

Rancho Seco's performance was eminently available to the citizenry, in part because it is a publicly owned utility, much of the information that proved most damaging to Rancho Seco would be available for any commercial nuclear power plant. Good sources of public information include NRC files, corporate reports, stockholder information and bond rating guides. Blackman concedes that when she became involved with the movement to close Rancho Seco, in the wake of the TMI accident of 1979, no one really thought they could close it. Even five years ago she would not have believed it possible. Today it is a reality.

### **Epilogue**

Many issues have yet to be decided at Rancho Seco, not the least of which is decommissioning. Nei-

ther the cost nor the procedures are clear yet. Rancho Seco will be the first commercial plant to require decommissioning. SMUD employees estimate that the plant will require a skeletal staff for about 20 years to allow the fuel to "cool off" before it can be removed from the core. Thereafter many questions will need to be answered regarding alternative uses for the plant. No one is certain whether it will ever be functional as a gas or coal-fired plant or whether such a use would even be desirable given Sacramento's poor air quality.

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*Andrew Sabey is a first year law student at U.C. Davis. Andrew would like to give special thanks to Michael Remy, Michael Krug, Martha Blackman and Ron Scott.*

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# **ASBESTOS HAZARD ASSESSMENT**

## **A View From the Trenches**

By Jennifer Decker

Most commercial applications of asbestos are already banned or are being phased out in response to governmental regulations, public fears, and industry concerns about current and future asbestos litigation. As asbestos disappears from the market place, complex, costly, and emotional asbestos lawsuits will appear with increasing frequency in our courts. According to a recent article in the San Francisco Chronicle, one-third of all new cases in San Francisco civil courts are asbestos related. Of the nearly 2,000 asbestos cases pending in San Francisco, 299 were filed in 1988 while 241 were filed in the first seven months of 1989; an increase of approximately 40%.

The latency period preceding the appearance of asbestos related diseases, such as asbestosis or mesothelioma, is generally twenty to thirty years after exposure. As a result, asbestos cases are typically brought by middle-aged or elderly plaintiffs who are nearing the end of their lives. Thus, as the Chronicle points out, the courts give these cases priority over other civil cases that have often waited three to five years to go to trial. Moreover, the U.S. Environmental Protection Agency (EPA) estimates that asbestos exposure causes 3,300 to

12,000 deaths per year. Clearly, the potential number of asbestos cases threatens our already overburdened judicial system

Society is responding to industry's mistakes from a generation ago and protecting future generations by imposing high jury awards for compensatory and punitive damages. However, asbestos cases are exorbitantly expensive to litigate. In U.S. v. Reserve Mining Company, 380 F. Supp. 11 (D. Minn. 19--), an asbestos trial lasted 139 days, principally due to the many unresolved technical issues involved. The trial included testimony by more than 100 witnesses, over 1,621 exhibits, and 18,000 pages of transcripts. The quantity of information needed to litigate each case and the magnitude of the current and potential asbestos cases, gives credence to Judge Marie-Victoire's statement that asbestos problems will plague our courts "way into the 21st century."

Industrial use of asbestos fell to a low of approximately 100,000 tons in 1988, down from nearly 900,000 tons in the early 1970's, primarily as a response to health concerns. Government measures were enacted to reduce exposure to asbestos containing materials (ACM's), thereby limiting asbestos-related diseases.

Regulations banning and phasing out ACM's attempt to reduce daily human exposure from various sources, including automobile brake and clutch wear and construction material deterioration. Legislatures have promulgated more stringent occupational exposure levels and tighter worker health and safety requirements and educational rules. In addition, Congress mandated that ACM's be removed from schools at a cost of billions of dollars in an attempt to protect the nation's children.

However, the regulations do not effectively solve the problems, and even create new ones. Many asbestos sources remain unregulated, are only partially controlled, or the existing regulations are not vigorously enforced. Furthermore, ACM's in buildings have led to the birth of new species of contractors, industrial hygienists and attorneys. These professionals must attempt to protect current occupants and avert disease-related lawsuits while anticipating when and what governmental regulations will affect them in the future. Improperly disposed of or illegally dumped ACM's, weakly regulated under the National Emission Standard for Hazardous Air Pollutants (NESHAPs), create additional problems. Often large quantities of ACM's are mixed with other toxins, eventually falling under the jurisdiction of state and federal Superfund cleanup programs.

