under 18 years old	35%	37%	26%
18-64 years old	60%	59%	62%
65 and over	5%	4%	12%
Education			
Less than 9th grade	40%	43%	9%
Some high school	28%	27%	15%
High school graduate	18%	18%	30%
Some college or higher	14%	13%	45%
Employment			
In labor force	68%	69%	65%
Not in labor force			35%
Employed	90%	88%	94%
Unemployed	10%	12%	6%
Poverty			
Income below poverty level	20%	22%	13%

expect if the incidence rates of these cancers in census tract 5334 population were the same as the rates in the U.S. population?

2. Are the incidence rates of asbestos-related cancers in census tract 5334 population from 1986-1995 higher than the rates in the U.S. population?

3. Is the number of people who died from asbestos-related disease while residing in ZIP Code 90270 from 1989-1998 higher than what we would expect if mortality rates in the ZIP Code 90270 population were the same as the mortality rates in the U.S. population?

4. Are the mortality rates for asbestos-related disease in the ZIP Code 90270 population from 1989-1998 higher than the mortality rates in the U.S. population?

These four questions are similar in that they all compare the incidence and mortality rates in the Vernon community with the incidence and mortality rates in the U.S. population. They differ, however, in how the comparison is made.

Statistical Measures of Comparison

The first question is explored by calculating a statistical measure called the standardized incidence ratio (SIR). SIR is a numerical expression that compares how many people in the census tract 5334 population were diagnosed with cancer and how many diagnoses would be expected (hypothetically) if the incidence rate of cancer in the census tract 5334 population was the same as the incidence rate of cancer in the U.S. population. Details on how SIR is calculated are provided in Appendix B. If the number of people who were diagnosed with an asbestos-related cancer while residing in census tract 5334 is the same as the expected number, SIR will equal 1. If the number of people in the census tract 5334 population who were diagnosed with an asbestos-related cancer is less than the expected number, SIR will be less than 1. If the number of people in the census tract 5334 population who were diagnosed with an asbestos-related cancer is more than one would expect, SIR will be greater than 1.

The second question is explored by calculating a statistical measure called the standardized rate ratio (SRR). The SRR is the ratio of the number of expected cancer diagnoses in the U.S. population, based on incidence rates of cancer in the census tract 5334 population, to the number of observed cancer diagnoses in the U.S. population. Details on how the SRR is calculated are provided in Appendix C. If the incidence rate of cancer in the census tract 5334 population is the same as the incidence rate of cancer in the U.S. population, SRR will equal 1. If the incidence rate of cancer in the census tract 5334 is higher than the incidence rate of cancer in the U.S. population, then the SRR will be greater than 1. If the incidence rate of cancer in the census tract 5334 is lower than the incidence rate of cancer in the U.S. population, then the SRR will be less than 1.

The third question is explored by calculating a statistical measure called the standardized mortality ratio (SMR)**.** SMR is essentially the same measure as SIR except that it evaluates the number of people who died from a disease rather than the number of people who were diagnosed with a disease. Thus, SMR is a numerical expression that compares how many people in ZIP Code 90270 died of an asbestos-related disease, and how many would be expected to die

(hypothetically) if the mortality rates of asbestos-related disease in the ZIP Code 90270 population were the same as the mortality rates in the U.S. population. Details on how SMR is calculated are provided in Appendix D. If the number of people who died from an asbestos-related disease while residing in ZIP Code 90270 is the same as the expected number, SMR will equal 1. If the number of ZIP Code 90270 residents who died from an asbestos-related disease is less than the expected number, SMR will be less than 1. If the number of people in ZIP Code 90270 who died from an asbestos-related disease is more than one would expect, SMR will be greater than 1.

Lastly, the fourth question is also answered by calculating SRR for mortality rates instead of cancer incidence rates. So SRR in this case is the ratio of number of expected cancer deaths in the U.S. population, based on mortality rates of cancer in ZIP Code population 90270, to the number of observed cancer deaths in the U.S. population.

Interpreting the Expected Number of People to Develop or to Die from a Disease

SIR, SMR, and SRR all compare the actual number of people to get or to die from a disease with an expected number. This expected number of people is a calculated and theoretical number that is often not a whole number. For example, the expected number might be 2.6 people. Because it is not possible for a fraction of a person to get or die from a disease, the expected number can be thought of as an approximation. In this example, the expected number 2.6 people can be interpreted to mean that either two or three people are expected to get or die from a disease.

Accounting for Differences between the Study Populations and the Comparison Population

In this review, the incidence and mortality rates of disease in the Vernon and U.S. populations are compared because it is thought that the Vernon population might have higher rates of disease due to past exposure to harmful levels of asbestos. However, other characteristics can also increase the risk for developing many of the diseases linked to asbestos. If the study populations differ from the U.S. population in terms of how common these characteristics are, then these differences can bias (i.e., create a faulty appearance) the results of the comparison unless they are accounted for in the analysis. For example, smoking can increase the risk of developing lung cancer. If smoking rates in the Vernon populations are lower than the smoking rates in the U.S. population, but the analysis does not adjust for this difference, then the study populations might appear to have lower rates of lung cancer in comparison with the U.S. population than they in fact do. This bias can hide a true excess of disease or it can create the appearance of an excess when none really exists.

This analysis did account for differences in age and sex, but did not account for other risk factors for asbestos-related disease (e.g., smoking, race/ethnicity, socioeconomic status).

Statistical Tests

The number of people who get or die from cancer or other diseases in a given geographic area changes from year to year; this fluctuating pattern is characteristic of the occurrence of disease and is expected. Because of this, the values of SIR, SMR, and SRR will also change, depending

on which time period is under study. If the number of cases occurring in one time period under study is higher than average, then SIR, SMR, or SRR will be higher than 1 (e.g., 1.2). If a different time period was under study when the number of cases was lower than average, SIR, SMR, and SRR will be less than 1 (e.g., 0.9). Some degree of fluctuation in the SIR, SMR, and SRR values from one time period to another is normal and expected.

An important question is when is SIR, SMR, or SRR higher or lower than what would be expected, given that the number of people getting disease in a given geographic area normally varies over time? In other words, is the incidence rate or mortality rate in the Vernon population the same as that in the U.S. population, or is disease or death occurring less or more frequently in the Vernon population than in the U.S. population?

