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ADMINISTRATIVE RECORD

LIBBY ASBESTOS SITE RESIDENTIAL/COMMERCIAL CLEANUP ACTION LEVEL AND CLEARANCE CRITERIA

TECHNICAL MEMORANDUM

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I. INTRODUCTION

In 2002, the U.S. Environmental Protection Agency Region 8 (EPA) began systematic investigation and emergency response cleanup of residential and commercial properties in Libby, Montana. The Action Memorandum Amendment dated May 8, 2002 ("the Action Memo") set forth general requirements and reasons for the emergency response cleanup (EPA 2002).

This document provides specific information about "action levels" that will be used for determining which properties or situations require an emergency response cleanup. It also provides specific information regarding "clearance criteria" that will be used to determine when such a cleanup is complete. The Appendix presents screening-level risk calculations that EPA has developed to help characterize the relationship between asbestos levels in site media and the resultant levels of health risk to residents. Although these relationships are uncertain and difficult to quantify, the calculations provide a frame of reference that helps guide decision-making at the site.

In this memorandum, the term "cleanup" is used generally to imply some type of response action and does not necessarily imply removal of contaminated material. In some instances, EPA's response action will be isolation or encapsulation of contaminated material. In some cases, where contaminated material is difficult to access or well-contained, and exposure is likely to occur very infrequently or not at all, the material may be managed in place. Details of EPA's cleanup approach can be found in the Response Action Work Plan (CDM 2003a).

II. REGULATORY PROCESS CONSIDERATIONS

EPA is currently conducting emergency response removal actions in Libby. This document sets forth action levels and clearance criteria that are applicable to these emergency response actions only. While the emergency response continues, EPA is also conducting a Remedial Investigation/Feasibility Study (RI/FS). The RI/FS will conclude with the development of a proposed plan, extensive opportunities for public comment, and publication of Record of Decision (ROD) that will set forth final action levels and cleanup decisions for Remedial Actions at Libby. Until a ROD is published, it is expected that this memorandum will guide decision-making for emergency response cleanup actions at residential and commercial properties in

Libby.

The RI/FS for Libby residential and commercial properties began in 2002. The first phase of the RI was called the Contaminant Screening Study (CSS). The CSS was a screening step intended to collect readily available information (through inspections, verbal interviews, and soil sampling) to be used in decision-making for each property. The objective was to classify properties as either (1) requiring emergency response cleanup, (2) requiring more investigation before a decision can be made, or (3) likely requiring no further action. The criteria in this memorandum, along with other information, are being used to interpret the results of the CSS and in planning for additional sampling and cleanup. Preliminary results of the CSS (soil sample results are not yet available) are found in the CSS Draft Final Technical Memorandum (CDM 2003b). The Technical Memorandum will be updated and expanded when soil sample results are available. As of this writing, more than 1200 properties have been identified that likely require cleanup. The RI/FS is expected to be complete in approximately 2005 at which time the total number of properties requiring cleanup will be known.

Again, final site-specific cleanup standards will be established upon completion of the RI/FS and publication of a ROD. Similarly, the site-specific decision-making approach, action levels, and clearance criteria set forth here may be changed upon receipt of new information. This has two important implications. First, some properties will not meet *any* of the criteria for emergency response, but may meet lower or different criteria that are established in the future. In such an instance, these properties would be addressed later. Second, it is possible that properties that are earmarked for cleanup based upon the criteria set forth here may not require cleanup if different criteria are established in the future.

III. SAMPLING APPROACH

Throughout this memorandum, there are general references to sampling and analysis methods. A detailed discussion of the many sampling approaches, analysis methods, counting methods, sample preparation methods, and quality assurance steps is beyond the scope of this document.

- Details of EPA's dust sampling and analysis protocol for various situations can be found in the Indoor Dust Sampling and Analysis Plan (EPA 2003).
- Details of EPA's air sampling and analysis protocol for various situations can be found in the Response Action Work Plan (CDM 2003a).
- Detail s of EPA's soil sampling strategy for various situations can be found in the
    - CSS Sampling and Analysis Plan (SAP) (CDM 2002)
    - CSS SAP Revision I (CDM 2003b)
    - Remedial Investigation SAP (CDM 2003c)
    - Response Action Work Plan (CDM 2003a)

It is also important to note that EPA's sampling and cleanup program is based solely upon the presence of "Libby asbestos." Libby asbestos (LA) is a form of amphibole asbestos unique to the Libby vermiculite deposit and is fundamentally different from more commonly found chrysotile asbestos. Chrysotile asbestos was used in commercial products for decades and is found throughout the environment of the U.S. and the world. EPA will not base cleanup decisions or take action based upon the presence of chrysotile asbestos not associated with the Libby mine, except where necessary to protect worker safety or where it may present an imminent and substantial endangerment.

IV. CLEANUP APPROACH AND DECISIONS REQUIRED FOR EACH PROPERTY

To date, much of EPA's investigation and cleanup approach has been geared toward finding and addressing *sources* of LA. The major sources in the area, such as the mine, the screening and export plants, and large vermiculite piles, have already been isolated or cleaned up. Remaining sources at residential/commercial properties generally include (but aren't necessarily limited to) vermiculite insulation or soils with elevated levels of LA. Sources, through a variety of mechanisms, can serve to contaminate indoor dust and have the potential to release significant amounts of LA when disturbed. Source removal or isolation ensures that loading to indoor dust (one of the most significant exposure pathways over a lifetime) is minimized immediately. With respect to this, each property in Libby generally requires three independent decisions regarding cleanup:

- Cleanup of the attic or interior walls (ATTICS/WALLS)
- Cleanup of indoor living space (INTERIORS)
- Cleanup of outdoor soils (SOILS)

Contamination in one area or bulk source does not automatically imply contamination in another. For instance, a particular property may require cleanup of an attic but not the interior or outdoor soils. Some properties may require cleanup in the attic, interior, and soils. Any combination is possible depending upon the unique conditions of each property.

EPA's cleanup approach considers not only the presence of source materials and the concentration of LA within them, but also the likelihood that these source materials may be disturbed. Based upon this approach, some source materials that are less likely to be disturbed may be left in place (such as in walls, below hard surfaces, and at depth). In some situations, EPA may remove or further isolate such materials to prevent even infrequent exposures, depending on the situation.

For those properties requiring emergency response cleanup, EPA is adopting cleanup procedures and criteria that will that help ensure we conduct only one cleanup action at individual

properties, even if action levels are lowered or changed in the future. It is obviously inconvenient, impractical, and costly to clean a property twice. This approach is cost effective and protective.

V. ACTION LEVELS

Any one of the following conditions will generally trigger emergency response cleanup for that portion of the property.

ATTICS/WALLS

- Visual confirmation of open, non-contained, or migrating vermiculite insulation

INTERIORS

- Visual confirmation of vermiculite in the indoor living space
- Concentration of LA in an indoor dust sample greater than 5,000 Libby asbestos (LA) structures per square centimeter (s/cm2) using AHERA counting methods. This will be referred to as 5,000 AHERA s/cm2.

Each level, or floor, of a building is evaluated and sampled separately. At least two samples are collected from each floor. Libby sampling data has shown that in many cases, only one floor is highly impacted (e.g. material tracked in from outside on the ground floor). This sampling and cleanup approach allows us to focus cleanup resources on the portion of the interior where the greatest problem exists.

SOILS

- Visual confirmation of vermiculite or other vermiculite mine related materials in "specific use areas." A specific use area is defined as a garden, former garden, planter, or other defined area of a yard likely to receive significant use and generally not covered with grass.
- Concentration of LA in specific use areas or other yard soils by any analytical method greater than or equal to 1% Libby asbestos.

VI. ACTION LEVEL RATIONALE AND DISCUSSION

ATTICS/WALLS

Based upon available information, EPA has determined that vermiculite insulation found in Libby is a potential source for current and ongoing exposures to LA. Past sampling by EPA in Libby has clearly shown that while LA concentrations in bulk vermiculite insulation may vary considerably (presumably even within the same home), all or most vermiculite insulation has the ability to release LA when disturbed and that disturbance can lead to excessive risk (EPA 2001). Given the collective magnitude of exposures in Libby, EPA has determined that visual confirmation of open, non-contained, or migrating vermiculite insulation is sufficient justification for emergency response cleanup. Cleanup is not contingent upon other factors or information such as the concentration of LA in bulk insulation, volume of insulation, condition of the building, or LA dust levels in the building, but such factors may be considered when determining how quickly EPA responds and how extensive the cleanup will be.

INTERIORS

Exposure to contaminated indoor dust, even dust with a relatively low level of LA, is an important exposure pathway. This is because people spend most of their lives in their homes and exposure occurs continually. However, indoor dust is a *secondary* medium - it can only become contaminated through disturbance of some other source of LA. Such sources may include , but are not limited to, vermiculite insulation, on-property soils, off-property soils, or past vermiculite processing operations. Again, the most important step to break this pathway is to address the sources that are contaminating indoor dust or have the potential to contaminate indoor dust in the future. In Libby, EPA is not relying upon measured dust levels to decide if residential/commercial sources must be addressed. Our approach is to find and address sources with the potential to contaminate indoor dust regardless of current indoor dust levels. In this regard, indoor dust action levels should not be considered triggers for overall cleanup, but only a trigger for aggressive interior cleaning by EPA. This approach ensures that situations that may present a short-term exposure hazard are addressed as quickly as possible.

EPA has established two key "action levels" relating to interior cleanup: presence of visible vermiculite in the indoor living space and indoor dust samples that contain greater than 5,000 AHERA s/cm2. During the CSS, EPA is visually inspecting interiors for the presence of visible vermiculite, such as insulation that has migrated into the living space from the attic or walls. If vermiculite is observed on a particular level, even in small amounts, cleanup of that entire level is triggered and no dust samples are collected on that level. If vermiculite is not observed on a particular level of a building, dust samples are collected on that level to determine if cleanup is necessary.

Visible Vermiculite

Using visual observation of uncontrolled vermiculite material as a trigger for an emergency cleanup action is conservative, protective, and cost effective. This approach ensures that primary source materials are removed, as well as any associated contamination. It addresses resident concerns regarding vermiculite in the living space. This approach also reduces the costs associated with routine sampling and analysis of interiors.

Indoor Dust Samples

Dust samples will be collected for those structures or levels of structures not containing visible vermiculite to determine if cleanup of those structures or levels is necessary. Unfortunately, establishing action levels based upon indoor dust levels is not straightforward. There are two primary reasons for this:

- Unlike air samples, there are no established regulatory or health-based standards to guide the determinations of acceptable concentrations of asbestos in indoor dust.

- The relationship between the concentration of asbestos in dust and the resultant concentration in air (the medium that actually determines human exposure and risk) is highly variable. This is because the relationship depends on a long list of different factors, most important of which is the nature and frequency of dust disturbance. This means that it is difficult to calculate a value in dust that corresponds to an acceptable level in air, and it is even harder to try to select a level in dust based on site-specific measurements. This difficulty is discussed more in the Appendix.

Given these difficulties, EPA has developed an interim site-specific action level of 5,000 AHERA s/cm2 for interior cleaning. In choosing this value, EPA considered several factors:

- Screening level risk estimates for exposure to indoor dust presented in the Appendix indicate that if a resident were exposed to 5,000 AHERA s/cm2 in dust throughout the home for 70 years, the risk of cancer would likely be in the range of 1 in 100 to 1 in 1,000, much higher than the level of 1 in 10,000 level that EPA usually considers to be the limit of acceptable risk. Although these calculations are screening-level and uncertain (see the discussion in the Appendix), and even though it is expected that the levels in dust will decline after source removal is complete, it is still clear that dust levels this high constitute a potential risk that warrants aggressive interior cleaning to ensure protectiveness and to stop even short-term exposures.

- Aggressive interior cleaning by EPA is costly and cleaning the interiors of all houses in Libby would be very expensive and significantly extend the cleanup duration. Therefore, a reasonable cutoff must be established below which such time-consuming and costly

cleanup can be omitted, so that available resources can be directed to source removal and the situations presenting the most risk. This does not mean that dust cleanup at levels below 5,000 AHERA s/cm2 is not appropriate, but only that less aggressive methods may need to be used. Providing each resident with a HEPA vacuum and encouraging frequent vacuuming and wet-wiping surfaces will be most effective. This will accelerate the process of decreasing dust loading levels and will achieve similar success to that of an EPA cleanup at a fraction of the cost and effort.

- Concentrations of 5,000 AHERA s/cm2 in dust appear to be on the lower end of the background levels of asbestos contaminated dusts observed in residences in other communities (see Appendix). While the types of asbestos fibers found in indoor dust in other communities is generally different from LA, this information provides some context regarding the dust concentrations of asbestos that people are being routinely exposed to in their homes and businesses in other areas. The health risks or consequences stemming solely from these routine dust-related asbestos exposures is unknown.

- Dust levels of 5,000 AHERA structures/cm2 can be readily detected using efficient sampling techniques. The sensitivity of the analytical methods EPA is using to quantify asbestos in dust vary based on several factors, but are typically on the order of 1,000 AHERA s/cm2. Detection of asbestos concentrations below this level in dust require more extensive analysis and are much more costly to achieve.

SOILS

EPA has established two key "action levels" relating to outdoor soil cleanup: presence of visible vermiculite or other vermiculite mine-related material in specific use areas and soil samples containing greater than or equal to 1% LA.

Visible Vermiculite

During the conduct of the CSS in 2002, EPA visually inspected many properties for vermiculite or vermiculite mine related materials (generally referred to just as vermiculite) in soils. If vermiculite was observed in a particular area (e.g. front yard, side yard, garden, etc), no soil sample was collected in that area. If vermiculite was not observed, a soil sample was collected from that area. Past observations showed that when visible vermiculite was noted, samples confirmed the presence of Libby asbestos approximately 70% of the time using polarized light microscopy (PLM) (CDM 2002). If more sensitive methods were used, this number may have been higher. Thus, the presence of visible vermiculite was considered a reasonably good indicator for the presence of LA and material that could serve as a potential source of LA to air or dust. Using visible vermiculite as a trigger for cleanup, rather than sampling every area that contained visible vermiculite, had the benefits of being conservative, protective, and simple.

This same general approach of using visual observations as a trigger for cleanup was also employed during the remediation of other large source areas in Libby, such as the screening plant, export plant, and flyway property. It will also be used for the remediation of the rail yard in Libby by Burlington Northern Santa Fe (BNSF Workplan 2002).

While conducting the CSS in 2002, EPA discovered three key points regarding visible vermiculite in soils:

- The number of properties with visible vermiculite in soils was far greater than originally anticipated.

- While there were exceptions to the trend, the amount of visible vermiculite varied considerably from a few flakes over a generally wide area to very concentrated amounts in small areas. The CSS, as originally planned, had no systematic way to account for this or differentiate it other than sampler observations.