California and a few other states face the additional problem of having natural asbestos deposits. California's state rock, serpentine, frequently contains a high percentage of asbestiform material, including chrysotile asbestos. Dozens of improperly closed or abandoned asbestos mine and mill sites allow, on a continuous low-level basis, overburden and mill wastes to enter exposure pathways. Additionally, the use of asbestos-bearing aggregate is not currently regulated in California; it is quarried and spread on hundreds of miles of unpaved roads as an inexpensive alternative to paving. Although eliminating these natural and anthropic sources is not possible, it is possible to reduce exposure to them. The pressing question for the 1990's is how far, and at what cost, society is willing to go to eliminate asbestos sources from our daily lives.

### **Where is it, how much is there, and is it a risk?**

To eliminate asbestos sources that have the potential to cause further disease, two steps must be taken. First, the amount of asbestos at the source must be determined. Asbestos regulatory programs identify and describe analytical and sampling techniques to

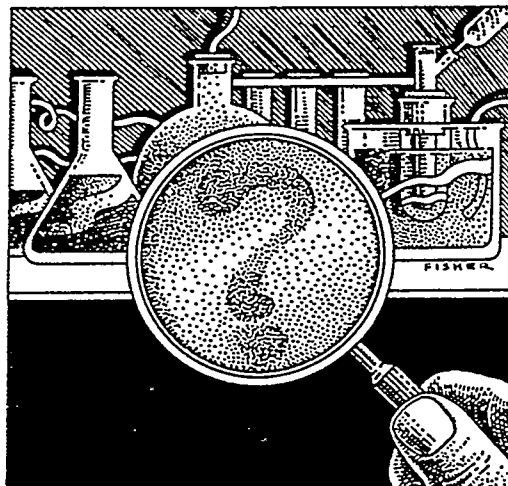
measure the asbestos in each regulatory context. Second, the measured level of asbestos in the sample must then be compared with risk tables and regulatory criteria. If that level exceeds permissible levels, action must be taken to correct the situation.

The federal government has already set criteria for certain exposure scenarios in various regulatory acts. These include the Occupational Safety and Health Administration (OSHA) regulations for worker protection; the Asbestos Hazard Emergency Response Act (AHERA) for schools; and the National Emission Standard for Hazardous Air Pollutants (NESHAPs) for asbestos disposal and mill sites. State governments also have regulatory programs for asbestos. Although the criteria, sampling, and analytical techniques vary between the various laws, these regulations do act as road maps for decision-makers in their attempts to bridge the gaps within and between 1) current levels of measured asbestos; 2) problems with the sampling and analytical techniques and data; and 3) how the levels in a location of concern relate to risks of asbestos related diseases. Most importantly, the criteria in the acts provide a common framework for assessing relative risks or for taking action in different locations.

### **What to do when no criteria, standardized sampling, or analytical method exists?**

When no regulatory criteria exists for a given situation or hazardous substance, industry and regulators must rely on their professional judgment for choosing equipment, sampling methodologies, and analytical techniques, and for performing risk assessments. This must be done on an individual basis for each chemical and at each site to determine how much asbestos or hazardous material is present and whether or not cleanup actions should ensue.

Setting criteria for asbestos on a site-by-site basis is more problematic. There is no consensus among



experts on many of the fundamental scientific issues involved. The lack of national consensus on technical issues renders decision-making at a particular site very difficult. An example of a problematic technical question is: To what degree do short asbestos fibers cause asbestos-related diseases? This affects whether or not short fibers should be quantitatively measured. Another problem is that in many situations involving asbestos, it is unclear which analytical method should be used and how qualitative data should be interpreted. Thus, which materials should be measured and how to quantitatively measure asbestos are unresolved issues.

### **The Basics of Asbestos Risk Assessments**

Risk assessments are difficult to perform and to understand for any hazardous substance. Asbestos risk assessments are more problematic than most. State-of-the-art asbestos risk assessments offer no guarantee that their results will reflect the true risks to the public. There is no assurance that there will be any correlation between future government regulations and the cleanup standard each waste site manager develops for a particular location.

Risk assessments involve two major components: hazard assessments and exposure assessments. These two components are ultimately compared, resulting in estimates of possible risks to humans from exposure to a particular hazardous substance.

### **Risk Assessments Part One: The Hazard Assessment**

The goal of a hazard assessment is to determine the potency of a given material, thus measuring how dangerous it is to humans and animals. Using data from animal studies and human epidemiological studies, experts develop a set of risk factors. The risk factors evaluate the relationship between exposure to various concentrations of asbestos and a related disease or response.