To answer this question, a statistical test measure called a confidence interval (CI) was calculated for SIR, SMR, and SRR using Byar's approximation method (27). A confidence interval is a range of possible values for SIR, SMR, or SRR that are consistent with the normal variation in disease over time in a geographic area. If the CI range includes the value one, then there is no "statistically significant" difference between the incidence or mortality rates in the Vernon and U.S. populations, as represented by SIR, SMR, or SRR. That is, the incidence or mortality rate in the Vernon population is the same as the incidence or mortality rate in the U.S. population. If the CI range is less than 1 or greater than 1, then there is a "statistically significant" difference between the incidence or mortality rates in the two populations: the incidence rate or mortality rate in the Vernon population is not the same as the incidence rate or mortality rate in the U.S. population.

Part of the process of calculating a confidence interval includes selecting a level of certainty for this statistical test. CDHS used a 95% level of certainty that is the standard value selected for these types of analyses.

Sources of Information on Incidence and Mortality Rates

Information on the number of people who developed cancer while residing in census tract 5334 was obtained from the California Cancer Registry (CCR). Information on cancer rates in the U.S. population was obtained from the Surveillance, Epidemiology, and End Results program of the National Cancer Institute (SEER) (28).

Information on the number of people who died while residing in ZIP Code 90270 was obtained from CDHS, Center for Health Statistics, Office of Vital Records (CDHS-OVR). Information on mortality rates in the U.S. population was obtained from the National Center for Health Statistics (NCHS) (29).

Results of the Cancer Statistics Review

SIRs and SRRs for the census tract 5334 population are presented in Table 2. Table 2 shows:

For each cancer group evaluated

- the reason for evaluating that type of cancer.

For the SIR analysis

- the number of people who were diagnosed with the type of cancer while residing in census tract 5334;
- the number of people expected to be diagnosed (if the census tract 5334 population had the same incidence rate as the U.S. population); and
- SIR and 95% CI for SIR.

For the SRR analysis

- the number of people who were diagnosed with the type of cancer while residing in the United States;
- the number of people expected to be diagnosed (if the U.S. population had the same incidence rate as the census tract 5334 population); and
- SRR and the 95% CI for SRR.

Between 1986 and 1995, the incidence rates of asbestos-related cancers in the census tract 5334 population were either statistically significantly lower than the rate in the U.S. population, or the same as the rate in the U.S. population. Twenty four people were diagnosed with lung or bronchial cancer, when 36.6 diagnoses would be expected if the incidence rate in the census tract 5334 population was the same as the incidence rate in the U.S. population (SIR=0.66). The 95% CI 0.42-0.98 indicates that the observed lung or bronchial cancer incidence rate was statistically significant lower than the expected incidence rate. The SRR analysis also indicated that the census tract 5334 population had a statistically significantly lower incidence rate of lung and bronchus cancer than the U.S. population: SRR=0.62 and 95% CI 0.41-0.93. Neither the SIR nor the SRR analysis found any evidence that the incidence rate of mesothelioma in the census tract 5334 population was different from the U.S. population: SIR=0 and 95% CI 0-6.15 and SRR=0.

The census tract 5334 population also experience statistically significantly lower incidence rates of digestive organ cancers than the U.S. population: SIR=0.64 and 95% CI 0.42-0.94; and SRR=0.67 and 95% CI 0.46-0.97.

The incidence rate of cancer of the respiratory system and intrathoracic organs in the census tract 5334 population was not statistically significantly different from the incidence rate in the U.S. population, as evaluated by the SIR analysis (SIR=0.70; 95% CI, 0.46-1.01). However, the SRR analysis did produce evidence that the census tract 5334 population did have statistically significantly lower incidence rates of these cancers than the U.S. population: SRR=0.66 and 95% CI 0.45-0.96. Neither analysis indicated that the census tract 5334 population had a different incidence rate of cancers of the peritoneum, retroperitoneum, and pleura than the U.S. population: SIR=0.93 and 95% CI 0.01-5.18; and SRR=1.27 and 95% CI 0.15-10.55.

Table 2. Standardized incidence ratio (SIR), standardized rate ratio (SRR), and 95% confidence intervals (CI) of selected cancers in the census tract 5334 population, 1986-1995. Germain's Seed Company, Vernon, California.

Cancer Group (ICD-O-2 Code)	Reason*	Census Tract 5334			U.S. Population		
		Number of diagnoses	Number expected	SIR (95% CI)	Number of diagnoses	Number expected	SRR (95% CI)
Lung and bronchus (C340:C349†)	1	24	36.6	**0.66 (0.42-0.98)**	148,246	91,704.7	**0.62 (0.41-0.93)**
Mesothelioma (M-9050:9053)	1	0	0.6	0 (0-6.15)‡	2,360	0.0	0§
Digestive organs (C150: C218, C260:C269†)	2	27	41.9	**0.64 (0.42-0.94)**	163,384	108,860.4	**0.67 (0.46-0.97)**
Respiratory system and intrathoracic organs (C320:C399†)	3	28	40.2	0.70 (0.46-1.01)	162,067	106,953.0	**0.66 (0.45-0.96)**
Peritoneum, retroperitoneum, and pleura (C480:C488, C384†)	3	1	1.1	0.93 (0.01-5.18)‡	3,814	4,828.8	1.27 (0.15-10.55)
All cancers (C000:C809†)	4	157	288.8	**0.54 (0.46-0.64)**	1,045,968	589,187.8	**0.56 (0.48-0.66)**
Female breast (C500:C509†)	4	28	45.3	**0.62 (0.41-0.89)**	154,568	99,362.8	**0.64 (0.44-0.94)**
Prostate (C619†)	4	23	34.0	0.68 (0.43-1.01)	153,845	102,532.1	0.67 (0.44-1.01)

†Excluding M-9590:9989. ‡Exact confidence interval based on Poisson distribution. §Confidence interval not calculated since expected number of deaths was 0 (W. Kaye, ATSDR, personal communication, 2004). **Bold** typeface indicates a statistically significant result.

* Reason for studying:

1. Exposure to asbestos is known to cause a type of cancer in this cancer group.
2. There is some, but inconclusive, evidence that exposure to asbestos might be associated with some digestive organ cancers.
3. This cancer group might include people with an asbestos-related cancer that was misdiagnosed.
4. This cancer or cancer group was studied to confirm that information on cancer diagnoses is reported to CCR and SEER in a consistent manner.