- There were several instances where vermiculite was observed in areas that were difficult to access and where exposure was likely to occur infrequently, if at all. There are likely many more of these situations that were not discovered during the CSS that will become apparent through subsequent, more detailed investigations or during cleanup.

Because of these factors, EPA reevaluated the proposed initial approach to visible vermiculite in soils described in the CSS SAP (CDM 2002). Rather than assuming that all occurrences of visible vermiculite would result in cleanup, EPA decided to limit the emergency response cleanup of visible vermiculite to specific use areas that pose the most substantial opportunities for disturbance. There are several reasons for this:

- Vermiculite was generally used as a soil amendment in specific locations such as gardens.

- Specific use areas are more likely to lack ground cover, such as grass, that would minimize creation of dust.

- Specific use areas are likely to be actively and frequently disturbed through activities such as gardening.

- Specific use areas are generally small and can be cleaned up quickly at low cost. A large scale sampling program may not be justified for these situations, considering that for many of these situations (CSS SAP, CDM 2002) sampling will confirm the presence of LA. Cleaning up entire yards, large portions of yards, or areas that are infrequently accessed or disturbed is a much larger and expensive task and additional sampling is clearly warranted.

Soil Samples

Similar to indoor dust concentrations, establishing action levels based upon soil contamination levels is not straightforward. There are two primary reasons for this:

- Unlike air samples, there are no established regulatory or health-based standards to guide the determination of acceptable concentrations of asbestos in soil.

- It is extremely difficult to predict airborne asbestos exposures (which is the exposure of concern for health and regulatory standards) based upon the asbestos concentrations in outdoor soil samples. A variety of factors can influence the extent of airborne exposures associated with asbestos fibers in soil, the most important of which appears to be disturbance of contaminated soil by human activity. Other factors which may affect the suspension of asbestos fibers into the air, and thus airborne asbestos exposures, include the environmental conditions, moisture content of the soil, concentration of asbestos in the soil, the type of the soil, and the characteristics of the asbestos present.

Thus, development of the site-specific information necessary to accurately predict the risk between concentrations of asbestos in soil and airborne exposures and secondary contamination of indoor dust, if even possible, would require an extensive sampling effort that included numerous outdoor areas under various test conditions and scenarios. Such investigations would be extremely difficult, costly, and lengthy. Further, considering the magnitude of the cleanup in Libby, such an investigation would divert limited financial resources away from the essential work of cleaning up the worst exposures and conditions present today.

At this time, and in the absence of visible vermiculite in a specific use area, EPA has selected a concentration of 1% LA or greater as a site-specific action level for emergency response soil cleanup. When selecting this level, EPA considered several factors.

- Although there are no standards for acceptable concentrations of asbestos in soil, this standard was applied during previous emergency response cleanups in Libby.

- Screening-level risk estimates for exposures at a home with contaminated soil (presented in the Appendix) suggest that risk levels for a resident living for 70 years at a property with a level of 1% asbestos in the soils are on the order of 1 additional cancer expected per 1000 people. This is well above the risk level of 1 in 10,000 that EPA usually considers to be the upper limit of acceptable risk. Although the calculations are uncertain (see the discussion in the Appendix), these results support the conclusion that removal of soils that contain 1% or more asbestos is needed to protect public health.

- Inexpensive analytical methods currently available (e.g. PLM) can detect levels of 1% or greater with some confidence. Site-specific improvements in the use of PLM analysis at

Libby have led to much higher confidence in sampling results and the ability to detect and quantify asbestos levels in soils at 1% and even less than 1%. EPA is currently testing several methods to determine their ability to detect and quantify levels less than 1%.

It is important to note that EPA does not assert that soil concentration of less than 1% LA are necessarily safe or acceptable, and in certain circumstances, soils with less than 1% Libby asbestos may be remediated under the current emergency response program. Depending on the accessibility and frequency of exposure, EPA may elect to remove or isolate soils containing less than 1% LA. Similarly, if a portion of a property meets either emergency response action level for soils (i.e., visible vermiculite in specific use areas or LA greater than 1%), EPA will remediate all soils at the property with any detectable LA. This is primarily so that properties will not have to re-cleaned later if a lower action level is adopted. This is considered protective and cost effective. The approach, however, is to target properties where this is *not* the case first. Soils that meet the emergency response action levels take priority whenever possible. This is also consistent with previous cleanups in Libby.

VII. CLEARANCE CRITERIA

Cleanup of a portion of a property is considered complete and the property "clean" when all of the following site-specific criteria are met.

ATTICS/WALLS

- No uncontrolled visible vermiculite remaining in accessible areas
- Any vermiculite remaining is well-contained
- The *average* of approximately 5 samples of disturbed air collected in the attic indicate less than .01 AHERA structures per cubic centimeter of air (AHERA s/cm3).

INTERIORS

- No visible vermiculite remaining in accessible areas or living space
- No LA structures are detected in *any* of approximately 5 samples of disturbed air on the level(s) or floor(s), indicating disturbed air concentrations are generally less than .001 AHERA s/cm3.

SOILS

- No substantial visible vermiculite or waste material remains within the area of excavation
- In excavated areas, soil samples collected at the depth of cut are non-detect for LA by PLM. If maximum depth of cut is reached (12 inches for yards, 18 inches for specific use

areas), soil samples collected at the bottom of excavation must be less than 1% LA by PLM. Clean backfill is then placed over the excavation. This approach ensures that no detectable LA (by PLM) remains to a depth of 12-18 inches, but allows small amounts of LA to remain well below ground surface, where soil is unlikely to be disturbed. More information on the clearance sampling approach for soils is found in the Response Action Work Plan (CDM 2003a).

If these criteria are not met, re-cleaning, additional excavation, or other steps may occur, and the process is repeated. If any situations occur where clearance criteria cannot be met, unique approaches may be considered.

VIII. CLEARANCE CRITERIA RATIONALE AND DISCUSSION

ATTICS and INTERIORS

Attics and interior living spaces are both cleared using an approach based generally upon procedures outlined in the Asbestos Hazard Emergency Response Act (AHERA), but with different final numerical standards to account for the different amount of exposure likely for each. Once physical cleanup is complete, and visual inspection shows that all vermiculite is removed or contained, each individual space (e.g. the attic or particular floor of the home) is blown with a 1 horsepower leaf blower for several minutes. The action of walking through the living space and aggressively blowing dust from all surfaces, effectively simulates a high-end exposure. Following this action, fans are set up in the space to keep the air circulating, and air samples are collected.

EPA considered the use of settled dust samples for a clearance criteria, rather than aggressive air sampling. However, because the property was just cleaned, a settled dust sample would likely not be representative and is not as directly correlated with risk estimates as air concentrations. The use of aggressive air sampling is also feasible in this situation because the resident is already relocated and a controlled environment is present.

When EPA selected these site-specific clearance criteria, we considered several factors:

- Sampling occurs after the source is removed and is conducted after the dust throughout the space is aggressively disturbed. These conditions will not simulate normal living conditions suspected in the future, but rather approach worst-case conditions. The primary intent of the all clearance sampling is to ensure that sources were effectively addressed, not to demonstrate an expected long-term exposure level.

- Requiring a non-detect for *each* of five samples in the living space, as opposed to calculating the *average* of the five samples, increases the protectiveness of the cleanup in

the interior living space. Under this scenario, the absolute maximum concentration in any one sample that is possible is less than .005 AHERA s/cm2, but average exposure concentrations across the living space are effectively less than 1/5 the detection limit of a single sample, or less than .001 AHERA s/cm3.

- Screening-level risk estimates for exposures to asbestos-contaminated air presented and discussed in the Appendix suggest that risk levels for someone exposed *continually* to an air concentration of 0.001 AHERA s/cm3 for 70 years are on the order of 1 additional cancer expected per 10,000 people. EPA generally only takes action if risk estimates exceed a level of 1 additional cancer per 10,000 people. Although the risk calculations are uncertain (see the discussion in the Appendix), the results support the conclusion that the clearance level is protective of human health, especially because the long-term average concentration in air is likely to be lower than that measured following active disturbance.

- Because exposure in attics is likely to occur far less frequently than in main living spaces, higher numerical standards are applied and a mean concentration is used. The clearance criteria for interior living space in Libby are currently about 5-10 times more stringent.

- EPA understands that attainment of the chosen indoor clearance criteria will not necessarily indicate complete removal of all interior LA contamination. It is anticipated that if primary sources of contamination are remediated, then settled dust levels will decline over time. To help ensure that these levels do, in fact, decline, EPA will provide a HEPA vacuum to property owners of all properties that EPA has cleaned. EPA will also provide HEPA vacuums to other property owners whose properties are below the action level and have not been cleaned. Details of the scope of the HEPA vacuum program are found in HEPA Vacuum Program Fact Sheet (EPA 2003b). Furthermore, post-cleanup sampling is being planned to ensure that indoor dust levels remain low or decline as expected. This is discussed more in the final section of this memorandum.

SOILS

Soils requiring cleanup are cleared using an step-by-step approach. Limited excavation of the defined area occurs until no visible vermiculite is observed, or until the native soil horizon is reached. At this point, a representative number of soil samples are collected dependent upon the size of the excavation. If these samples are non-detect by PLM, the excavation is considered complete and the area is backfilled with clean soil. If LA is detected by PLM, excavation continues until the maximum depth of excavation is reached (12 inches for general yard areas, 18 inches for specific use areas). At this point, excavation would only proceed further (generally to a maximum of three feet regardless of contaminant levels) if gross contamination is observed or PLM samples indicate higher levels of LA (e.g. greater than 1%).

When establishing this approach, EPA considered the following factors:

- Nearly all exposure comes from near-surface soils. These soils generate dust and are often actively disturbed. In most circumstances, contamination is also limited to near surface soils. To ensure resources are focused on the soils that are most likely to result in human exposures, a maximum depth of excavation was established at 12-18 inches. These depths are based on based on the depth that typical residential activities may intrude into the soil (such as planting, rototilling, or installation of sprinklers). Below this depth, disturbance and exposure will occur very infrequently if at all.

- It is important to distinguish that at least two variations of PLM analysis are being used in the Libby residential/commercial investigation and cleanup. A site-specific PLM method, which involves off-site preparation of the sample, is currently being used to analyze surface soil samples (where frequent, ongoing exposure and dust generation occurs). This analysis is used to determine which specific areas require cleanup. Other methods of soil sample analysis are also being considered for these samples. All of these methods are intended to provide lower detection limits than "standard" PLM, which has traditionally been used for analysis of asbestos in bulk materials. However, "standard" PLM, by NIOSH Method 9002, was selected as the analytical method for clearance testing of soils at depth because of it's ability to recognize soils that exceed 1% LA, and because PLM can be performed on-site with a short turn-around time. This allows real time decisions to be made about whether further excavation is needed, and allows the excavation to be closed as soon as possible. Use of alternative analytical methods that might have lower detection limits than PLM are not feasible because they require off-site analysis and results may not be available for days or weeks. Leaving an excavation open for this time is hazardous and very cost inefficient.

IX. FUTURE ACTIONS AND FOLLOW UP

Based on the information available, EPA has developed an emergency response cleanup program that:

- focuses on elimination of exposures that are likely to occur frequently and continually over time;
- removes nearly all identified LA sources, focusing on sources that are most likely to be disturbed;
- isolates sources that are impractical to remove;
- addresses the highest exposures in the quickest manner possible;
- leaves low residual levels of LA and minimizes the likelihood of future re-cleaning;
- considers the many uncertainties regarding asbestos analysis and risk assessment that suggest risks could be higher than anticipated and employs strategies (from sample

collection to cleanup) to help compensate for these;
- reduces future management needs; and
- is protective, cost-effective, and implementable.

EPA recognizes the program does not completely eliminate all potential exposure to LA in Libby. In fact, such a program is impossible to fund or implement. Because of this, future management and review will be required to ensure the long-term protectiveness of the remedy. Nearly all cleanups require some level of long-term management. At Libby, EPA is already taking several steps to address this issue:

- EPA is providing HEPA vacuums and interior cleaning guidance to residents so they can immediately, and continually, address low levels of residual contamination and any particulate contamination that may be reintroduced into their homes. Guidance on additional steps to take to minimize the potential for exposure to residual asbestos and to increase their confidence in the safety of their home or business will be included in a package of information that residents and business owners receive after cleanup of their property.

- EPA, in conjunction with the Montana Department of Environmental Quality and local government, will develop a long-term operations and maintenance (O&M) plan to deal with future management issues. Key points of this plan will likely include ongoing education, guidance for residents encountering or working with vermiculite in the future, and a management system for any necessary removals of vermiculite including cleanup assistance and disposal procedures at the Lincoln County landfill.

- Most importantly, as part of the Remedial Investigation, EPA will institute a monitoring program for properties that were cleaned up. Not all properties will be visited, but a sufficient number to draw statistical conclusions will be sampled. This monitoring will measure actual dust and air levels, allowing EPA to (1) determine the efficacy of the cleanups after some time has passed, (2) test assumptions that affect the cleanup approach (e.g. Have dust levels declined? Have textiles and carpets that were not removed affected ambient conditions? Have heating and ventilation systems reintroduced contamination?), and (3) provide actual exposure data for use in the baseline risk assessment for the site. Based upon the results of this sampling, it is possible that the cleanup approach and/or criteria may be modified. EPA will also continue to implement other sampling programs to help aid in understanding of Site conditions.

- Using the best information available, a baseline risk assessment will be completed for the site. Using this and other information, final cleanup levels will be established. These will be compared to the measured residual levels at properties where cleanup has occurred, and levels at properties that did not meet the criteria for cleanup, to ensure that all necessary cleanup occurs and that final conditions are protective. The final decisions

and actions for the Libby cleanup will undergo extensive public review and comment.

X. POTENTIAL QUESTIONS AND ANSWERS

Question: How do Libby indoor air clearance levels compare to existing regulatory standards?

The current standard for worker protection, the Permissable Exposure Limit (PEL), established by the Occupational Safety and Health Administration (OSHA), is no greater than 0.1 Phase Contrast Microscopy Equivalent (PCME) s/cm3 for an eight hour exposure. While few consider this level protective, and OSHA clearly states that it is *not* intended to be fully protective, it nonetheless is a current standard which governs worker exposure. The clearance standard for Libby interior cleanings, after accounting for differences in counting rules (AHERA vs PCM), and for differences in assumed exposure frequency and duration, is equivalent to approximately 1/50 this amount. This means that Libby clearance levels are much more protective.

Without going into the details of the Asbestos Hazard and Emergency Response Act (AHERA) clearance protocol for schools, it can be generalized to say the clearance standard for asbestos removals is 70 AHERA structures per square millimeter (s/mm2) on the sample filter. This generally corresponds to an airborne concentration of about 0.02 s/cc. This standard is compared against the *average* of multiple samples, whereas in Libby interiors we compare each of approximately five samples to our clearance standard. Thus, EPA's effective clearance criteria at Libby (less than 0.001 AHERA s/cm3) is approximately 20-fold lower than the AHERA standard. Again, Libby clearance levels are more protective.