**1. Measuring Asbestos Concentrations: a Fibrous Particulate.** One of the factors complicating the process of assessing asbestos hazards is its shape. Asbestos is a fibrous particulate. Because of this, the number of parameters needed to describe the exposure level for asbestos is much greater than for most chemicals. A gas, for example, tends to be homogenous, and measuring its concentration (one parameter) is enough to measure the exposure level. Dust clouds made of spherical particles are more complicated, since the concentration and distribution of particle diameters must be determined to measure the exposure. That is, two

parameters must be accurately and precisely measured. In both of these examples, many types of mechanized forms of measuring concentrations exist which increase the accuracy and precision of the data generated.

In contrast to gases, quantitatively measuring the concentration of asbestos and other fibrous particulate is more difficult since a series of parameters must be measured. Both human epidemiological and animal studies support a general finding that parameters such as fiber length, aspect ratio, and other aerodynamic properties affect the carcinogenicity of asbestos. Thus, the parameters used in asbestos hazard assessments must describe the distribution of: 1) lengths; 2) diameters; 3) irregular shapes such as matrix debris; 4) complex structures such as bundles and clusters; and 5) overall concentrations of asbestos. Since microscopists individually count and describe these fibers and structures, a significant element of subjective professional judgment based partially on the microscopist's level of experience can greatly affect which fibers are counted and which are not.

**2. Epidemiological Studies are Based on PCM Measurements.** Most risk assessments are based on human epidemiology studies conducted in the 1940's and 1950's. These studies generally used Phase Contrast Microscopy (PCM) as the analytical technique to determine asbestos concentrations to which workers were exposed. However, PCM, when compared to modern qualitative analytical methodologies, is not state-of-the-art; it gives qualitative measurements only. PCM cannot measure accurately nor precisely the previously discussed parameters necessary to measure the asbestos fibers' ability to cause disease. PCM cannot differentiate asbestiform from non-asbestiform materials. Furthermore, PCM is unable to quantify fibers shorter than 5 microns in length or less than about .25 microns in



diameter. PCM can only qualitatively identify the possible presence or absence of long asbestos fibers.

Additionally, using PCM outdoors and at hazardous waste sites poses problems not found when testing for asbestos in an indoor setting. The ratio of dust to fibers is much greater outdoors than indoors. Typical outdoor environments have asbestos concentrations of less than one percent of the total particulate matter on sample filters. The greater dust levels obscure the fibers, making the analysis needed beyond the technical limitations of PCM.

**3. The Short Fiber Question.** Asbestos hazard assessment controversies most often focus on evaluating risks posed by asbestos fibers of different shapes and sizes. Most asbestos fibers in outdoor environments are less than five microns in length. If these short fibers cause disease it is important to quantify them. However, as discussed above, PCM is unable to even detect their presence.

Asbestos research clearly indicates a correlation between the respirability and the carcinogenicity of airborne asbestos structures. The results of this correlation are apparent in the numbers of workers exposed to airborne asbestos who are now appearing in our courtrooms with cancers. Physical characteristics of the fibers such as length, aspect ratio, aerodynamic diameter, and durability of the fibers determine the overall carcinogenicity of asbestos. Fibers having both diameters of .025 microns or less and lengths of more than five to eight microns penetrate into the alveolar spaces of the lungs, and have a higher correlation with disease than shorter fibers.

Although short fibers of less than five microns have been shown to be less carcinogenic than long, thin structures, short fibers are still biologically active. There is no concentration below which there is no risk to humans. As stated by William Nicholson in Airborne Levels of Mineral Fibres in the Non-occupational Environment, "Because of their much greater number, fibres less than 5 um (microns) may be the dominant contributors to the cancer risk of a particular aerosol." (1) The critical question is not if short fibers are active, but rather how active they are in causing disease.

The EPA and other agencies simplify the short-long fiber controversies by supporting a one fiber, non-threshold theory for all types of asbestos exposure. There is no real consensus, however, between the EPA theory and other federal laws. Nor is there agreement on criteria between local and state or federal laws and regulations. Criteria are not based on strong scientific