In terms of reference cancer analyses, according to both the SIR and SRR analysis, the incidence rates of all types of cancer and female breast cancer in the census tract 5334 population were all statistically significantly lower than the incidence rates in the U.S. population. For all types of cancer, SIR=0.54 and 95% CI 0.46-0.64; and SRR=0.56 and 95% CI, 0.48-0.66. For female breast cancer, SIR=0.62 and 95% CI, 0.41-0.89; and SRR=0.64 and 95% CI, 0.44-0.94. Neither analysis found evidence that the incidence rates of prostate cancer were different in the census tract 5334 and U.S. populations (SIR=0.68 and 95% CI, 0.43-1.01; and SRR=0.67 and 95% CI, 0.44-1.01).

Deficits were noted in incidence rates for cancers overall and female breast cancer. A possible reason for deficits is that the Hispanic population comprises a much greater percentage of the census tract 5334 population than the U.S. population and as a group, Hispanics have substantially lower rates of cancers overall and female breast cancer than non-Hispanic whites (30). Other factors which may contribute to these deficits are unknown, but may be due to other aspects of the risk factors beyond the scope of this analysis, such as population differences in factors associated with health such as smoking status, race/ethnicity, diet, and obesity, or other aspects of the data reporting/recording, either for numerators or denominators. Overall, this analysis did not suggest the presence of systematic bias in reporting or other data anomalies affecting the results.

Results of the Mortality Statistics Review

SMRs and SRRs for the ZIP Code 90270 population are presented in Table 3. Table 3 shows:

For each disease group evaluated
- the reason for evaluating the disease.

For the SMR analysis
- the number of people who died from the disease while residing in ZIP Code 90270;
- the number of people expected to die (if this population had the same disease mortality rate as the U.S. population); and
- SMR and 95% CI for SMR.

For the SRR analysis
- the number of people who died from the disease while residing in the United States;
- the number of people expected to die (if the U.S. population had the same disease mortality rate as the ZIP Code 90270 population); and
- SRR and 95% CI for SRR.

The mortality statistics review found no evidence that the ZIP Code 90270 population experienced statistically significantly higher rates of death from some asbestos-related disease than the U.S. population between the years 1989-1998. In fact, the ZIP Code 90270 population had statistically significantly lower mortality rates for cancer of the lung and bronchus: SMR=0.67 and 95% CI 0.47-0.92; and SRR=0.76 and 95% CI 0.65-0.89. And, there was no statistically significant difference between the mortality rates for cancer of the peritoneum,

retroperitoneum, and pleura (including mesothelioma), and for asbestosis in the ZIP Code 90270 and U.S. populations. For cancer of the peritoneum, retroperitoneum, and pleura (including mesothelioma), SMR=2.30 and 95% CI 0.03-12.81 and SRR=3.8 and 95% CI 0.89-16.32. For asbestosis, SMR=0 and 95% CI 0-36.89 and SRR=0.

Neither the SMR nor the SRR analyses produced evidence that the ZIP Code 90270 population experienced statistically significantly different rates of death from digestive organ cancers, which have been inconclusively linked to asbestos exposure in previous epidemiologic studies. SMR=0.99 and 95% CI 0.68-1.39, and SRR=1.05 and 95% CI 0.89-1.24.

The ZIP Code 90270 population had statistically significantly lower mortality rates from cancer of the respiratory system and intrathoracic organs (SMR=0.67 and 95% CI 0.47-0.91, and SRR=0.76 and 95% CI 0.65-0.89) and from diseases of the pulmonary circulation (SMR=0.17, 95% CI 0.00-0.96, and SRR=0.07, 95% CI 0.03-0.17). There was no statistically significant difference between the mortality rates in the ZIP Code 90270 and U.S. populations for the following diseases: cancer (no site specified) (SMR=1.12, 95% CI 0.62-1.84, and SRR=1.16, 95% CI 0.86-1.55); pneumoconiosis (SMR=0, 95% CI 0-9.22, and SRR=0); chronic obstructive pulmonary disease (SMR=1.02, 95% CI 0.72-1.40, and SRR=1.18, 95% CI 1.00-1.41); and other diseases of the respiratory system (SMR=0.39, 95% CI 0.08-1.14, and SRR=0.87, 95% CI 0.56-1.35).

In terms of reference outcome analyses, compared to the U.S. population, the ZIP Code 90270 population had statistically significantly lower mortality rates from all cancers: SMR=0.75 and 95% CI 0.64-0.87; and SRR=0.82 and 95% CI 0.75-0.89. The ZIP Code 90270 and U.S. populations had the same mortality rates for female breast cancer (SMR=0.76 and 95% CI 0.44-1.24, and SRR=0.95 and 95% CI 0.71-1.26). The SRR analysis indicated that the mortality rate for prostate cancer was statistically significantly higher in the ZIP Code 90270 population than in the U.S. population (SRR=1.62 and 95% CI 1.23-2.13), but the SMR analysis did not (SMR=1.52 and 95% CI 0.87-2.47).

A deficit was shown for cancers overall, and an elevation was shown for prostate cancer. A possible reason for the deficit in cancers overall is that the Hispanic population comprise much greater percentages of the ZIP Code 90270 population than the U.S. population, and as a group, Hispanics have substantially lower rates of cancer than non-Hispanic whites (30). Variations in prostate cancer rates may be due to regional differences in screening tests for early detection (31). Other factors which may contribute to these varying results are unknown, but may include other aspects of the risk factors beyond the scope of this analysis, such as population differences in factors associated with health such as smoking status, race/ethnicity, diet, and obesity, or other aspects of the data reporting/recording, either for numerators or denominators.

Table 3. Standardized Mortality Ratio (SMR), Standardized Rate Ratio (SRR) and 95% Confidence Intervals (CI) of Selected Causes of Death Occurring in ZIP Code 90270, 1989-1998. Germain's Seed Company, Vernon, California.