Question: How will indoor air in Libby compare to other locations across the country?

This is hard to say, but it is safe to say that asbestos (mainly chrysotile asbestos) is present in the air and dust nearly all countries, specifically in urban environments. This is due to its widespread use for decades and the fact that it is a naturally occurring mineral. While there is no single widely acknowledged "background" level of asbestos, several studies have shown asbestos levels (mainly chrysotile) in urban or industrial environments on the order of 0.01 s/cm3 or higher (Murchio, 1973; John et al, 1976; Chatfield, 1983). This is approximately ten times the clearance level for Libby. This does not imply these levels are safe or acceptable, but it does illustrate that all urban areas, and many rural homes with asbestos containing construction materials, are impacted by asbestos to some degree due to its widespread use over time.

Data on the levels of amphibole asbestos in other locations around the US are limited, but it is important to recall that products from the Libby vermiculite mine, including vermiculite insulation, were shipped and used in many, many homes across the county. At this point, it is unclear what, if any, cleanup will occur at these homes. At this point, Libby is the only place in

country where vermiculite insulation is being systematically removed from attics.

In the recent cleanup of the apartments around the former World Trade Center, EPA used similar techniques for air clearance sampling. While the details of the sampling and analysis are beyond the scope of this memo and the cleanup situation is somewhat different, it is safe to say that the numerical air clearance criteria used at the WTC cleanup is very similar to the criteria we are using at Libby.

Question: A concentration of 0.001 s/cm3 in air seems like a very low number, but 5,000 s/cm2 in dust seems very high. Why is there such a difference?

The main reason is related to the fact that only a small fraction of dust finds its way into air at any given time - perhaps about 0.1%. If 0.1% of dust that contains 5000 s/cm2 becomes distributed in the air of a room, the concentration in air would be about 0.009 s/cc. Thus, even though the numbers are very different, the risk they represent is similar. This is discussed in more detail in the Appendix.

Question: I thought asbestos-containing materials had to contain greater than 1% asbestos to be a problem. Why are you cleaning up soils and insulation with less than 1% asbestos?

A level of 1% asbestos is a regulatory standard that generally applies to asbestos containing commercial products such as brake pads, pipe wrap, and construction materials. The history of this regulatory standard is too long to discuss here, but the standard is not risk-based and does not apply to all situations In Libby, we have based our decisions for soil action levels and clearance criteria on site-specific risk calculations that show soils below 1% may still present risks that are higher than EPA generally considers acceptable.

Question: Why is EPA using AHERA analysis and counting rules for air/dust samples in Libby?

There are many ways to determine what constitutes an asbestos structure or fiber. Different analytical methods have different rules for determining what structures to count and what not to count. In Libby, we have analyzed such a large number of samples and counted so many asbestos fibers that we know what the general distribution of all fibers is. This enables us to convert sample results among different counting methods, no matter what method we used in the first place on a particular sample. We use AHERA for air and dust analysis because: (1) it is a standard method that can be performed by many labs, (2) it is economical, and (3) similar to the ISO 10312 Method, it counts short length fibers (e.g. fibers less than 5 microns in length). However, we can easily convert our AHERA sample results to PCME or ISO or otherwise. This is discussed in detail in the Appendix.

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Question: When you are done, you should be done. Why do you have to go back and revisit cleaned up properties to sample again?

EPA is making every effort to ensure that any cleanup at a property will be sufficient that a return visit to that property will not be needed. However, because we are not sure what the final action levels will be for soil and dust, we cannot guarantee that we may not need to come back in a few cases. In addition, we are not yet certain that re-contamination from residual sources (dust in heating ducts, carpets, upholstery, etc) is not a problem. It is for this reason that we believe the only way to ensure the cleanup worked, and continues to work, is to revisit cleaned-up homes and sample after some time has passed, and compare the measured levels to final action levels. There is no better measure of potential exposure than testing homes over time while people live in them.

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APPENDIX

SCREENING LEVEL ESTIMATES OF EXPOSURE AND RISK FROM LIBBY AMPHIBOLE IN AIR, DUST, AND SOIL

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APPENDIX

SCREENING LEVEL ESTIMATES OF EXPOSURE AND RISK FROM LIBBY AMPHIBOLE IN AIR, DUST, AND SOIL

NOTE: All numeric values derived from the Libby database are based on data available at the time of document preparation and are subject to change pending updates or corrections to the database or revision of data selection procedures.

1.0 INTRODUCTION

This appendix is a description of the methods used by EPA to perform a screening-level evaluation of the potential risks of cancer to residents in Libby, MT, from inhalation exposures to amphibole asbestos fibers in air. For convenience, amphibole fibers of this type are referred to as Libby Amphiboles (LA). At present, quantitative methods are not available for estimating the level of non-cancer risks from asbestos exposures.

The methods used in this appendix to evaluate risks from asbestos in air are the same as those that have been used previously (Weis 2000, 2001a, 2001b), but take advantage of new information on concentration and particle size distribution derived from site-specific samples. In addition, the methods used here begin to assess the relationship between asbestos concentrations in various source media (indoor dust, outdoor soil) and potential health risks to residents for asbestos-related cancers. These assessments are intended to help provide a basis and frame-of-reference for establishing action levels and cleanup criteria for the ongoing emergency response actions in Libby. As additional information becomes available and as the cleanup progresses towards final remedial decisions, these approaches may be modified as appropriate, in consultation with the community, to ensure a safe and healthy environment.

2.0 BASIC APPROACH

Risk from asbestos is associated mainly with inhalation exposure of suspended asbestos fibers. Because asbestos fibers are heavier than air and settle out onto surfaces, they will not typically be found in air measurements unless they have been released from contaminated surfaces or source materials by a disturbance:

Disturbance
Source ----------> Air -----> Inhalation Exposure -----> Increased Risk of Lung Disease

The concentration of fibers that occur in air following disturbance of a source and the resultant level of human exposure and risk depend on a very wide variety of highly variable factors, including:

- the concentration of fibers in the source material
- the nature of the disturbance of the source
- the physical properties of the source
- the volume of air into which the fibers are released
- the air flow or ventilation rate in the area where fibers are released
- the particle size distribution of the released fibers
- the frequency and duration of the release
- the frequency and duration of human exposure in the area where release has occurred

Because of these many factors and the wide range of values that each may assume, our ability to predict risk to a resident based only on a measure of the concentration of fibers in the source material is very limited. For similar reasons, our ability to specify a concentration of fibers in the source material that is "safe" is also very limited. Nevertheless, even though there are many difficulties and uncertainties in attempting to predict the potential risks associated with asbestos contaminated surfaces and materials, we can apply available information to develop a useful construct and derive reasonable screening-level estimates of the "safe" concentration of asbestos in source materials. This process provides an important tool for risk managers to help determine which areas, sources, and situations require the most immediate attention for remediation.

3.0 RISKS FROM ASBESTOS FIBERS IN AIR

3.1 Inhalation Risk Models

At present, government agencies in the United States have not developed a standard method to estimate risks for asbestos-related non-cancer health endpoints such as asbestosis or pleural fibrosis. However, methods have been developed to estimate the risk of pulmonary cancer (lung cancer, mesothelioma) due to inhalation exposure to asbestos.

Data on the quantitative relationship between inhalation exposure to asbestos and increased risk of pulmonary cancer are derived mainly on studies of workers who have been exposed to various types and levels of asbestos in the workplace. Most of these studies estimated the concentration of asbestos

in air using phase contrast microscopy (PCM). In order for a particular asbestos structure[1] to be counted as a PCM fiber, the structure must have an aspect ratio (length divided by width) of at least 3:1, must have a length of 5 um or more, and must be thick enough to be detectable under PCM (about 0.25 um or more). The empiric relationship between excess lifetime cancer risk and airborne concentration of PCM fibers established by USEPA is expressed as follows:

$$\text{Excess Pulmonary Cancer Risk} = C_{air}\ (\text{PCM fibers/cc}) \cdot 0.23\ (\text{per PCM fiber/cc})$$

For example, if an individual were exposed to an airborne concentration of 0.001 PCM fibers/cc for a lifetime, the risk (probability) of that individual developing pulmonary cancer because of the asbestos exposure would be about 0.00023 (2.3E-04). Stated another way, if a total of 100,000 people were exposed to 0.001 PCM fibers/cc for a lifetime, about 23 extra cases of pulmonary cancer would be expected to occur in the group of 100,000.

Although the PCM-based risk model remains the current standard for estimating pulmonary cancer risk from asbestos (IRIS 2003), there are some technical issues associated with the approach. First, the PCM analysis method has a poor ability to distinguish asbestos fibers from non-asbestos fibers. This is unlikely to have been a major problem in most workplace studies because most of the airborne fibrous particles would likely have been asbestos, but may be a problem in the residential setting where many PCM fibers may not be asbestos (Weis 2001b). Second, most researchers believe that risk of cancer from inhalation of asbestos depends in large part on the size (length and width) and type (chrysotile, amphibole) of the asbestos, although the exact relationship is not yet clear. Thus, the empiric risk factors for cancer derived from workplace studies may not be appropriate for use at a location such as Libby if the asbestos fiber characteristics (fiber size distribution and mineral type) in Libby are substantially different than in the workplace studies.

Because of these issues, some researchers are working to develop new methods for predicting cancer risk from inhalation of asbestos. One of these efforts is being sponsored by the USEPA and is being performed by Berman and Crump (USEPA 1999). The method being developed by Berman and Crump explicitly takes mineral class (chrysotile, amphibole) and particle size (length, width) into account. Based on work completed to date, Berman and Crump have concluded that the concentration of long (>10 um) and thin (< 0.5 um) asbestos fibers is the primary determinant of

[1] Asbestos particles may occur in a variety of sizes and shapes. The word "structure" is used to refer to any asbestos particle, while the word "fiber" refers to asbestos structures that have a long and thin shape, usually defined as a aspect ratio (length divided by width) of 3 to 5 (depending on the counting rules).

cancer risk, with a smaller contribution from intermediate length (5-10 um) thin fibers. Because thin fibers may be difficult to measure by PCM, the Berman-Crump approach uses a more powerful technique (transmission electron microscopy, or TEM) as the preferred measurement technique. For convenience, structures observed in TEM that are longer than 10 um and thinner than 0.5 um are referred to as "Berman-Crump protocol structures-long" (BCPS-l), and structures observed in TEM that are 5-10 um long and thinner than 0.5 um are referred to as "Berman-Crump protocol structures-short" (BCPS-s). For lifetime exposure, the cancer risk factors for short and long protocol structures are shown below:

$$\text{Risk} = C_{air}(\text{BCPS-s}) \cdot 0.049 + C_{air}(\text{BCPS-l}) \cdot 15$$

3.2 Methods for Estimating PCM and BCPS Concentrations in Air

In order to estimate health risk from asbestos concentrations in air, estimates of airborne asbestos levels must have units of concentration that are consistent with the risk model selected for use (i.e., PCM fibers for the IRIS risk model, and BCPS for the Berman Crump risk model). Most samples of air analyzed at the Libby site have been analyzed using TEM and a set of counting rules specified by ISO-10312 (ISO 1995). In addition, a large number of samples have also been analyzed by TEM using a set of counting rules specified by AHERA (USEPA 1987). In both cases, all LA structures (including not only fibers but also bundles, clusters and matrices) greater than about 0.5 um in length and containing one or more elements with an aspect ratio of about 3:1 or higher have been recorded so that the raw data are available to characterize the complete LA particle size distribution in air and dust samples.

For ISO 10312, data are available for over 6200 individual structures[2]. The distributions of length, width, and aspect ratio are shown in Figure 3-1. The availability of these data makes it possible to calculate the fraction of all LA ISO structures[3] that fall into any particular size class, including the risk-based classes above. Note that a structure identified by TEM that has the same size attributes as required for PCM is referred to as a PCM-equivalent (PCME) structure. Based on these data, the following fractions are observed:

---

[2] See Attachment 1 for a detailed description of the data selection and calculation procedure.

[3] This includes not only the particle size classes traditionally included under ISO counting rules, but also "excluded" fibers that have been included for purposes of more fully characterizing the particle size distribution.

PCME = 0.28·(Total ISO)
BCPS-s = 0.13·(Total ISO)
BCPS-l = 0.042·(Total ISO)

For example, on average, about 28% of the total LA structures recorded during analysis by ISO 10312 would be counted as PCME fibers. Similarly, for particles recorded using AHERA rules[4], the conversion factors for estimating risk-based structures from total AHERA-based counts are as follows:

PCME = 0.43·(Total AHERA)
BCPS-s = 0.15·(Total AHERA)
BCPS-l = 0.059·(Total AHERA)

Because these factors are known with good confidence, it is possible to estimate the number of a particular risk-based structure type in a sample by measuring the total number of structures and multiplying by the appropriate fraction. The advantage of estimating the number and concentration of risk-based structures by this approach is increased statistical confidence and decreased cost. For example, on average, only about 4% of all ISO structures are BCPS-l. Thus, to get a reliable count of the number of BCPS-l structures in a sample, it would be necessary to count at least 100-200 total structures (a slow and costly requirement). Alternatively, if the estimate of concentration is based on total structures, then a reliable estimate can be obtained by counting only 5-10 total structures and multiplying by the factor above. Because of the advantages in statistical confidence and cost savings, this is the approach that EPA has selected for use in assessing risks from various source materials at this site.

Figure 3-2 shows the relationship between PCME fibers actually observed in individual samples of air and dust and the value calculated from the total ISO count using the ratio described above. As expected, observed values may be either higher or lower than the calculated value, but the overall correlation is good.

[4] This ratio is based only on fibers that meet AHERA counting rules, not including any "excluded" fibers that have been recorded in the database.

3.3 Calculation of Risk-Based Concentrations in Air

Long-Term Exposures

Based on the risk models described above, the concentrations of Libby amphibole in air that correspond to various levels of lifetime excess pulmonary cancer risk are as follows:

Cancer Risk-Based Concentration of Libby Amphibole Fibers in Air (s/cc)

Excess Cancer Risk Level	Based on IRIS Risk Model			Based on Berman-Crump Risk Model			
	PCM/ PCME	Total ISO	Total AHERA	BCPS-s	BCPS-l	Total ISO	Total AHERA
1E-02	4.3E-02	1.6E-01	1.0E-01	2.0E-01	6.6E-04	1.6E-02	1.1E-02
1E-03	4.3E-03	1.6E-02	1.0E-02	2.0E-02	6.6E-05	1.6E-03	1.1E-03
1E-04	4.3E-04	1.6E-03	1.0E-03	2.0E-03	6.6E-06	1.6E-04	1.1E-04
1E-05	4.3E-05	1.6E-04	1.0E-04	2.0E-04	6.6E-07	1.6E-05	1.1E-05

For example, based on the on the IRIS PCME risk model, an excess cancer risk of about 1E-04 would be predicted for a person exposed to a long-term average concentration of 0.0016 (1.6E-03) total ISO s/cc or 0.0010 (1.0E-03) total LA AHERA s/cc. Based on the Berman-Crump risk model, a risk level of 1E-04 would be predicted for a person exposed to a concentration of 0.00016 (1.6E-04) total ISO s/cc or 0.00011 (1.1E-04) total AHERA s/cc. In both cases, it is important to note that the risks are based on an assumed long-term (70-year lifetime) exposure. If exposure is for shorter times, risks are also lower, as discussed below.