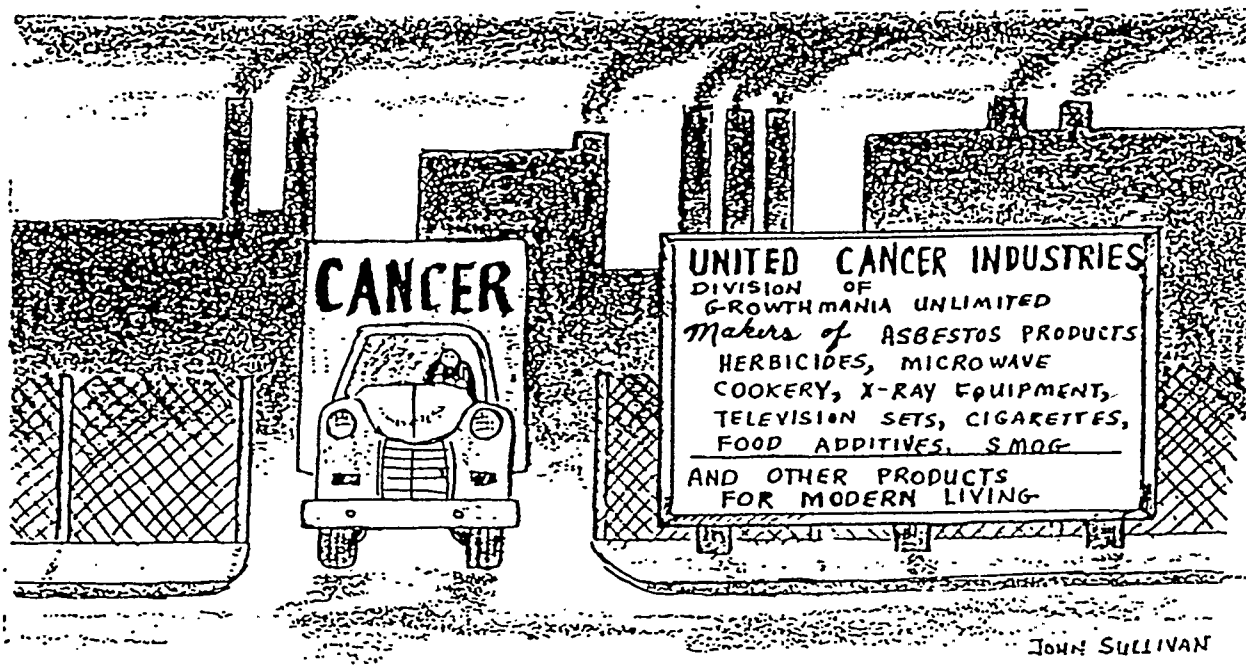
evidence but rather on the quantum leap from high levels measured in the epidemiological worker studies to the very low fiber levels of concern today.

The issue of short fiber risk is particularly important for asbestos waste sites and asbestos used on roads. These situations involve long-term exposure to very low concentrations of predominantly shorter fibers. Additionally, other particulate and debris associated with the asbestos at these sites may influence the biological activity of the fibers. Unfortunately, definitive resolution of the issue of the risks from short fiber hinges on a significant amount of additional research.

**4. Today's Air Samples are Analyzed by TEM, not PCM.** Because of uncertainties involved in other methods, transmission electron microscopy (TEM) is the only means for measuring true airborne asbestos concentrations outdoors and at hazardous waste sites. TEM has far superior resolution power which ensures that counted fibers are actually asbestiform structures and not cellulose or other organic debris. TEM detects fibers less than .01 micron in diameter and confirms the crystalline structures of observed fibers using secondary analytical methods. Finally, microscopists using TEM can document the length and width of asbestos fibers one by one, an approach that is more accurate and precise than PCM.

TEM, however, is not a perfect solution for measuring asbestos concentrations. Quality TEM samples generally cost \$300 to \$800 each. Thus, the cost of determining asbestos levels at any location can be tremendous. This is a particularly serious consideration when measuring ambient levels in a multi-storied building, throughout a city, or at a large hazardous waste site. In these situations, many samples must be taken in order to yield statistically significant results. Like PCM, TEM also suffers from variability between microscopists, a problem inherent in any analytical technique dependent on subjective human counting. Moreover, there are serious concerns with using an analytical technique such as TEM when minute sample results are extrapolated to characterize large areas. The decision whether or not to initiate a cleanup may depend on the presence or absence of just a few fibers in a sample that may not be representative of the entire site.

**5. The Need to Relate PCM Risk Charts to TEM Measurements.** Usually, exposure data for hazardous waste site air samples is collected by TEM. However, risk factors derived from epidemiological studies are based on PCM measurements. Thus, there needs to be a conversion factor between these analytical techniques.