Cause of Death (ICD-9 Code)	Reason*	ZIP Code 90270			U.S. Population		
		Number of deaths	Number expected	SMR (95% CI)	Number of deaths	Number expected	SRR (95% CI)
Cancer of the lung and bronchus (162.2-162.9)	1	38	56.6	**0.67 (0.47,0.92)**	1,476,326	1,120,906.3	**0.76 (0.65, 0.89)**
Cancer of the peritoneum, retroperitoneum and pleura (including mesothelioma) (158, 163)	1	1	0.4	2.3 (0.03, 12.81)	10,615	40,381.8	3.8 (0.89, 16.32)
Asbestosis (501)	1	0	0.1	0 (0-36.89)†	3,367	0.0	0‡
Cancer of the digestive organs (150-154, 159)	2	33	33.3	0.99 (0.68, 1.39)	832,523	876,906.0	1.05 (0.89, 1.24)
Cancer of the respiratory system and intrathoracic organs (161-165)	3	39	58.6	**0.67 (0.47, 0.91)**	1,524,872	1,161,288.1	**0.76 (0.65, 0.89)**
Cancer (no site specified) (199)	3	15	13.4	1.12 (0.62, 1.84)	327,646	378,589.2	1.16 (0.86, 1.55)
Pneumoconiosis (500-505)	3	0	0.4	0 (0-9.22)†	11,617	0.0	0‡
Chronic obstructive pulmonary disease (490-496)	3, 4	37	36.3	1.02 (0.72, 1.40)	986,772	1,168,045.3	1.18 (1.00, 1.41)
Other diseases of the respiratory system (510-519)	4	3	7.7	0.39 (0.08, 1.14)	172,155	149,356.9	0.87 (0.56, 1.35)
Diseases of pulmonary circulation (415-417)	4	1	5.8	**0.17 (0,00, 0.96)**	119,554	8,003.0	**0.07 (0.03, 0.17)**
All cancers (140-208)	5	163	218.3	**0.75 (0.64, 0.87)**	5,259,810	4,298,120.9	**0.82 (0.75, 0.89)**
Female breast cancer (174)	5	16	20.9	0.76 (0.44, 1.24)	430,680	408,812.2	0.95 (0.71, 1.26)
Prostate cancer (185)	5	16	10.5	1.52 (0.87, 2.47)	334,151	541,055.9	**1.62 (1.23, 2.13)**

†Exact confidence interval based on Poisson distribution. ‡Confidence interval not calculated since expected number of deaths was 0 (W. Kaye, ATSDR, personal communication, 2004). **Bold** typeface indicates a statistically significant result.

* Reason for studying:

1. Exposure to asbestos is known to cause a type of cancer in this cancer group or this disease.
2. There is some, but inconclusive, evidence that exposure to asbestos might be associated with some digestive organ cancers.
3. This cancer group might include people with an asbestos-related cancer that was misdiagnosed.
4. Exposure to asbestos might have exacerbated the condition of people with these diseases and thereby led to premature or increased chance of death.
5. This cancer or cancer group was studied to confirm that information is reported to CDHS-OVR and NCHS in a consistent manner.

Limitations of the Health Statistics Review

Five limitations of this analysis are worth discussion and exploration because they might 1) affect the accuracy of the results, 2) limit the ability of the analyses to observe an excess of asbestos-related disease attributable to vermiculite processing at Germain's, if one exists, or 3) limit the degree to which this analysis can serve as an indicator of community exposure to Libby asbestos.

1. *The SIR, SMR, and SRR results might be biased if the analyses do not account for the ways that the Vernon and U.S. population differ with respect to other risk factors for asbestos-related diseases (e.g., race/ethnicity, socioeconomic status, or smoking).*

As discussed previously, this analysis does not account for all the ways that the Vernon population differs from the U.S. population with respect to risk factors for diseases that can be caused by exposure to asbestos (e.g., smoking, race/ethnicity, or socioeconomic status). As a result, this analysis might not accurately identify an excess or lack of excess of disease attributable to asbestos exposure.

To assess whether the Vernon and U.S. populations differ with respect to other risk factors for asbestos-related disease, CDHS gathered information from the U.S. Census. Table 1 shows that the population in census tract 5334 differs substantially from the U.S. population in terms of race/ethnicity and socioeconomic status (measured by education level and poverty status). Also, the ZIP Code 90270 population differ substantially from the U.S. population in terms of these characteristics. No information on smoking rates in the study populations is available. However, however, smoking has historically been less common in California (32), and, since the late 1980s, smoking rates in California have been declining more rapidly than the rest of the country (33). Smoking rates also tend to be higher among people of low socioeconomic status (34) and tend to differ by race and ethnicity (35-37). Using these statewide trends, it is likely that the smoking rates in the Vernon study populations are different from those in the U.S. population.

It is not possible to predict whether or how the combined racial, ethnic, and socioeconomic differences between the study and U.S. populations could bias the analysis (that is, whether they could be masking a true elevation in rates of asbestos-related disease.) However, any conclusions drawn from this health statistics review could be made more definitively if these differences were accounted for in the SIR, SMR, and SRR analyses.

2. *The results of the analyses might be inaccurate if the study populations are larger or smaller than they are assumed to be.*

Information on the size of the study populations during the study periods (1986-1995 for the cancer statistics review and 1989-1998 for the mortality statistics review) is needed to calculate SIR, SMR, and SRR as well as 95% CIs. Information on the size of the populations in census tracts and ZIP Codes is collected by the U.S. census once every decade, but not during the intervening years. Therefore, to calculate the statistical measures of comparison, ATSDR made the customary assumption that the size of the study populations in 1990 (as determined by the U.S. Census) represents the average size of the populations during the study periods.

If this assumption does not hold true, then the results of the SIR, SMR, and SRR analyses will be biased (inaccurate). Specifically, if the size of the study populations in 1990 is smaller than the average size of the study populations during the study periods, then SIR, SMR, and SRR will be inaccurately high numbers, and the statistical tests might falsely indicate a statistically significant excess of disease. And, if the size of the study populations in 1990 is larger than the average size of the study populations during the study periods, then SIR, SMR, and SRR will be inaccurately low numbers, and the statistical tests might falsely indicate a lack of disease excess.

Without knowing the true size of the study populations during the study periods, it is not possible to predict whether, or in what way, these statistical measures might be biased. However, it is possible to obtain some sense of whether any bias is occurring by referring to information on the size of these populations during U.S. Census years.

According to U.S. Census data, the census tract 5334 population grew by 23% between 1980 and 1990 and by 1% between 1990 and 2000 (38). If these trends represent the growth of the census tract population between 1986 and 1995, then the assumed size of the cancer statistics review study population is smaller than the true size. This difference will bias the values of SIR, SRR, and 95% CIs in a way they that makes them higher than actually are.

The ZIP Code 91201 population grew by 6% between the years 1990 and 2000 (38). If this trend represents the growth of this population during the years 1989 and 1998, then the assumed size of the mortality statistics review study population is smaller than the true size. This difference will bias the values of the SMR, SRR, and 95% CIs in a way that makes them higher than they actually are.