Intermediate and Short-Term Exposures

When intermediate or short-term exposures occur, the exact magnitude of the risks depends on the duration of exposure as well as the age at exposure. For example, an exposure of 10-years duration that occurs at age 20-30 will pose a higher risk of lung cancer and mesothelioma than if the exposure were to occur at age 40-50. This age dependency is relatively minor for lung cancer, but is quite marked for mesothelioma. However, as an initial approximation, risk from less-than-lifetime exposure may be estimated by assuming risk is a linear function of the time-weighted average exposure concentration. For example, the risks to a person exposed for 40 years would be about 40/70 (57%) as large as the risks to a person who was exposed for a lifetime (70 years). Likewise, an exposure that occurs only for 1 hour per day is about 1/24 (4%) as hazardous as if the exposure

occurred for a full day, and an exposure that occurs only 10 days per year is about 10/365 (2%) as hazardous as if the exposure occurred every day per year. Because of this, risks from brief and intermittent exposures (e.g., those that may be encountered by firefighters at a burning house with vermiculite insulation, or those that might be experienced by a homeowner during once-only remodeling in an area with vermiculite insulation) are generally of lower concern than long-term exposures, even if the short-term exposures are to levels that would be of great concern if the exposure were long-lasting.

3.4 Risk Estimates for Indoor Air Concentrations Observed in Libby

"Typical" Indoor Air Levels

Measurements of Libby amphibole concentrations in indoor air have been performed at a number of residential and commercial properties in Libby. Based on current data, LA structures have been detected in one or more air samples from about 40% of the locations tested. The following table summarizes the range of values observed[5], and the excess cancer risk levels that would be associated with residential exposure to the levels that have been detected.

Pulmonary Cancer Risks from Indoor Air in Libby

Parameter	Low Detect (5th percentile)	Average Detect (mean)	High Detect (95th Percentile)
Concentration (Total ISO s/cc)	0.00013	0.0083	0.0621
Risk (IRIS model) - 40 years exposure	5E-06	3E-04	2E-03
Risk (IRIS model) - 70 years exposure	8E-06	5E-04	4E-03
Risk (Berman-Crump model) - 40 years exposure	5E-05	3E-03	2E-02
Risk (Berman-Crump model) - 70 years exposure	8E-05	5E-03	4E-02

As seen, in some cases the levels of LA detected are so low that there is little basis for concern. However, both average and high-end values are above the risk level of 1E-04 where EPA typically takes action under Superfund.

Comparing the risk estimates above with those that have been presented previously (Weis 2002a, 2002b) is difficult, since there have been a number of changes in the database as well as a change in

[5] See Attachment 1 for a detailed description of the data selection and calculation procedure.

the methods used to estimate the concentration of risk-based structures (see Section 3.2, above). Nevertheless, the range of estimated PCME concentrations used to estimate risks above are generally quite similar to those used previously, as shown below.

Comparison of Current and Previous Concentration Estimates

Evaluation	Number	PCME Concentration (Detects Only) (f/cc)		
		Low	Average	High
Previous (Weis 2001b, as corrected in SRC 2002)	39 samples	0.0003	0.0017	0.0120
This report	154 properties (property average)	0.00004	0.0023	0.0174

Risks from Repeated Exposures to Disturbed Vermiculite Insulation

EPA is currently taking actions to eliminate or reduce the potential for exposure of residents and workers to vermiculite insulation. As discussed in previous memos (Weis 2002a, 2002b), vermiculite insulation is of concern because it contains LA, and disturbance of the insulation can lead to locally high concentrations of LA in air. As described above, the risks from such exposures are related both to the concentrations of LA fibers in air which may be generated, and also to the frequency and duration of such exposures. Presented below are screening-level risk estimates for two populations of people who may have this type of exposure, including residents in houses with vermiculite insulation who may be exposed periodically, and tradespeople (e.g., electricians, plumbers, other contractors) whose profession may bring them into contact with vermiculite insulation on a regular basis. All calculations are based on an assumed air concentration of 0.68 total ISO structures per cc (the mean value measured in person air monitors during active disturbance of vermiculite insulation at three homes studied during the Phase II Scenario 3 studies performed by EPA in Libby)[6]. This total ISO concentration corresponds to about 0.19 PCME s/cc, 0.089 BCPS-s s/cc and 0.028 BCPS-l s/cc.

[6] See Attachment 1 for a detailed description of the data selection and calculation procedure.

Screening-Level Risk Estimates for Disturbance of Vermiculite

Exposed Population	Assumed Exposure Scenario				Estimated Excess Risk of Cancer	
	Description	hrs/day	days/ yr	yrs	IRIS Risk Model	B-C Risk Model
Resident	Getting holiday decorations out of storage in attic	0.5	2	40	3E-06	3E-05
	Once-only do-it-yourself home remodeling project	4	10	1	3E-06	3E-05
	Multiple do-it-yourself home remodeling projects	4	20	10	6E-05	6E-04
Trades person	Remodeling or repair work in homes with vermiculite insulation	8	150	25	2E-03	2E-02

As seen, infrequent exposures (such as going into an attic with exposed vermiculite only a few times per year, or a once-only remodeling project that leads to direct exposure to disturbed vermiculite) have estimated risks that do not exceed EPA's usual level of concern (1E-04). However, risks may enter a range of concern for residents who frequently engage in activities that bring them into direct exposure to vermiculite, or for tradespeople who frequently work in houses with vermiculite insulation

Short-term Risks from Exposures to Disturbed Sources

Even though cancer risk from exposure to asbestos is most appropriately viewed as a chronic concern, short-term standards have been established by OSHA to limit exposures of workers in the workplace. There are two types of short-term limits, as follows:

STEL (Short-term exposure limit)	1.0 PCM f/cc
TWA PEL (8- hr time-weighted average permissible exposure level)	0.1 PCM f/cc

In Libby, all EPA workers engaged in sampling or remedial activities wear personal air monitors to help guard against excess asbestos exposures. Two types of sample are collected:

- "excursion samples", which are short-term samples (usually about 30 minutes) and are taken during activities that are suspected to have the highest potential for exposure

- "TWA" samples, which usually span a longer collection interval (2-4 hrs), and are intended to help characterize the daily average exposure of the worker

Data from the personal air monitors of EPA workers provide a large database of PCM measurements that can be used to characterize how likely it is that short-term exposure limits may be exceeded. These data are shown below:

Frequency of Short-Term OSHA Exceedences for EPA Workers

Sample Type	OSHA Standard	Total Number of Samples	Number Exceeding OSHA Standard
Excursion	1 f/cc	1474	40 (2.7%)
TWA	0.1 f/cc	2117	419 (19.8%)

As seen, a number of short-term exceedences have occurred during EPA's remedial activities, supporting the conclusion that disturbance of asbestos-containing sources can be of potential human health concern[7]. However, a majority of the exceedences are associated with activities that are not likely to be representative of activities that area residents will engage in:

Location of Activity	Type of Activity		
	Disturbing Soil	Disturbing Vermiculite	Misc Other
Current residential/commercial area of Libby	4	154	66
Current or former mining/processing areas	63	8	164

As seen, in the main residential/commercial area of Libby, the majority of exceedences have been associated with vermiculite removal. Because locations with exposed vermiculite will be eliminated by EPA's current clean-up program, this pathway will not be applicable to residents in the future except as a consequence of remodeling activities that may expose new vermiculite. Disturbances of soil in the residential area appear to be unlikely to cause exceedences of the short-term standards, but

[7] Note: all EPA workers wear appropriate personal protection equipment so that these exceedences are not a basis for health concern in the workers. However, these same exceedences would be of potential concern for unprotected residents.

have been a common source of exceedences for workers doing clean-up in the current or former mining/processing areas.

Based on these data, it is concluded that, except for vermiculite disturbance, most area residents have low probability of an exposure that will exceed short-term asbestos exposure guidance values.

3.5 Risk Estimate for EPA's Air Clearance Criterion

At present, EPA is using a concentration of 0.001 AHERA s/cc as the clearance criterion for determining that remedial activities in homes or workplaces have been successful and that risks are within acceptable bounds. If this concentration were assumed to be an accurate measure of the long-term average air concentration in a home, risks to a resident would be about 1E-04 based on the IRIS risk model, and about 9E-04 based on the Berman-Crump risk model. Risks to a tradesman working in a house remediated to this level would be about 2E-06 to 2E-05. However, the actual risks are likely to be substantially lower, since the air samples used to evaluate any remaining contamination in a home or workplace are collected immediately after vigorous disturbance of dust with a leaf-blower. Thus, the airborne exposure concentrations measured under these conditions are likely to be higher than the true long-term average exposure concentrations which occur during normal daily activities. Thus, application of this clearance criterion is considered to be highly protective of human health for the cancer risks of concern, both for residents and for tradespeople.

4.0 RISKS FROM ASBESTOS FIBERS IN DUST

4.1 Basic Equations

As noted earlier, asbestos structures in dust are of potential health concern primarily because they can become resuspended in air where they can be inhaled. The relationship between the concentration of structures in air (s/cc) and the asbestos loading in dust (s/cm^2) may be expressed as a ratio:

$$K = C(air) / L(dust)$$

Clearly, the value of K is expected to be highly variable, depending on the nature of the forces that disturb the dust and cause the fibers to become resuspended. Thus, it is appropriate to consider that there are a series of K values, depending on the forces acting on the dust, and that the average K factor for a house is the time weighted-average (TWA) of the K-factors for all of the different types of activities that disturb the dust:

$$K(\text{average}) = \sum K_i \cdot TWF_i$$

where:

K_i = K factor for activity type "i"
TWF_i = Time-weighting factor for activity type "i"

For the purposes of this screening assessment, two basic types of K factors are identified for a residential setting:

- the "baseline" value that applies under routine household conditions. The forces that lead to dust resuspension include thermal air currents, mechanical vibrations, and human or pet movements and activities.

- The "active cleaning" value that applies when dust is being actively disturbed by an activity such as sweeping, dusting, beating carpets or upholstery, etc.

Thus, the average value of C(air) is calculated from L(dust) as

$$\text{Average } C(\text{air}) = L(\text{dust}) \cdot (K_{baseline} \cdot TWA_{baseline} + K_{cleaning} \cdot TWA_{cleaning})$$

Given the estimate of average C(air), risks may be estimated using the various risk models above.

4.2 Parameter Values

TWA Values

The time weighting factors for "baseline" and "cleaning" activities are expected to vary widely between different homes and different people. Based on surveys of human activity patterns reported in EPA's Exposure Factors Handbook (USEPA 1977), an average of about 2 hours per day are spent in cleaning activities (Table 15-71 and Table 15-90), and this activity occurs an average of about twice per week (Table 15-51). Based on this, the TWA for cleaning is:

$$TWF_{cleaning} = (2 \text{ hrs}/24 \text{ hrs}) / (2 \text{ days}/7 \text{ days}) = 0.024$$

Defining "baseline" as all time other than that spent in active cleaning, the TWF for baseline is:

$$TWF_{baseline} = 1 - TWF_{cleaning} = 0.976$$

K Factor for Active Cleaning

Data on resuspension factors (K factors) for dust resuspension due to various types of activities are limited, and values range widely. Values published in the literature from studies at other sites are summarized in Table 4-1 (Millette and Hayes 1994). As seen in the lower half of Table 4-1, K factors for resuspension of asbestos under controlled conditions tend to fall mainly in the range of 1E-04 to 1E-06 s/cc per s/cm^2. After excluding the values associated with operating a forklift and a cable pull (these are not representative of exposures that would occur in a home), the geometric mean value of the remaining values is about 2E-05 s/cc per s/cm^2. In this regard, the maximum possible value for the K factor is 4.1E-03, which represents the case when 100% of the dust is resuspended in the air of a room that is 8 feet high. Thus, a K factor of 2E-05 represents a case where only 0.5% of the total dust is suspended in air.

Data collected by EPA at the site during Phase II Scenario 2 (USEPA 2001b) were intended to provide a basis for deriving a site-specific K factor for active cleaning, but the results are disappointing. In these studies, samples of air and dust were collected in several homes during various types of active cleaning activities (sweeping, vacuuming, etc). Although the ratio of the average concentration in personal air samples (total ISO s/cc) divided by the average loading in dust (total ISO s/cm2) is 1.8E-05 s/cc per s/cm^2 (similar to the value derived from the literature)[8], there were no instances in which structures were detected in both air and dust at the same home. This prevents a meaningful analysis of the relationship in paired samples (as would be preferred). This result is partly a consequence of the statistical uncertainty around each measurement, as well as the inherent variability between different homes and different types of cleaning activities. While the site-specific data are consistent with published estimates of K factors, the extreme variability and uncertainty of the site-specific data necessitates our usage of the literature-based estimates for active cleaning.

K Factor for "Baseline" Activities

No data were located in the literature on the K factor that describes the resuspension of dust and asbestos particles during baseline (non-active cleaning) activities in a home or workplace, although

[8] See Attachment 1 for a detailed description of the data selection and calculation procedure.

Lumley et al. (1971) reported that the concentration of PCM fibers in air of an asbestos-insulated warehouse increased about 10-fold over baseline ("hardly any activity") when there was "a lot of activity", and that moving boxes in another warehouse increased airborne levels about 3-fold compared to baseline (no activity). Based on these data, it may be concluded that the K-factor for baseline is probably about 1/3 to 1/10 that of active disturbance. Based on the screening-level K value of 2E-05 s/cc per s/cm^2 for active cleaning activities identified above, this would correspond to a baseline K-factor value of about 2E-06 to 7E-06 s/cc per s/cm^2.