The ZIP Code 90270 population grew by only 1% between the years 1990 and 2000 (38). If this trend represents the growth of this population during the years 1989 and 1998, then the assumed size of the mortality statistics review study population is similar enough to the true size that the difference will not substantially bias the values of SMR, SRR, and 95% CIs.

In summary, if more accurate information on population size was used in the analysis, then the values of SIRs and SRRs of the cancer statistical review would be lower than they were in these results. That is, the incidence rates in the Vernon study populations might be even lower, in comparison to the rates in the U.S. population, than this analysis indicates. However, SMRs and SRRs of the mortality statistics review are not likely to be biased by assuming that the size of the ZIP Code 90270 population in 1990 represents the size of the study population.

3. *The analysis might fail to observe a true excess of asbestos-related cancers and disease if the study populations include people who could not have been exposed to asbestos from the processing of vermiculite at Germain's.*

This health statistics review would ideally evaluate the health status of only those people who were exposed to asbestos from the processing of Libby vermiculite at Germain's, assuming that off-site contamination and exposure did occur. The effect of including people who were not exposed to asbestos in the study population is to lessen the ability of the study to see an excess of asbestos-related disease in the population. This occurs because the people who were never

exposed to asbestos can make the population appear healthier than it would otherwise appear if they were not included in the analysis.

Due to several reasons (e.g., lack of information on whether asbestos pollution from Germain's occurred, lack of information on how far the asbestos pollution would have traveled in the air, and restrictions on the geographic area for which cancer and mortality statistics are available), it is likely that this health statistics review evaluated the occurrence of asbestos-related cancers and death in a population that included people who were never exposed to asbestos. Therefore, SIRs, SMRs, SRRs and 95% CIs are likely to be smaller numbers than they would otherwise be if unexposed people were not included in the study population. The incidence and mortality rates in the Vernon population might be higher, in comparison to the rates in the U.S. population, if the study populations only included people who were exposed to Libby asbestos from the processing of Libby vermiculite at Germain's.

4. *The analysis might fail to observe a true excess of asbestos-related cancers and disease, attributable to vermiculite processing at Germain's if the study periods do not correspond to the years that this excess of disease would be expected to occur.*

The diseases caused by exposure to asbestos take many years to develop. Current knowledge is that lung cancer will develop 20 to 30 years after exposure to asbestos, mesothelioma will develop 30 to 40 years after exposure, and asbestosis will develop 10 to 20 years after exposure. Germain's received shipments of Libby vermiculite between the years 1967 and 1969. Therefore, we would expect that any lung cancer caused by exposure to Libby asbestos would occur between 1987-1999, any mesothelioma caused by exposure to Libby asbestos would occur between 1997-2009, and any asbestosis caused by exposure to Libby asbestos would occur between 1977-1989.

This health statistics review evaluated the incidence rates and mortality rates from asbestos-related diseases between the years 1985-1996 and 1989-1998, respectively. These study periods do not correspond entirely to the years that disease caused by exposure to Libby asbestos is most likely to occur (see Table 4). Therefore, it is possible that this analysis did not find an excess of asbestos-related disease in the Vernon community because this excess of disease has not yet occurred (in the case of mesothelioma), or because it has already occurred (in the case of asbestosis).

Table 4. Years that Disease Due to Exposure to Libby Asbestos from Vermiculite Processing at Germain's Would Be Expected to Occur (Assuming that Hazardous Exposure Occurred), and Number of Period Years During Which Exposure-Related Disease Is Expected to Occur. Germain's Seed Company, Vernon, California.

Disease	Years During Which Asbestos-Related Disease Is Most Likely to Occur (Based on Latency Period)	Number of Years of Overlap Between the Period Evaluated and the Years that Asbestos-Related Disease Is Most Likely to Occur	
		Cancer Statistics Review (1986–1995)	*Mortality Statistics Review (1989–1998)*
Cancer of the lung and bronchus	1987-1999	9	10
Mesothelioma	1997-2009	0	2
Asbestosis	1977-1989	—	1

5. *The results of the health statistics review can serve as an indicator of community exposure to Libby asbestos only if the study populations include the people who were living near Germain's at the time that Libby vermiculite was processed.*

According to the protocol for this health statistics review, finding a statistically significant elevation in asbestos-related disease in a community would alert CDHS and ATSDR to the possibility that community members might have been exposed to asbestos as a result of the facility's handling or processing of vermiculite from Libby. This interpretation is based on an assumption that the study population consists of people who were exposed to Libby asbestos. Therefore, this interpretation is appropriate only if the study populations include the people who were living near Germain's during the time that Libby vermiculite was processed.

Cancer registry and vital statistics records do not collect information on residential history. Therefore it is not possible to determine whether the people in the study populations lived near Germain's during the years that Libby vermiculite was processed. However, information on population mobility from the U.S. Census can provide some insight into the likelihood that the study populations included the people who were living near Germain's during the years that Libby vermiculite was processed (1967-1969).

According to the 1990 and 2000 U.S. Census, between approximately 93% to 97% of the people residing in census tract 5334 moved into their home after 1969, and between approximately 93% to 97% of the people residing in ZIP Code 90270 moved into their home after 1969 (39). Therefore, almost all of the people in the study populations are unlikely to have had the potential to be exposed to Libby asbestos, since they moved into their homes after Germain's stopped using Libby vermiculite.

Child Health Considerations

ATSDR and CDHS recognize that infants and children may be more vulnerable to exposures than adults in communities faced with environmental contamination. Children could be especially vulnerable to asbestos exposure 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. Children might also be more biologically susceptible to the toxic effects of asbestos. Whether the latency period for asbestos-related disease is different for people exposed during childhood is also unknown.

This review of health statistics screened people of all ages, including the people who were infants or children during the years that Libby vermiculite was shipped to the Germain's facility. This group of people who were 18 years old or younger during the years of potential exposure to Libby asbestos (1967-1969) would be between the ages of 17 and 46 during the years that the cancer statistics review evaluates (1986-1995), and between 20 and 49 during the years that the mortality statistics review evaluates (1989-1998).

Conclusions

Germain's received 44 tons of asbestos containing vermiculite from Libby, Montana, between 1967 and 1969. CDHS was able to identify possible times in the seed pelleting process in which workers could be exposed to dust from handling vermiculite contaminated with asbestos. Because of the lack of company records, CDHS was not able to contact former workers of Germain's and inform them about the health hazards of exposure to Libby vermiculite.