An alternative value can be estimated from data collected in Libby during Phase I and Phase II studies. These studies provide data on the concentration of asbestos in indoor air (both personal and stationary monitors) and in dust in residential and commercial locations. Two approaches are possible. In the first approach, the baseline K-factor can be estimated simply by dividing the average indoor air concentration by the average indoor asbestos loading in dust[9]. The results are shown below:

Estimated K Factors for Baseline Activities in Libby

Data Collection Phase	Detection Freq.		Mean C(air) (Total ISO s/cc)	Mean L(dust) (Total ISO s/cm^2)	Ratio (Baseline K Factor)
	Air	Dust			
Phase I	54/145	195/484	0.0029	830	3.5E-06
Phase II	7/16	3/14	0.0015	213	7.2E-06

As above, because these estimates of concentrations in air and loading in dust are not paired (i.e., air and dust were not collected at the same time or place), the K-values should be interpreted only as an estimate of what may be typical under baseline conditions.

The second approach is to utilize only those data that are paired in space (i.e., both air and dust are from the same house), and to calculate the best fit line of the following form: C(air) = K·L(dust). A total of 146 such data points exist. Based on these data[10], the best fit linear regression has a slope of 1.8E-06 s/cc per s/cm^2. However, most of the data points (127 out of 146) are non-detect either for air and/or for dust, so the slope estimate is highly uncertain.

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[9] See Attachment 1 for a detailed description of the data selection and calculation procedure.

[10] See Attachment 1 for a detailed description of the data selection and calculation procedure.

Based on these very limited data, it is concluded that the value of K under baseline conditions likely falls in the range of 1E-06 to 8E-06 s/cc per s/cm^2, and a value of 4E-06 s/cc per s/cm^2 was selected to be representative. Clearly, this value should be viewed as only a rough estimate, and it should be understood that actual values could vary substantially from home to home and from time to time.

4.3 Calculation of Cancer Risk-Based Loadings for Dust

Based on the equations and inputs discussed above, the relationship between lifetime excess cancer risk and the level of asbestos structures in dust are as follows:

Cancer Risk-Based Loading in Dust (s/cm^2)

Cancer Risk Level	Based on IRIS Risk Model			Based on Berman-Crump Risk Model			
	PCM/ PCME	Total ISO	Total AHERA	BCPS-s	BCPS-l	Total ISO	Total AHERA
1E-02	9,930	35,700	23,200	46,600	151	3,580	2,560
1E-03	993	3,570	2,320	4,660	15	358	256
1E-04	99	357	232	466	1.5	36	26
1E-05	10	36	23	47	0.15	3.6	2.6

For example, based on the IRIS PCME risk mode, a 1E-04 excess cancer risk is expected when the dust loading is about 232 total AHERA s/cm^2. Based on the Berman-Crump risk model, an excess risk of 1E-04 is predicted for a total AHERA dust loading of 26 s/cm^2. However, it is evident from the discussions of the equations and inputs above that these risk-based values for dust should be viewed as estimates that contain a substantial amount of uncertainty. This uncertainty is due mainly to the uncertainty regarding the relationship between air and dust, as well as uncertainty in the relative contribution of different activity patterns to the average value of K. Thus, actual risk-based concentration (RBC) values may be either higher or lower, depending on the actual range of conditions that exist across the community of Libby.

4.4 Cancer Risk Estimates for Dust Levels Observed in Libby

Measurements of Libby amphibole concentrations in indoor dust have been performed at a number of residential and commercial properties in Libby. At present, the majority of dust analyses have been performed using ISO 10312 counting rules, although most future dust samples will be evaluated using AHERA (ASTM 1995). Of the dust samples evaluated to date by ISO 10312, LA fibers have been

detected in about 40% of the locations (199/491). The following table summarizes the range of values observed[11], and the excess cancer risk levels that would be associated with lifetime residential exposure to the levels that have been detected.

Predicted Cancer Risks from Indoor Dust in Libby

Parameter	Low Detect (5th percentile)	Average Detect (mean)	High Detect (95th Percentile)
Concentration (Total ISO s/cm^2)	28	2,048	7,418
Risk (IRIS model)	8E-06	6E-04	2E-03
Risk (Berman-Crump model)	8E-05	6E-03	2E-02

As seen, in some cases the levels of LA detected in dust are so low that there is little basis for concern, but both average and high-end values are above the risk level of 1E-04 where EPA typically takes action under Superfund.

4.5 Evaluation of Cancer Risk Associated with EPA's Action Level for Dust

At present, EPA takes active steps to clean dust on any floor of a home where the average loading on that floor exceeds 5,000 total AHERA structures per cm^2. It is important to recognize that this action level is not based on a consideration of the long-term acceptability of this level, since the predicted lifetime risks would be quite high (on the order of 2E-03 to 2E-02, depending on which risk model is used) if it were assumed that this value was the true long-term average concentration in the entire home. However, actual house-wide average levels are likely to be several-fold lower, since dust samples are collected from areas most likely to be contaminated, and usually only one level of a house is substantially impacted. In addition, after remediation of primary sources, it is expected that dust levels will fall over time as a result of normal air cycling and routine cleaning by residents. Although the rate at which levels would fall is hard to predict, EPA anticipates that once the major primary sources are removed, the indoor dust concentrations and any corresponding risks to human health will be substantially reduced in a relatively short time frame. Further, training of occupants in appropriate cleaning techniques and use of EPA-supplied HEPA vacuum cleaners will help ensure reduction of indoor dust concentrations. EPA is currently planning additional investigations to validate that dust levels are in fact dropping to acceptable levels.

[11] See Attachment 1 for a detailed description of the data selection and calculation procedure.

5.0 RISKS FROM ASBESTOS FIBERS IN SOIL

5.1 Basic Equations

Asbestos fibers in outdoor soil can lead to human exposure by one or more of three different pathways:

1. Resuspension from soil into outdoor air as the result of wind forces acting on exposed soil
2. Resuspension from soil into outdoor air as a result of active disturbance of the soil (e.g., working in the garden, rototilling, etc).
3. Transport of soil from outdoors into indoor dust, from which indoor activities can lead to inhalation exposure as discussed in Section 5 (above).

For erosion of asbestos from soil into outdoor air, the basic equation is:

$$C(\text{outdoor air}) = C(\text{soil}) \cdot PEF/s \cdot FPG \cdot 10^{-6}$$

where :

C(outdoor air) = concentration of asbestos structures in air (s/cc)
C(soil) = concentration of asbestos in soil (grams of asbestos per gram bulk soil)
PEF = particulate emission factor (grams of silt per m^3 of air)
s = silt content of soil (grams of silt per gram of bulk soil)
FPG = average number of asbestos fibers of per gram of asbestos
10^{-6} = conversion factor (m^3 per cc)

For transport of outdoor soil into indoor dust, the basic equation is:

$$C(\text{dust}) = ksd \cdot C(\text{soil})$$

where:

C(dust) = concentration of asbestos structures in dust (grams of asbestos per gram of dust)
ksd = fraction of indoor dust that is attributable to outdoor soil (grams soil per gram dust)
C(soil) = concentration of asbestos in soil (grams per gram)

Given an estimate of C(dust), L(dust) may be estimated as:

$$L(dust) = C(dust) / D \cdot FPG$$

where:

L(dust) = asbestos loading in dust (s/cm^2)
C(dust) = asbestos concentration in dust (grams asbestos per gram dust)
D = mass of dust per unit area (grams dust per cm^2)
FPG = Number of asbestos fibers per gram asbestos

Given L(dust), risk may be calculated as described above (see Section 4.1).

Note that this approach assumes that all asbestos that is present in soil is currently (or may become in the future) in the form of respirable particles. This approach is an over-simplification in some cases, since some asbestos particles in soil are too large to become airborne and be inhaled. However, such large particles may become disaggregated to free fibers in the future due to weathering or mechanical forces, so the risk estimates should be considered to reflect what risks may be now (if all particles are currently fibers) or may become in the future (if some particles are currently large).

5.2 Parameter Values

TWA Values

The time that different people spend indoors and outdoors is highly variable, but the average values based on a national survey are about 1.5 hours per day outdoors, and 21 hours per day indoors (the remainder is spent in vehicles) (USEPA 1997, page 15-16). Thus, the TWF for exposure to ambient outdoor air and indoor air are approximately:

TWF(ambient outdoor air) = 1.5 hrs / 24 hr = 0.0625
TWF(indoor air) = 21 hrs / 24 hr = 0.875

The time spent engaging in outdoor activities that result in active disturbance of soil (e.g., working in the garden) is also likely to be highly variable. Based on a national survey, about 2/3 of the total respondents did not engage in gardening (USEPA 1997, Table 15-61). Of the remaining respondents, a large majority (nearly 80%) spent less that 24 hours per month gardening. Taking 12 hours per month as an estimate of what is likely to be typical for people who garden, the TWF is as follows:

TWF(disturbed outdoor air) = (12 hrs/month) / (720 hrs/month) = 0.0167

PEF Factors

The release of soil particles into outdoor air as a function of wind erosion is a complex function of the wind speed, the "roughness" of the terrain (which influences how turbulent the air flow is), the size of the exposed soil source area, and the properties of the soil (including the fraction that is covered with vegetation). Based on conservative national default values, the USEPA (1996, 2001a) has calculated a default as follows:

PEF (wind erosion) = 7.4E-10 kg of soil per m^3 of air

Because the fine particles in soil are preferentially eroded in preference to the coarser soil particles, it is assumed the wind-eroded soil particles all belong to the silt fraction (< 50 um in diameter).

Mathematical models exist for calculating PEFs for various types of active disturbances of soil (plowing a field, driving a vehicle on a dirt road, etc.) (Cowherd et al. 1985), but these are all very crude models and none are likely to be particularly relevant for the types of active disturbances that may affect a resident while working in their yard. Therefore, the PEF for active soil disturbance was simply assumed to be 100 times higher than for wind erosion:

PEF(active disturbance) = 100 · PEF(wind erosion) = 7.4E-08 kg of soil per m^3 of air

As will be seen below, the overall risk from asbestos in soil is not very sensitive to this assumption, so efforts to derive a more reliable value do not appear to be warranted.

Ksd Value

Indoor dust is composed of particles derived from many different sources, and only a fraction of the total is derived from exterior soil. Studies on the relationship between arsenic and lead in soil at numerous mining sites in the western United States suggest that in most cases, the fraction of dust derived from soil is likely to be about 20%-40% (ISSI 2001). Thus, for the purposes of the screening calculations at this site, a value of 30% (Ksd = 0.3) is assumed. Note that this assumes that the outdoor yard soil is uniformly contaminated with asbestos. In cases where only a portion of the yard is contaminated, the total soil contribution to dust may still be 30%, but only a fraction of that will contain asbestos. Thus, the value of 30% is likely to be conservative in many cases.

FPG value

The number of fibers per gram (FPG) of any particular size category of asbestos per gram total asbestos varies widely as a function of the size distribution of the asbestos particles composing the sample. At this site, an estimate of FPG for each risk-based fiber type was derived by estimating as follows:

$$FPG(x) = \frac{x}{\sum_{i=1}^{N} \left(w_i^2\right) \cdot l_i \cdot \delta \cdot 1E-12}$$

where:

N = total number of LA fibers observed in samples of air and dust from Libby
x = total number of fibers of type "x" observed in the total set of N fibers
w_i = width (um) of LA fiber "i"
l_i = length (um) of LA fiber i"
δ = density of LA fibers (3.1 grams/cc)
1E-12 = conversion factor (cc per um^3)

Based on a total of over 8,300 structures observed at Libby, estimates of FPG for each of the three main risk-based fiber types is as follows:

Fiber Type	Estimated FPG
Total	2.9E+10
PCM/PCME	9.0E+09
BCPS-s	3.9E+09
BCPS-l	1.3E+09

Silt Fraction

The fraction of a soil sample that is composed of particles that are silt-sized or smaller varies widely from location to location. Site-specific measurements of the silt content of soils in Libby have not yet been performed. However, the U.S. Department of Agriculture Soil Survey Program database for Montana does provide some data on the silt fraction for soils collected in and around Lincoln County

(USDA 2003). The fraction of silt in surface soil (depth < 25cm) ranged from 0.23 to 0.95, with a mean of 0.70. The mean value of 0.70 was used in the screening-level risk calculations for soil.

Dust Loading

The amount of total dust on a surface (g/cm^2) is expected to vary widely from location to location and from time to time, depending on the types and rates of dust deposition on surfaces and on the frequency and thoroughness of cleaning. At this site, a set of 20 samples of dust were collected by vacuuming five template areas of 100 cm^2 each (total area = 500 cm^2) from carpets and floors in residential properties in Libby, and weighing the amount of dust collected. Values ranged from a minimum of non-detect (< 0.0002 mg/cm^2) to a maximum of 0.06 mg/cm^2, with a mean of about 0.01 mg/cm^2. The mean value (1E-05 g/cm^2) was used in the screening-level risk calculations for soil.

5.3 Calculation of Cancer Risk-Based Concentrations for Soil

Based on the equations and inputs discussed above, the risk-based concentrations of asbestos structures in soil (expressed as mass percent) are as follows:

Cancer Risk-Based Concentrations in Soil (mass percent)

Risk Level	Based on IRIS Risk Model	Based on Berman-Crump Risk Model
1E-02	36%	3.7%
1E-03	3.6%	0.37%
1E-04	0.36%	0.04%
1E-05	0.04%	0.004%

An interesting point to note is that most of the risk (about 86%) from asbestos in soil is attributable to the transport of the soil to indoor dust rather than the exposures which occur to asbestos in ambient or disturbed outdoor air. This is mainly because the time spent outdoor exposed to ambient air or to air near disturbed soil are quite small compared to the time spent indoors.

5.4 Cancer Risk Estimates for Soil Levels Observed in Libby

Measurements of Libby amphibole concentrations in outdoor yard soil have been performed at a number of residential and commercial properties in Libby using polarized light microscopy (PLM).

Of these properties, LA fibers have been observed in one or more soil samples from about 20% of the locations (64 out of 328)[12]. In most of these cases, the levels of LA in soil have been too low to quantify (these are reported as "Trace" or "<1%"), which probably corresponds with concentrations that are mainly in the 0.1-1% range. Based on the screening-level assumptions described above, soil concentrations in this range are predicted to correspond with excess lifetime cancer risk levels of 3E-05 to 3E-04 (IRIS risk model) to 3E-04 to 3E-03 (Berman Crump risk model). In a few cases, levels of asbestos were high enough to quantify, with levels of 4% to5% having been observed. If these values were assumed to be representative of the entire yard, they would correspond to a lifetime excess cancer risk in the range of 1E-03 to 1E-02 (depending on which risk model is used).