Neither the cancer statistics review nor the mortality statistics review produced any evidence that the census tract 5334 or the ZIP Code 90270 populations experienced high incidence or mortality rates for asbestos-related diseases during the years 1986-1995 and 1989-1998, respectively. In fact, compared to the U.S. population, the study populations had either the same or lower incidence and mortality rates of lung cancer, mesothelioma, and asbestosis.

The SIR and SRR results for the reference cancers evaluated in this review indicate than an excess of asbestos-related cancers is not being obscured by physician misdiagnosis. The mortality statistics review showed that ZIP Code 90270 had either the same or statistically significantly lower mortality rates of cancer of the respiratory system and intrathoracic organs, cancer (no site specified), and pneumoconiosis.

This analysis indicated that the incidence and mortality rates of digestive organ cancers (that have been inconclusively linked to asbestos exposure) were either the same or statistically significantly lower in the study populations than in the U.S. population. The mortality statistics review indicated that the ZIP Code 90270 population had either the same or statistically significantly lower rates of death from diseases that could theoretically be worsened by exposure

to asbestos, including chronic obstructive pulmonary disease, other diseases of the respiratory system, and diseases of pulmonary circulation.

The results for the remaining diseases evaluated in the health statistics review indicate that an excess of asbestos-related disease in this Vernon population is not being obscured by physician misdiagnosis.

In addition, cancers overall and selected outcomes assumed to have no causal relationship with asbestos were reviewed for comparison. Results of these analyses were inconsistent, with cancers overall showing a slight deficit. This deficit was likely due to differences in the racial composition of the study populations as compared to the U.S. population as a reference. Other unknown factors may also have contributed, such as differences in other health risk factors between populations beyond the scope of this analysis.

A very similar protocol to the one used in this health statistics review identified a statistically significant excess of asbestos-related disease in the Libby, Montana, community. If the Vernon study populations were similar to the Libby community in terms of level of exposure to Libby asbestos, population mobility, and other characteristics, then this type of analysis would be expected to also be able to detect a statistically significant excess of asbestos-related disease in the Vernon community.

The Vernon study populations differ from the Libby community in ways that increase the limitations of this type of analysis. Therefore, although the results of this health statistics review could be correctly reflecting that the health of the Vernon community was not impacted by exposure to Libby asbestos, the lack of consistent evidence of disease excess could be due to any or all of the following reasons:

1. this analysis did not account for the ways in which the Vernon and U.S. populations differ with respect to other risk factors for asbestos-related disease;

2. the assumptions about the size of the Vernon study populations made the incidence rates in the cancer statistics review study population appear more similar to the rates in the U.S. population than they truly are;

3. the study populations included people who were never exposed to Libby asbestos from Germain's, which also made the incidence and mortality rates in the Vernon study populations appear more similar to the rates in the U.S. population than they truly are; and

4. given the years that exposure to Libby asbestos would have occurred, combined with the amount of time that asbestos-related disease takes to develop, this analysis might be failing to observe an excess of disease or death, because the time period it evaluates either precedes or falls after the time period that most of the disease attributable to Libby asbestos would occur.

More important than these limitations is the likelihood that the study populations do not include the people who were living near Germain’s during the years that Libby vermiculite was processed. Because the study populations do not appear to consist of a substantial proportion of

people who were potentially exposed to Libby asbestos, the results of this analysis do not serve as a reliable indicator of past community exposure. Therefore, the lack of evidence of high rates of asbestos-related disease or death during the years 1986-1995 or 1989-1998, respectively, in the Vernon study populations does not establish that the community neighboring Germain's Seed Company was not exposed to Libby asbestos.

Recommendations

CDHS recommends efforts to:

1. expand public awareness of the potential for and ways to avoid or reduce exposure to asbestos in consumer products made with WR Grace-Libby vermiculite; and

2. make information available to former workers at Germain's of their potential exposure to asbestos and of ways to reduce risk of asbestos-related disease (e.g., smoking cessation) via the CDHS website.

Public Health Action Plan

The Public Health Action Plan is a collection of activities intended to ensure that this health statistics review also provides a plan of action to mitigate and to prevent adverse effects on human health resulting from exposure to asbestos from Libby vermiculite. Some activities have already been completed by CDHS or ATSDR. Others activities are either ongoing or planned for the future.

Actions Completed

1. CDHS conducted a needs assessment with the Los Angeles County Health Officer and Environmental Health Departments, the goals of which were to educate the departments about the vermiculite health statistics review project, to obtain information about the extent and level of stakeholder concerns, to develop an information dissemination plan, and to identify ways CDHS can support local efforts or activities pertaining to Germain's.

2. CDHS disseminated information materials on consumer products made with Libby vermiculite to increase public awareness of the potential for and ways to reduce or avoid current or future exposure to asbestos from this source via the CDHS website.

3. CDHS briefed the Occupational Health Branch of CDHS about asbestos contamination of Libby vermiculite, the facilities in California that processed this vermiculite and the potential for workers at these facilities to have been exposed to asbestos.

4. Information on the potential for, and ways to reduce exposure to asbestos in vermiculite consumer products was included in this health consultation and provided to the Los Angeles County Health Officers and Environmental Health Directors.

Ongoing Actions

1. CDHS will continue to provide technical assistance to the Los Angeles County Health Officers and Environmental on the vermiculite health statistics review.

Planned Actions

1. ATSDR has funded health statistics reviews in 25 states with facilities that received Libby vermiculite. Once all of the results from participating states have been received, ATSDR will compare SRRs for all the sites examined in order to identify trends that might not be apparent when each facility is evaluated individually. The results of the health statistics reviews will also be evaluated in combination with all information on environmental exposures to asbestos produced by research by the National Asbestos Exposure Review project of ATSDR. ATSDR will distribute the results of these analyses to contributing state health departments and other interested parties.

2. Using the results of ATSDR's review of health statistics for all vermiculite facilities nation wide, CDHS will conduct follow-up activities with the Los Angeles County Health Officer and Environmental Health Departments. The specifics of these activities will depend on what is learned from the nation-wide review.

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Certification

The Germain's Seed Company, 4820 E. 50th Street, Vernon, Los Angeles County, health consultation was prepared by the California Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health consultation was prepared. Editorial review was completed by the Cooperative Agreement partner.