5.5 Estimated Cancer Risks at EPA's Action Level for Soil

At present, EPA removes and replaces soils that are estimated to contain 1% or more asbestos (grams per gram). In addition, EPA removes all soils with visible vermiculite at a residence if any soil location at that residence exceeds 1% asbestos. Based on the assumptions described above, a concentration of 1% LA in soil poses an excess cancer risk of about 3E-04 based on the IRIS PCM risk model and about 3E-03 based on the Berman-Crump risk model. However, these calculations are based on several assumptions that may tend to overestimate actual hazard. Most important is the assumption that the entire yard is contaminated with asbestos, while most sites evaluated to date tend to have asbestos in only one or two parts of the yard. If the total area contaminated were only 1/10 of the yard, this would tend to reduce the amount of asbestos entering house dust from yard soil, and risk estimates might be as much as 10-fold lower. In addition, the calculations do not account for the effects of snow cover and frozen ground, both of which tend to reduce transport of soil into indoor dust. Finally, the calculations do not take actual particle size into account, and particles that are too large to be respirable are evaluated as if they have undergone degradation to individual fibers. Based on these considerations, EPA is using an emergency response action level of 1% asbestos concentration in soil. It is anticipated that EPA's actions to remove or otherwise minimize exposure to soil asbestos concentrations above 1% are likely to capture areas of major concern from this medium at this time. Depending on site conditions and circumstances of potential human exposure, final action levels may be reduced even further to ensure protection of long-term human health.

6.0 SUMMARY

Reliable prediction of human health risk due to asbestos in environmental media (air, dust, soil) is very difficult. This is because of uncertainty at all stages of the risk assessment process. Table 6-1

[12] See Attachment 1 for a detailed description of the data selection and calculation procedure.

lists the main sources of uncertainty, and provides a judgement about how large and in which direction the error associated with the uncertainty might be. Inspection of this table emphasizes the many different sources of uncertainty that exist, and how uncertain the risk estimates are (especially those associated with expected releases from soil or dust). Risk managers and the public should take these uncertainties into account when interpreting the calculations in this document.

Despite this uncertainty, the screening level calculations reported in this appendix provide a starting point for quantitative risk-based decision-making at this site. More specifically, the calculations have shown that there are numerous locations in Libby where concentrations of Libby amphibole in air, dust, and/or soil are above a level of potential health concern and provide further basis for ongoing emergency response actions. Based upon the screening level calculations, and other available information concerning exposures and health effects within the community, EPA believes that the current "action levels" and "clearance criteria," described above, provide a reasonable framework to allow for progress of time-critical remediation work to reduce high risk exposures and protect public health.

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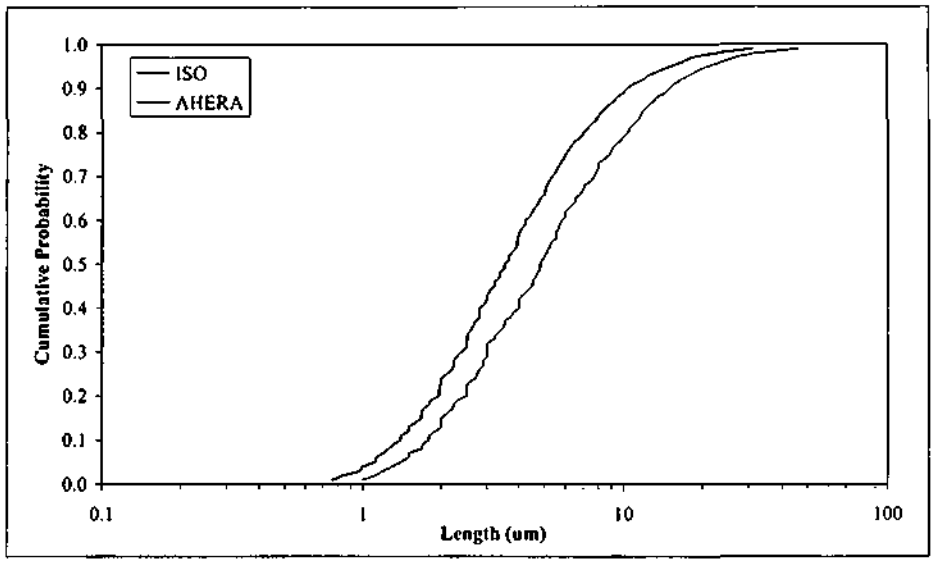
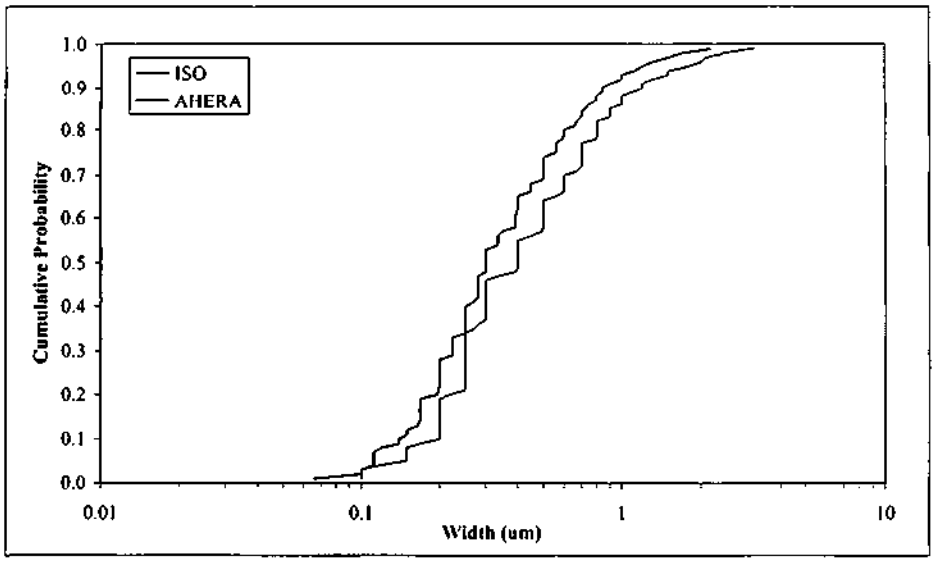
Figure 3-1
Structure Characteristic Distributions





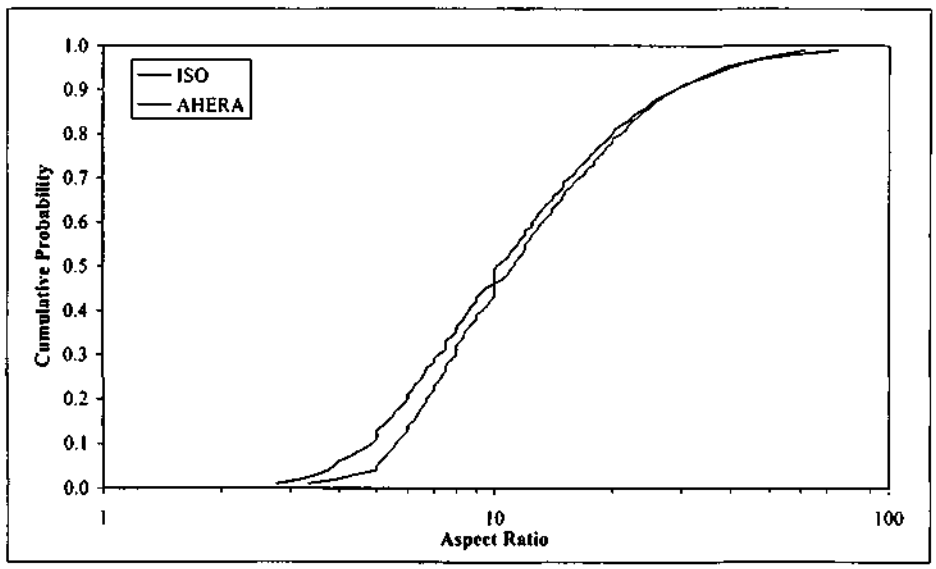


Figure 3-2. Correlation of Observed and Calculated PCME Fiber Levels

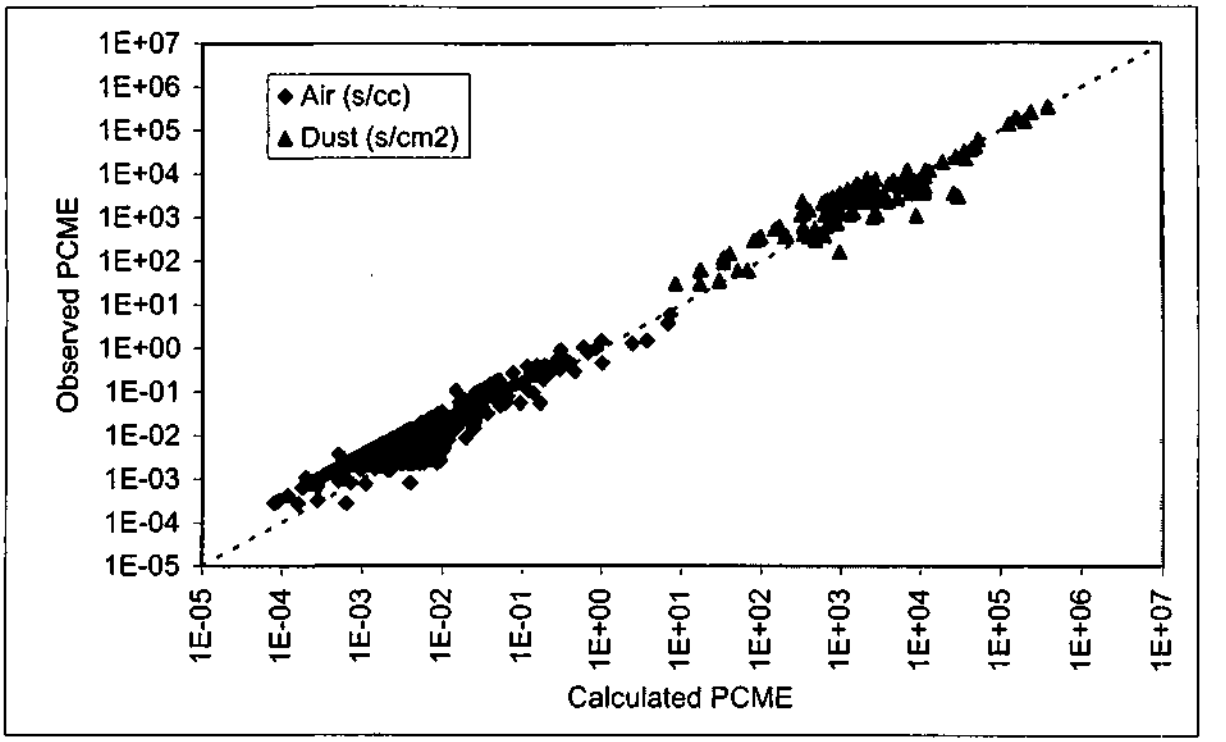


TABLE 4-1. K FACTORS REPORTED AT OTHER SITES

Contaminant	Activity	K (s/cc per s/cm^2)
^{131}I-labeled dust	Active work in confined space	4.3E-05
Beryllium	Warehouse inventory	2E-02
Alpha emitters	Walking	4.9E-04
Uranium particles	Cart movement	1.45E-04
Chrysotile dust in a warehouse	Handling contaminated materials	2.0E-03 to 4.2E-03
Microorganisms	Air jet Moist mopping	1.2E-03 2.0E-04
Zinc Sulfide powder	Vigorous sweeping	1.9E-04
Asbestos (controlled studies)	Gym/athletic activities	2.4E-05
	Cleaning a storage area	3.1E-05
	Operating a forklift in a warehouse	3.6E-03
	Cable pull	1.4E-05
	Broom sweeping	7.1E-05
	Conventional carpet cleaning	3.9E-06

Source: Values are compiled from numerous reports as summarized by Millette and Hayes (1994)

TABLE 6-1. SUMMARY OF UNCERTAINTIES

Pathway	Variable	Basis of Uncertainty	Likely Magnitude in Overall Risk Estimate	Likely Direction of Error
Inhalation of fibers in air	C(air)	Based on typical number of grid openings counted (10-40), estimates have moderate to high statistical uncertainty. Values may vary as a function of time and location.	Medium	Either higher or lower
	Cancer Unit Risk Factors	Dependence of cancer risk on fiber size and type of asbestos not certain; more than 10-fold difference between different models	Medium-Large	Unknown
	Non-cancer reference concentration	No value is currently available; dependence on fiber size and type is unknown	Large	Underestimate non-cancer risk
Exposure to fibers from disturbance of indoor dust	C(dust)	Based on typical number of grid openings counted (10-40), estimates have moderate to high statistical uncertainty. Values may vary as a function of time and location.	Medium	Either higher or lower
	K Factor for active cleaning	Value is highly variable, depends on details of source, disturbance, and location; values from literature span 2 orders of magnitude; site specific estimate of mean is within literature range	Large	Either higher or lower
	K Factor for "baseline" residential activities	Nearly no information from literature. Site value is crude estimate of "typical". Actual values may vary widely.	Very Large	Either higher or lower
	TWF for active cleaning and baseline exposures	Based on national default values. Activity patterns in Libby may be different.	Small	Either higher or lower

Pathway	Variable	Basis of Uncertainty	Likely Magnitude in Overall Risk Estimate	Likely Direction of Error
Exposure to asbestos in outdoor air due to releases from soil	C(soil)	Quantification of asbestos in soil is difficult; current methods are only semi-quantitative. Estimates do not account for the presence of large (non-respirable) particles, since these may become respirable in the future.	Medium	Either higher or lower
	PEF for release of asbestos from soil to ambient outdoor air	Based on conservative national default values. Conditions in Libby may be different. For example, the factor assumes 50% vegetative cover, while actual site conditions may vary. The factor does not consider effect of snow cover or frozen ground.	Small	More likely to overestimate than underestimate
	Silt content of soil	Based on county wide statistics. Conditions in Libby may differ.	Small	Either higher or lower
	TWF for exposure to ambient outdoor air	Based on national default values. Activity patterns in Libby may be different.	Small	Either higher or lower
Exposure to asbestos in outdoor air due to releases from soil	TWF for active soil disturbance	Based on national default values for gardening. Activity patterns in Libby may be different.	Small	More likely to overestimate than underestimate
	PEF for release of asbestos from soil to outdoor air following active disturbance	Assumed value, very uncertain. Nevertheless, because exposure frequency and duration are assumed to be small, overall contribution to risk is small.	Small	Unknown
Exposure to asbestos in soil following transfer to indoor dust	Transfer of asbestos from soil into indoor dust	Based on studies on lead and arsenic at other sites. Conditions in Libby may vary. Assumes that entire yard is contaminated with asbestos. If only hot-spots exist, risks will be lower. Does not quantitatively consider effect of snow, frozen ground, or vegetative cover.	Large	Either higher or lower; probably higher in most cases.

Pathway	Variable	Basis of Uncertainty	Likely Magnitude in Overall Risk Estimate	Likely Direction of Error
	Estimate of fibers per gram of asbestos	Based on site data.	Small.	Unknown.
	Dust loading	Based on limited site data. Values are highly variable between locations, and are also likely to vary with time.	Large	Either higher or lower.

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ATTACHMENT 1
DOCUMENTATION OF DATABASE QUERIES AND DATA REDUCTION

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1 INTRODUCTION

This attachment provides details of methods used to obtain data from the Libby 2 Database and to calculate values and parameters needed in risk evaluation. All results are based on the database as it existed on July 31, 2003. Many of the results in this attachment involve calculations in Excel® spreadsheets. These spreadsheets are frequently noted in footnotes ("filename.xls") and are available upon request.

2 CREATING A HORIZONTAL DATABASE LAYOUT FOR TEM RESULTS

The Libby 2 Database table that contains all of the raw results data (called "BtblResults") is organized in a vertical layout (see tables below for an example of horizontal vs. vertical layout). For the purposes of running efficient queries, SRC has converted the organizational structure of

the TEM structure data to a horizontal layout using a crosstab query [1].

Example of a horizontal layout:

Analysis IDSeqN	Grid Name	Primary Structure	Total Structure	Length	Width	Aspect Ratio	Class
5678	A3	1	1	5.88	0.28	21.00	LA

Example of a vertical layout:

Analysis IDSeqN	Grid Name	Characteristic	Result	Class
5678	A3	Primary Structure	1	LA
5678	A3	Total Structure	1	LA
5678	A3	Length	5.88	LA
5678	A3	Width	0.28	LA
5678	A3	Aspect Ratio	21.00	LA

3 PARTICLE SIZE DISTRIBUTIONS

3.1 ISO/AHERA Structure Distribution Figures

The Libby amphibole (LA) structure distributions shown in Figure 3-1 were generated by querying the database to obtain all LA structures reported for air and dust samples by both TEM-ISO and TEM-AHERA (N = 6238 ISO structures, N = 2116 AHERA structures). Cumulative frequency distributions were generated for length, width and aspect ratio [2].

Interim DB: TEM Calc ISO (Btbl Linkage).mdb & TEM Calc AHERA (Btbl Linkage).mdb Query Name: structure dist graph *Based on the Horizontal Layout of Raw Structure Data (see below for details)*		
Field	Constraint	Comment
SampleMediaDesc	Like "Air" Or Like "Dust"	
SampleQCTypeDesc	Like "Field Sample"	Excludes all QC samples (e.g. blanks, etc.)

[1] The crosstab queries (qryTEMResultsCrosstab) for ISO and AHERA are located in the interim DBs "TEM Calc ISO (Btbl Linkage).mdb" and "TEM Calc AHERA (Btbl Linkage).mdb", respectively. Because of their complexity, query details are not provided in this attachment but are available upon request.

[2] Dist graphs 7-31-03.xls

Interim DB: TEM Calc ISO (Btbl Linkage).mdb & TEM Calc AHERA (Btbl Linkage).mdb Query Name: structure dist graph *Based on the Horizontal Layout of Raw Structure Data (see below for details)*		
Field	Constraint	Comment
AnalysisMethod	Like "TEM-ISO10312" or Like "TEM-AHERA"	
ResultsMineralClass	Like "LA"	
TSTRUC (Total)	Is Not Null And Not Like 0	Excludes all non-countable structures

3.2 ISO/AHERA Structure Statistics

Every LA structure identified by TEM-ISO or TEM-AHERA for both air and dust (using the same structure data set used to prepare structure distribution figures above) was classified as to its size class on the basis of length, width, and aspect ratio as follows [3]:

AHERA: Length ≥ 0.5um, Aspect Ratio ≥ 5
PCME: Length ≥ 5um, Width > 0.25um, and Aspect Ratio ≥ 3
BCPS-short: Length ≥ 5um and < 10um, Width ≤0.5um
BCPS-long: Length ≥ 10um, Width ≤ 0.5um

Based on these classifications, the following ratios were established:

		Ratio
PCME/ISO	1734/6238	0.28
BCPS-s/ISO	812/6238	0.13
BCPS-l/ISO	261/6238	0.042
PCME/AHERA	872/2034	0.43
BCPS-s/AHERA	303/2034	0.15
BCPS-l/AHERA	119/2034	0.059

[3] Dist stats 7-31-03.xls

		AnalysisMethod		
		TEM-AHERA	TEM-ISO10312	Total
Air	Total Structures	2018	4401	6419
	AHERA	1945	3876	5821
	PCME	848	1388	2236
	BCPS-s	290	574	864
	BCPS-l	113	208	321
Dust	Total Structures	98	1837	1935
	AHERA	89	1728	1817
	PCME	24	346	370
	BCPS-s	13	238	251
	BCPS-l	6	53	59
Air + Dust	Total Structures	2116	6238	8354
	AHERA	2034	5604	7638
	PCME	872	1734	2606
	BCPS-s	303	812	1115
	BCPS-l	119	261	380

3.3 Fibers per Gram

The number of asbestos fibers per gram of total asbestos (FPG) was calculated as follows [4]:

$FPG = \#\text{ of LA Structures}_{\text{fiber type}} / \text{Total LA Mass}$

where: fiber type = PCME, BCPS-s or BCPS-l

$\text{Total LA Mass (g)} = \sum \text{length (um)} \cdot \text{width}^2 \text{ (um)} \cdot 1E\text{-}12 \text{ (cm}^3\text{/um}^3\text{)} \cdot 3.1 \text{ (g/cm}^3\text{)}$

Asbestos fibers per gram of total asbestos (FPG)			
	LA structures	LA mass (g)	FPG
total	8354	2.89E-07	2.9E+10
PCME	2606		9.0E+09
BCPS-s	1115		3.9E+09
BCPS-l	380		1.3E+09

4 CALCULATING THE AREA-EVALUATED-WEIGHTED (AEW) CONCENTRATION/LOADING VALUE

This risk evaluation focused on air concentrations and dust loadings as analyzed by TEM-ISO. For each ISO analysis, concentration/loading is reported for each of three mineral classes – Libby amphibole (LA), other amphibole (OA), and crysotile (C) – for seven structure dimension "bins". The structure dimension bins are defined as follows:

[4] Dist stats 7-31-03.xls

Bin	Length	Width	Aspect Ratio
A			< 5
B	< 0.5um		≥ 5
C		> 0.5um	≥ 5
D	≥ 0.5um - 5um	≤ 0.5um	≥ 5
E	5um - 10um	≤ 0.5um	≥ 5
F	> 10um	≤ 0.5um	≥ 5
G	all	all	all

Summary statistics for air and dust were based on concentrations/loadings from LA, Bin G.

If an air or dust sample (which is represented by a unique Index ID) was analyzed using the same Prep Method (Direct or Indirect) more than once (e.g.: one sample analyzed by ISO Indirect counting 10 grid openings (GOx) on 7/12/01 and 30 GOx on 9/2/01), it is necessary to calculate the total Area-Evaluated-Weighted (AEW) concentration/loading value across all analyses for the sample.

The AEW concentration/loading is calculated using the following steps and equations [5]:

AEW Concentration or Loading = $\sum$ (GOx · GO area · Concentration or Loading) / $\sum$ (GOx · GO area)

Step 1 – For each Analysis ID, calculate GOx · GO area · Concentration or Loading (GOxAC)
Step 2 – For each Analysis ID, calculate GOx · GO Area (GOxA)
Step 3 – For each Prep Method, calculate the $\sum$(GOxAC) and $\sum$(GOxA)
Step 4 – For each Prep Method, calculate the AEW by dividing $\sum$(GOxC) by $\sum$(GOx)
Step 5 – If an Index ID has results for both Prep Methods (Direct and Indirect), select the maximum concentration/loading value to represent the Index ID.

Example:

Index ID	Analysis ID	Media	Analysis Method	Prep Method	GOx	LA Bin G count	LA Bin G conc	AEW LA Bin G conc	Final AEW LA Bin G conc
X-00123	001	Air	ISO	Indirect	10	1	0.008	0.011	0.03
X-00123	002	Air	ISO	Indirect	30	2	0.012		
X-00123	003	Air	ISO	Direct	10	1	0.03	0.03	

[5] The AEW calculations are performed within the interim DB "TEM Calc ISO (Btbl Linkage).mdb" in a four part query (qry_ISO LA BinG Conc). Because of its complexity, query details are not provided in this attachment but are available upon request.

5 INDOOR AIR CONCENTRATIONS OBSERVED IN LIBBY

5.1 Exposures to Typical Indoor Air

In order to evaluate risks from typical residential and workplace exposures to indoor air in Libby, the database was queried to obtain air concentrations for all indoor air samples (personal and stationary) collected during Phase 1, Phase 2 Scenario 1 (routine activity scenario), and Phase 2 Scenario 2 (cleaning scenario, pre-activity). Air samples collected during the Phase 1R investigation were excluded because they are likely to be impacted by remedial activities and not representative of typical exposure scenarios.

Air concentrations were averaged first across all samples within a property and then summary statistics were calculated across properties [6].

Total ISO, AEW Bin G LA Concentration

Media		Detect. Freq.	Mean[1]	5th Percentile[1]	95th Percentile[1]	Mean sensitivity[2]
Indoor Air (s/cc)	by sample	96/309	0.0230	0.00021	0.1420	0.0064
Indoor Air (s/cc)	by property	59/154	0.0083	0.00013	0.0621	0.0025

1 Based on Detects only

2 Based on NDs only

Interim DB: TEM Calc ISO (Btbl Linkage).mdb Query Name: phase 1 air-dust data		
Field	Constraint	Comment
SamplePhaseDesc	Like "Phase 1"	
LocationLandUse Desc	Not Like "Industrial"	Excludes any industrial properties that are not representative of the risk evaluation exposure scenarios.
LocationProperty GroupDesc	Not Like "*Screen*" and Not Like "*Export*" and Not Like "2059 Bryant St (Denver, CO)"	Excludes any samples collected from the Screening Plant or Export Facility because they are not representative of the risk evaluation exposure scenarios. Excludes properties not located in Libby, MT.
SampleMediaDesc	Like "Air" or Like "Dust"	
SampleQCTypeDesc	Like "Field Sample"	Excludes all QC samples (e.g. blanks, etc.)

[6] air dust summ stats_risk calc v2.xls

Interim DB: TEM Calc ISO (Btbl Linkage).mdb Query Name: phase 1 air-dust data		
Field	Constraint	Comment
For Air Samples,		
SampleMatrixDesc	Not Like "Outdoor"	Excludes any samples that are not representative of indoor exposures.
For Dust Samples,		
SampleMatrixDesc	Not Like "Cloth" and Not Like "Vehicle"	Excludes any samples that are not representative of indoor exposures.

Based on a review of the air and dust samples collected as part of Phase 1 by the data managers and Libby field team, the following samples were also excluded from summary statistics as being unrepresentative of typical residential and workplace exposures.

Excluded Phase 1 Indoor Air Samples:
--1020 California Ave (1-00295, 28-28152)
--1022 1/2 California Ave (1-07238, 1-07239)
--107 W. 4th St - EMSL Lab (1-06863, 1-06870, 1-06931)
--110 River Run Ln (1-06804, 1-06805)
--115 W. 2nd St - Kootenai Angler (1-07242, 1-07243, 1-07244, 28-28124)
--120 River Run Ln (1-06801, 1-06802)
--1203 Minnesota Ave - Millwork West (1-06907, 1-06908)
--303 W. Thomas St (Planer Bldg) (1-04593, 1-04594, 1-04595, 1-04598, 1-04599, 1-06871, 1-06872, 1-06873, 1-06874, 1-07209, 1-07210, 1-07231, 1-07232)
--318 Louisiana Ave - CDM Federal (1-07207)
--517 Montana Ave (1-01946, 1-01947)
--Location = NA (1-02121, 1-06862, 28-28132, 28-28134, 28-28136, 28-28138, 28-28140)

Excluded Phase 1 Dust Samples:
--1022 1/2 California Ave #A (1-01959)
--1022 1/2 California Ave #B (1-01961, 1-01962)
--107 W. 4th St - EMSL Lab (1-07911, 1-07912, 1-07913, 1-06651, 1-06739, 1-06740, 1-06741, 1-06742, 1-06743, 1-06744, 1-06745, 1-06746, 1-06747, 1-06748, 1-06749, 1-06750, 1-06751, 1-06754, 1-06755, 1-06756, 1-06757, 1-06866, 1-06889, 1-06890, 1-07184, 1-07195, 1-07233, 1-07250, 1-07367, 1-07368, 1-07427, 1-07429)
--17115 Highway 37 N - Libby Dam (1-03373, 1-03374)
--2293 Kootenai River Rd Barn (1-07871, 1-07872)
--3496 Highway 2 S (1-03935, 1-03936, 1-03937, 1-03938)
--517 Montana Ave (1-01950, 1-01951)
--High School Bleachers (1-03858, 1-03859)
--Libby Pub Schools Admin Bldg (1-03151, 1-03152)

Interim DB: TEM Calc ISO (Btbl Linkage).mdb Query Name: phase 2, scenario 1 data		
Field	Constraint	Comment
SamplePhaseDesc	Like "Phase 2"	
SampleScenarioDesc	Like "01-*"	Restricts samples to those collected during Phase 2, Scenario 1 (routine activity).
SampleMediaDesc	Like "Air"	
SampleQCTypeDesc	Like "Field Sample"	Excludes all QC samples (e.g. blanks, etc.)
For Air Samples,		
SampleMatrixDesc	Not Like "Outdoor"	Excludes any samples that are not representative of indoor exposures.
PumpFilterDiameter	Like 25	Excludes any Hazdust samples.

Interim DB: TEM Calc ISO (Btbl Linkage).mdb Query Name: phase 2, scenario 2 data		
Field	Constraint	Comment
SamplePhaseDesc	Like "Phase 2"	
SampleScenarioDesc	Like "02-*"	Restricts samples to those collected during Phase 2, Scenario 2 (cleaning).
SampleMediaDesc	Like "Air"	
SampleQCTypeDesc	Like "Field Sample"	Excludes all QC samples (e.g. blanks, etc.)
For Air Samples,		
SampleMatrixDesc	Not Like "Outdoor"	Excludes any samples that are not representative of indoor exposures.
PumpFilterDiameter	Like 25	*Note: several samples designated as NULL required reclassification.* Excludes any Hazdust samples.
SampleTWAEXC	Like "TWA"	*Note: several samples required reclassification.* Restricts samples to those collected across the full period, excludes any excursion samples.
SamplePrePostClear	Like "Pre"	*Note: several samples required reclassification.* Restricts samples to those collected prior to commencement of cleaning activities.

5.2 Exposures to Disturbed Vermiculite

In order to evaluate the exposure of residents and workers to vermiculite insulation, the database was queried to obtain air concentrations for all indoor air samples (personal and stationary) collected during Phase 2 Scenario 3 (collected during active vermiculite disturbance).

Air concentrations were averaged first across all samples within a property and then summary statistics were calculated across properties [7].