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Appendix A—Glossary

ATSDR
The Agency for Toxic Substances and Disease Registry. ATSDR is a federal health agency based in Atlanta, Georgia, that deals with hazardous substance and waste site issues. ATSDR provides information to the public on harmful chemicals in the environment and on how to be safe from contact with chemicals.

Cancer Risk
The potential for exposure to a contaminant to cause cancer in an individual or population is evaluated by estimating the probability of an individual developing cancer over a lifetime as the result of the exposure. This approach is based on the assumption that there are no absolutely "safe" toxicity values for carcinogens. USEPA has developed cancer slope factors for many carcinogens. A slope factor is an estimate of a chemical's carcinogenic potency, or potential, for causing cancer.

If adequate information about the level of exposure, frequency of exposure, and length of exposure to a particular carcinogen is available, an estimate of excess cancer risk associated with the exposure can be calculated using the slope factor for that carcinogen. Specifically, to obtain risk estimates, the estimated chronic exposure dose (which is averaged over a lifetime or 70 years) is multiplied by the slope factor for that carcinogen.

Cancer risk is the likelihood, or chance, of getting cancer. We say "excess cancer risk" because we have a "background risk" of about one in four chances of getting cancer. In other words, in a million people, it is expected that 250,000 individuals would get cancer from a variety of causes. If we say that there is a "one in a million" excess cancer risk from a given exposure to a contaminant, we mean that if one million people are exposed to a carcinogen at a certain concentration over their lifetime, then one cancer above the background chance, or the 250,000th cancer, may appear in those million persons from that particular exposure. In order to take into account the uncertainties in the science, the risk numbers used are plausible upper limits of the actual risk based on conservative assumptions. In actuality, the risk is probably somewhat lower than calculated, and in fact may be zero.

Concern
A belief or worry that chemicals in the environment might cause harm to people.

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

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

population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

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 Statistics Review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Incidence
The number of new cases of disease in a defined population over a specific time period.

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

Population
A group of people living in a certain area or the number of people in a certain area.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases.

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

Source (of Contamination)
The place from which a chemical comes, such as a landfill, pond, creek, incinerator, tank, or drum.

Toxic
Harmful. Any substance or chemical can be toxic at a certain dose (amount).

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

Appendix B—Standardized Incidence Ratio

The standardized incidence ratio (SIR) is a measure that compares the incidence rate of disease in two populations. In this health statistics review, SIR compares, for the time period 1986 through 1995, the number of people who were diagnosed with a type of cancer while residing in census tract 5334 and the number of people expected to be diagnosed with cancer if the incidence rate of cancer in the census tract 5334 population was the same as the incidence rate in the U.S. population. SIR was calculated to account for ways in which census tract 5334 and U.S. populations differ in terms of age and sex. SIR is calculated in two steps.

Step 1

The expected number is calculated by 1) multiplying the incidence rate in various age and sex groups in the U.S. population by the number of people in those age and sex groups in the census tract 5334 population; then 2) summing the products to obtain the total number of expected cases in the census tract 5334 population.

Step 2

SIR is calculated by dividing the actual number of people who were diagnosed with cancer by the expected number.

These steps are demonstrated at right for all types of cancer.

	U.S. Incidence Rate, All Cancers 1986-1995		Number of People in Census Tract 5334 1986-1995		Number Expected of Cases in Census Tract 5334
STEP 1					
Females					
0 to 4	0.000188	X	7,440	=	1.4
5 to 9	0.000097	X	5,880	=	0.6
10 to 14	0.000116	X	5,310	=	0.6
15 to 19	0.000205	X	5,380	=	1.1
20 to 24	0.000351	X	6,060	=	2.1
25 to 29	0.000605	X	5,870	=	3.6
30 to 34	0.000948	X	5,150	=	4.9
35 to 39	0.001601	X	4,360	=	7.0
40 to 44	0.002631	X	3,420	=	9.0
45 to 49	0.004182	X	2,390	=	10.0
50 to 54	0.005868	X	1,720	=	10.1
55 to 59	0.008014	X	1,620	=	13.0
60 to 64	0.010734	X	1,360	=	14.6
65 to 69	0.013577	X	1,190	=	16.2
70 to 74	0.016334	X	740	=	12.1
75 to 79	0.018378	X	800	=	14.7
80 to 84	0.019683	X	610	=	12.0
85 and up	0.019640	X	770	=	15.1
Males					
0 to 4	0.000216	X	7,540	=	1.6
5 to 9	0.000123	X	6,160	=	0.8
10 to 14	0.000124	X	5,550	=	0.7
15 to 19	0.000210	X	6,700	=	1.4
20 to 24	0.000333	X	8,270	=	2.8
25 to 29	0.000573	X	7,200	=	4.1
30 to 34	0.000871	X	5,830	=	5.1
35 to 39	0.001191	X	4,380	=	5.2
40 to 44	0.001630	X	3,470	=	5.7
45 to 49	0.002697	X	2,310	=	6.2
50 to 54	0.004991	X	1,570	=	7.8
55 to 59	0.008856	X	1,300	=	11.5
60 to 64	0.014763	X	1,060	=	15.6
65 to 69	0.022620	X	830	=	18.8
70 to 74	0.030244	X	650	=	19.7
75 to 79	0.035267	X	420	=	14.8
80 to 84	0.038441	X	320	=	12.3
85 and up	0.037822	X	180	=	6.8
Total number of expected cases in census tract = 288.8					
STEP 2					
$SIR = \frac{157}{288.8} = 0.54$					

Appendix C—Standardized Rate Ratio

The standardized rate ratio (SRR) is a measure that compares the incidence rate or the mortality rate for a disease in two populations. For the cancer statistics review, SRR compares the number of people in the United States who were diagnosed with a type of cancer, and the number of people expected to be diagnosed if the incidence rate in the U.S. population was the same as the incidence rate in the census tract 5334 population. For the mortality statistics review, SRR compares the number of people in the United States who died from a disease and the number of people expected to die if the mortality rate in the U.S. population was the same as the mortality rate in the ZIP Code 90270 population.

SRR is calculated in a manner that accounts for ways in which the study populations and the U.S. population differ in terms of age and sex. SRR is calculated in two steps.

Step 1

The expected number of cases or deaths in the U.S. population is calculated by 1) multiplying the incidence or mortality rate in various age and sex groups in the study population by the number of people in those age and sex groups in the U.S. population, then 2) summing the products to obtain the total number of expected cases or deaths in the U.S. population.