Total ISO, AEW Bin G LA Concentration

Summary across properties:	
0.45	average air conc (s/cc) stationary
0.68	average air conc (s/cc) personal

Interim DB: TEM Calc ISO (Btbl Linkage).mdb Query Name: phase 2, scenario 3 data		
Field	Constraint	Comment
SamplePhaseDesc	Like "Phase 2"	
SampleScenarioDesc	Like "03-*"	Restricts samples to those collected during Phase 2, Scenario 3 (active disturbance).
SampleMediaDesc	Like "Air"	
SampleQCTypeDesc	Like "Field Sample"	Excludes all QC samples (e.g. blanks, etc.)
For Air Samples,		
SampleMatrixDesc	Not Like "Outdoor"	Excludes any samples that are not representative of indoor exposures.
PumpFilterDiameter	Like 25	*Note: several samples designated as NULL required reclassification.* Excludes any Hazdust samples.
SampleTWAEXC	Like "TWA"	*Note: several samples required reclassification.* Restricts samples to those collected across the full period, excludes any excursion samples.

[7] Phase 2, Scenario 3 Air Data.xls

Interim DB: TEM Calc ISO (Btbl Linkage).mdb Query Name: phase 2, scenario 3 data		
Field	Constraint	Comment
SamplePrePostClear	Like "N/A"	*Note: "N/A" = During; several samples required reclassification.* Restricts samples to those collected during active disturbance activities.

5.3 Exposures to Disturbed Sources

In order to evaluate short-term risks from exposures to disturbed sources, the database was queried to obtain air concentrations for all worker personal monitoring air samples. Because the OSHA limits which were used to evaluate these short-term exposures are based on PCM, the database was queried to obtain air samples that had been analyzed by PCM-7400.

Interim DB: Non ISO-AHERA DB (Btbl Linkage).mdb Query Name: pcm personal air data		
Field	Constraint	Comment
SamplePersonalStationary	Like "Personal"	Restricts samples to those that are personal monitoring.
SampleMediaDesc	Like "Air"	
SampleQCTypeDesc	Like "Field Sample"	Excludes all QC samples (e.g. blanks, etc.)
AnalysisMethod	Like "PCM-7400"	Restricts samples to those that were analyzed by PCM-7400.
AnalysisFilterStatus	Is NULL or Like "Analyzed"	Excludes any samples that were overloaded or that were not analyzed.

After a review of the query output, several additional samples were excluded for the following reasons:

- The sample comment field indicated that the sample was a hazdust sample or that the filter size was 37mm (indicating a hazdust sample). {N = 24 samples}
- The total number of fields counted was zero or NULL. This typically indicates that the sample was either overloaded or not analyzed. {N = 203 samples}
- The limit of detection (LOD) was reported as zero or NULL. The LOD should be calculated for every sample. {N = 28 samples}
- The reported air volume collected was reported as zero or NULL. This typically indicates that the sample is a field blank. {N = 7 samples}
- The reported structure concentration (f/cc) was reported as zero or NULL. This field should report either the calculated concentration for a detect or < LOD for a non-detect. {N = 79

samples}

- The reported structure concentration (f/cc) for a non-detect was not equal to < the calculated sample LOD. {N = 3 samples}

Two types of air samples were collected as part of the worker exposure monitoring process - excursion (EXC) samples and time-weighted average (TWA) samples. In some cases the sample type (EXC or TWA) was not assigned and was inferred based on the sample collection period [8].

Each personal monitoring air concentration was compared to the appropriate OSHA short-term limit without adjustment for differences in collection period duration. EXC samples were compared to the short-term exposure limit (STEL = 1.0 PCM f/cc) and TWA samples were compared to the 8-hr time-weighted average permissible exposure level (PEL = 0.1 PCM f/cc).

Number of PCM Worker Air Samples Above the OSHA Limit

Sample Type	N total	N detects > std
TWA std = 0.1 f/cc	2117	419
EXC std = 1 f/cc	1474	40

Samples that were detected above their respective OSHA limit, were classified according to the type of activity (active vermiculite disturbance, active soil disturbance, other) and the general location in which the activity was performed (current residential/commercial area of Libby, current or former mining/processing areas) [9].

Locations/Types of Activities for Samples Above the OSHA Limit

	Mining Related			Residential/Commercial		
Sample Type	Soil Dist.	Verm Dist.	Other	Soil Dist.	Verm Dist.	Other
TWA	57	7	155	4	136	60
EXC	6	1	9	–	18	6

6 DERIVATION OF RESUSPENSION (K) FACTORS

6.1 K Factor for Active Cleaning

In order to derive site-specific estimates of resuspension (K) factors associated with active cleaning, the database was queried to obtain air concentrations and dust loadings for all indoor samples collected during Phase 2 Scenario 2. The data set is nearly identical to that provided by the query "phase 2, scenario 2 data" (see Section 4) with the following exceptions:

[8] PCM Exceedance Calcs_10-21-03.xls

[9] PCM Exceedance Calcs_10-21-03.xls

Field	Constraint	Comment
SampleMediaDesc	Like "Air" or Like "Dust"	
For Air Samples,		
SamplePrePostClear	Like "N/A"	*Note: several samples required reclassification.* Restricts samples to those collected during active cleaning.
For Dust Samples,		
SamplePrePostClear	Like "Pre"	*Note: several samples required reclassification.* Restricts samples to those collects prior to commencement of cleaning activities.

The average Scenario 2 personal air AEW LA Bin G concentrations (non-hazdust, full period, during activity) were calculated within each property. The average Scenario 2 dust AEW LA Bin G loading (pre-activity) was calculated within each property. Non-detects were evaluated at 0. The average Scenario 2 air concentration across all properties was then divided by the average Scenario 2 dust loading across all properties [10].

Cleaning K: 3.89E-03 / 2.13E+02 ⟶ **1.8E-05**
Avg Scenario 2 Air (Personal, Full, During) / Avg Scenario 2 Dust (Pre-Activity)

6.2 K Factor for "Baseline" Activities

6.2.1 Based on Phase 2 Data

In order to derive site-specific estimates of resuspension (K) factors associated with "baseline" activities, the database was queried to obtain air concentrations and dust loadings for all indoor samples collected during Phase 2 Scenario 1 and Phase 2 Scenario 2 (pre-activity). The data sets are identical to that provided by the queries "phase 2, scenario 1 data" and "phase 2, scenario 2 data" (see Section 4).

The average Scenario 1 personal and average stationary air AEW LA Bin G concentrations (non-hazdust, full period) were calculated within each property. The average Scenario 2 dust AEW LA Bin G loading (pre-activity) was calculated within each property. Non-detects were evaluated at 0. The average Scenario 1 air concentration across all properties was then divided by the average Scenario 2 dust loading across all properties [11].

[10] site-specific K_7-31-03.xls

[11] site-specific K_7-31-03.xls

Background K: 1.53E-03 / 2.13E+02 ⟶ **7.2E-06**
Avg Scenario 1 Air (Personal+Stationary) / Avg Scenario 2 Dust (Pre-Activity)

Detection Freq.:	Air	Dust
	7/16	3/14

6.2.2 Based on Phase 1 Data

Several air and dust samples collected at residential and commercial locations as part of the Phase 1 investigation are representative of "baseline" activities, therefore the database was queried to obtain air concentrations and dust loadings for all indoor samples collected during Phase 1. The data set is identical to that provided by the query "phase 1 air-dust data" (see Section 4).

The average Phase 1 personal and average stationary air AEW LA Bin G concentrations were calculated within each property. The average Phase 1 dust AEW LA Bin G loading was calculated within each property. Non-detects were evaluated at 0. The average Phase 1 air concentration across all properties was then divided by the average Phase 1 dust loading across all properties [12].

	detect. freq.		Avg	Stdev	50th	90th	99th
air	54/145	37%	2.91E-03	1.71E-02	0.00E+00	7.27E-04	1.00E-01
dust	195/484	40%	8.30E+02	3.94E+03	0.00E+00	1.14E+03	1.76E+04
			↓				
	Phase 1, Baseline K:		**3.5E-06**				

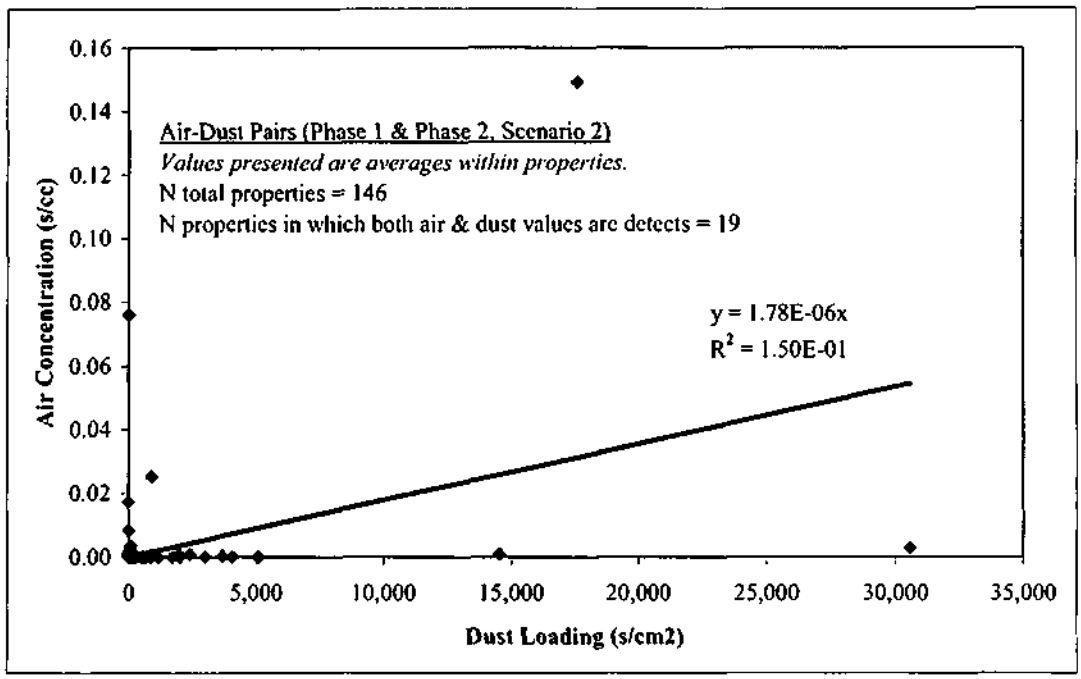
6.2.3 Based on Phase 1 and Phase 2 Data

For each property in which both air and dust were sampled, the average Phase 1 & Phase 2, Scenario 2 personal and average stationary air AEW LA Bin G concentration (non-hazdust, full period, pre-activity) was calculated within each property. The average Phase 1 & Phase 2, Scenario 2 dust AEW LA Bin G loading (pre-activity) was calculated within each property. Non-detects were evaluated at 0. The paired data for each property was plotted and a linear regression line was fit assuming a y-intercept of zero [13].

---

[12] ph1 air-dust v2.xls (TAB: all_house avg)

[13] ph1 & ph2 air-dust pairs v2.xls



7 DUST LEVELS OBSERVED IN LIBBY

In order to evaluate risks from typical residential and workplace exposures to indoor dust in Libby, the database was queried to obtain dust loading for all indoor dust samples collected during Phase 1 and Phase 2 Scenario 2 (pre-activity). The data sets are identical to that provided by the queries "phase 2, scenario 1 data" and "phase 2, scenario 2 data" (see Section 4). Dust samples collected during the Phase 1R investigation were excluded because they are likely to be impacted by remedial activities and not representative of typical exposure scenarios.

Dust loadings were averaged first across all samples within a property and then summary statistics were calculated across properties [14].

Total ISO, AEW Bin G LA Loading

Media	Detect. Freq.	Mean[1]	5th Percentile[1]	95th Percentile[1]	Mean sensitivity[2]
Indoor Dust (s/cm2)	196/485	2,048	28	7,418	1,129

1 Based on Detects only

2 Based on NDs only

[14] air dust summ stats_risk calc v2.xls

8 SOIL LEVELS OBSERVED IN LIBBY

In order to evaluate risks from typical residential exposures to surface soil in Libby, the database was queried to obtain asbestos mass fraction estimates for all soil samples collected during the Contaminant Screening Study. Results were restricted to analyses performed by PLM-NIOSH 9002, PLM-Gravimetric, or PLM-Visual Estimation (VE).

Interim DB: Non ISO-AHERA DB (Btbl Linkage).mdb
Query Name: soil data_PLM-VE

Field	Constraint	Comment
SamplePhaseDesc	Like "Contaminant Screening Study"	
LocationProperty GroupDesc	Not Like "Screening Plant"	Excludes any samples collected from the Screening Plant because they are not representative of typical residential exposure scenarios.
SampleMediaDesc	Like "Soil-Like"	
SampleMatrixDesc	Like "Surface Soil"	Excludes soils collected from subsurface depths because residential contact is unlikely.
SampleQCTypeDesc	Like "Field Sample"	Excludes all QC samples (e.g. blanks, etc.)
AnalysisMethod	Like "PLM-VE"	
AnalysisLabQCDesc	Like "Not a QA*"	Excludes all QA samples (e.g. Recounts, etc.)
ResultsMineralClass	Like "LA"	

Interim DB: Non ISO-AHERA DB (Btbl Linkage).mdb
Query Name: soil data_PLM-Grav

Identical to "soil data_PLM-VE" with the following exceptions:

Field	Constraint	Comment
AnalysisMethod	Like "PLM-Grav"	

Interim DB: Non ISO-AHERA DB (Btbl Linkage).mdb
Query Name: soil data_PLM-9002

Identical to "soil data_PLM-VE" with the following exceptions:

Field	Constraint	Comment
AnalysisMethod	Like "PLM-9002"	

Interim DB: Non ISO-AHERA DB (Btbl Linkage).mdb Query Name: soil data_PLM-9002 *Identical to "soil data_PLM-VE" with the following exceptions:*		
Field	Constraint	Comment
ResultsMineralClass	Like "TREM-ACTN"	This mineral class is representative of "LA".

In cases where more than one analysis was performed for the same sample, the highest analysis result was used to represent the sample [15]. In cases where more than one sample was collected for the same property, the highest sample result was used to represent the property. The following ranking system was used to select the highest result:

Detected >> below QL >> Trace >> Not Detected

328	N Properties w/ 1+ soil samples analyzed via PLM		
	264	ND	*80%*
	46	Tr	*14%*
	14	<QL	*4%*
	4	Detect	*1%*

For soil samples in which both the coarse and fine fractions were analyzed and one or both of the result values were detects, the final sample result was the mass-weighted average of the two fractions [16]. The mass-weighted average was calculated as:

$$(MF\%_{coarse} \cdot Mass_{coarse} + MF\%_{fine} \cdot Mass_{fine}) / (Mass_{coarse} + Mass_{fine})$$

[15] soil summ stats_risk calc.xls

[16] soil summ stats_risk calc.xls