Step 2

SRR is calculated by dividing the expected number of cases or deaths (calculated in step 1) by the actual number of cases or deaths that occurred.

These steps are demonstrated at right for the mortality rate of all types of cancer.

	ZIP Code 90270 Mortality Rate, All Cancers 1989-1998		Number of People in the United States 1989-1998		Number of Expected Deaths in the United States 1989-1998
STEP 1					
Females					
0 to 4	0.000000	X	93,966,244	=	0.0
5 to 9	0.000000	X	91,867,322	=	0.0
10 to 14	0.000000	X	89,304,231	=	0.0
15 to 19	0.000000	X	87,811,833	=	0.0
20 to 24	0.000138	X	90,427,466	=	12,464.2
25 to 29	0.000508	X	98,755,306	=	50,172.0
30 to 34	0.000000	X	108,681,120	=	0.0
35 to 39	0.000324	X	107,902,167	=	34,995.3
40 to 44	0.000720	X	98,780,341	=	71,167.4
45 to 49	0.000372	X	82,737,629	=	30,757.5
50 to 54	0.000667	X	67,120,643	=	44,747.1
55 to 59	0.002023	X	57,368,622	=	116,063.7
60 to 64	0.002888	X	54,716,238	=	158,025.2
65 to 69	0.002146	X	54,396,949	=	116,731.7
70 to 74	0.007955	X	48,337,651	=	384,504.0
75 to 79	0.005036	X	39,220,867	=	197,515.2
80 to 84	0.005714	X	27,563,804	=	157,507.5
85 and up	0.008397	X	24,880,271	=	208,918.3
Males					
0 to 4	0.000000	X	98,444,382	=	0.0
5 to 9	0.000075	X	96,375,416	=	7,213.7
10 to 14	0.000076	X	93,779,769	=	7,088.4
15 to 19	0.000000	X	92,727,275	=	0.0
20 to 24	0.000000	X	93,916,511	=	0.0
25 to 29	0.000000	X	99,300,884	=	0.0
30 to 34	0.000000	X	107,836,073	=	0.0
35 to 39	0.000382	X	106,638,555	=	40,779.6
40 to 44	0.000515	X	96,528,396	=	49,692.9
45 to 49	0.001035	X	79,706,353	=	82,511.8
50 to 54	0.001253	X	63,474,519	=	79,542.0
55 to 59	0.003584	X	52,786,640	=	189,199.4
60 to 64	0.006569	X	48,333,937	=	317,522.2
65 to 69	0.004128	X	44,815,676	=	185,018.8
70 to 74	0.017857	X	36,773,021	=	656,661.1
75 to 79	0.022449	X	26,482,551	=	594,506.2
80 to 84	0.018421	X	15,345,068	=	282,672.3
85 and up	0.022727	X	9,774,311	=	222,143.4
Total number of expected deaths in US = 4,298,120.9					
STEP 2					
SRR = $\frac{4,298,120.9}{5,259,810}$ = 0.82					

Appendix D—Standardized Mortality Ratio

The standardized mortality ratio (SMR) is a measure that compares the mortality rate for a disease in two populations. In this health statistics review, SMR compares, for the time period 1989 through 1998, the number of people who died from a disease while residing in ZIP Code 90270 to the number of people expected to die, if the mortality rate for the disease in the ZIP Code 90270 population was the same as the mortality rate for the disease in the U.S. population.

SMR was calculated in a manner that accounts for ways in which the ZIP Code 90270 and U.S. populations differ in terms of age and sex. SMR is calculated in two steps.

Step 1

The expected number of deaths is calculated by 1) multiplying the mortality rate in various age and sex groups in the U.S. population by the number of people in those age and sex groups in the ZIP Code 90270 population; then 2) summing the products to obtain the total number of expected deaths in the ZIP Code 90270 population.

Step 2

SMR is calculated by dividing the actual number of deaths that occurred by the expected number (calculated in step 1).

These steps are demonstrated at right for death from all types of cancer.

	U.S. Mortality Rate, All Cancers 1989-1998		Number of People in ZIP Code 90270 1989-1998		Number of Expected Deaths in ZIP Code 90270
STEP 1					
Females					
0 to 4	0.000027	X	16,140	=	0.4
5 to 9	0.000026	X	15,510	=	0.4
10 to 14	0.000024	X	11,450	=	0.3
15 to 19	0.000033	X	12,890	=	0.4
20 to 24	0.000045	X	14,510	=	0.7
25 to 29	0.000082	X	11,810	=	1.0
30 to 34	0.000162	X	13,580	=	2.2
35 to 39	0.000319	X	9,250	=	2.9
40 to 44	0.000591	X	6,940	=	4.1
45 to 49	0.001075	X	5,380	=	5.8
50 to 54	0.001851	X	4,500	=	8.3
55 to 59	0.002916	X	3,460	=	10.1
60 to 64	0.004336	X	2,770	=	12.0
65 to 69	0.005933	X	2,330	=	13.8
70 to 74	0.007832	X	880	=	6.9
75 to 79	0.009567	X	1,390	=	13.3
80 to 84	0.011546	X	1,050	=	12.1
85 and up	0.014049	X	1,310	=	18.4
Males					
0 to 4	0.000031	X	16,920	=	0.5
5 to 9	0.000032	X	13,360	=	0.4
10 to 14	0.000032	X	13,230	=	0.4
15 to 19	0.000047	X	14,380	=	0.7
20 to 24	0.000064	X	19,970	=	1.3
25 to 29	0.000090	X	15,870	=	1.4
30 to 34	0.000145	X	14,190	=	2.1
35 to 39	0.000252	X	10,460	=	2.6
40 to 44	0.000498	X	7,770	=	3.9
45 to 49	0.001033	X	4,830	=	5.0
50 to 54	0.002057	X	3,990	=	8.2
55 to 59	0.003744	X	2,790	=	10.4
60 to 64	0.006262	X	1,370	=	8.6
65 to 69	0.009319	X	2,180	=	20.3
70 to 74	0.012953	X	840	=	10.9
75 to 79	0.016628	X	490	=	8.1
80 to 84	0.021582	X	380	=	8.2
85 and up	0.027371	X	440	=	12.0
Total number of expected deaths = 218.3					
STEP 2					
SMR = $\frac{163}{218.3}$ = 0.75					