Suggested conversion factors between TEM sample results and PCM risk tables have aroused great debate among asbestos researchers. Various conversion factors have been tried with varying degrees of success. Some researchers have modified the TEM counting rules to count only those fibers that the microscopist determines would be seen using PCM, while others have used mass conversion to PCM equivalents. However, no definitive study has shown any standard correlation between accepted conversion factors and air sampling results. Moreover, using one conversion factor rather than another can change the data results, and thereby the overall risk assessment results, by several orders of magnitude. Consequently, the risk assessment's conclusions can be considered qualitative at best, useful only for limited purposes.

### Risk Assessments Part Two: The Exposure Assessment

**1. Exposure Assessments in General.** The exposure assessment is the second major component in determining the risk to humans from exposure to toxins at a particular site. Exposure assessments consist of a number of different elements, including:

- \* the location of all possible sources of the hazardous substance at the site;
- \* the mechanisms by which hazardous substances are released from those sources and are transported to other locations;
- \* the routes of exposures to people and animals (such as inhalation); and

- \* the levels of exposure to people and animals, determined by direct measurements or modeling efforts.

**2. Difficulties in Obtaining Needed Information for Asbestos Exposure Assessments.** Determining asbestos exposure levels is the most difficult aspect of an exposure assessment and can result in a high degree of variability and error. It also involves the greatest expense since an exposure assessment includes sampling and analytical costs. Many of the problems faced in conducting asbestos exposure assessments are similar to those of a hazard assessment. The same analytical technique limitations and other technical problems surrounding fibrous particulate measurement must be confronted.

Each of the elements listed above which influence an asbestos exposure assessment present unique problems. Asbestos sources, for example, are not limited to primary logical sources such as construction materials, waste piles, or serpentine rock. Since asbestos fibers are principally carried by air, they continually move and settle in different places. Because of this, objects such as clothing, carpets, drapes and nearby property become important secondary sources in the assessment.

**3. TEM: Air Sampling.** The mechanisms by which asbestos is released and its rate of release are difficult to identify and measure since they are affected by human disturbance of the ACM's, wind speeds, humidity, and other factors. Air sampling helps determine spatial and temporal differences in concentration,

including upwind and downwind patterns, and changes due to meteorological conditions. Ideally, long-term air sampling should be conducted. This helps determine long-term average exposures to asbestos. The data can then be compared to the hazard assessment dose/response factors which are based on life-time exposures to asbestos.

Unfortunately, even a few weeks of quality air sampling and analysis can cost hundreds of thousands of dollars. Thus, exposure levels and rates of release are usually determined using fewer samples than most scientists and decision-makers would desire. Whether to use TEM or PCM for analysis, as discussed in the hazard assessment, is another problematic issue which must be resolved before taking samples.

In areas with high levels of particulate such as construction sites or other outdoor areas, sampling methodology choices must be resolved as well. A few factors that can dramatically affect the sampling results are sample volumes, types of pumps used, availability of power, and weather. The ratio of dust to total asbestos can be so great that high volumes of air must be pumped through the filters to turn up a few asbestos fibers under the microscope. Conversely, using too much air will overload and obscure the filters. If filters are overloaded, the samples cannot be analyzed using the most common direct TEM methods. If indirect sample preparation methods must be used, the TEM sample results will be useful only for limited purposes. Generally these results cannot be used to compare data from site to site, for legal cases, or for most risk decisions.

**4. PLM: Measuring Asbestos in Building Materials and Soil Samples.** Building material and asbestos-laden soil samples should ideally help determine the total amount of asbestos available for release into the air and its rate of release. This rate varies greatly based on factors such as whether the ACM is left undisturbed, or if, for example, heavy trucks drive over it on a regular basis. Meteorological conditions such as heavy rains or high wind patterns also affect the release rate. The results of the soil analyses are used in conjunction with air data and other factors, and are plugged into computer models. The models can help estimate future exposures to affected occupants, workers, or community members.

If the building material or asbestos-laden soil sample is highly non-homogenous, it presents a different set of hurdles. Problems stem from the analytical technique itself, and from the inability to interpret what the data results mean in terms of risk to humans.

The EPA developed the "Interim Method for the Determination of Asbestos in Bulk Insulation Samples," known as Polarized Light Microscopy (PLM), as a test for the presence or absence of asbestos in building materials only. Its application is not intended for quantification of non-homogenous materials, and PLM cannot measure shorter fibers. Such factors limit the use of PLM data in transport or risk assessment models. In the absence of any other method and out of necessity, however, the Interim Method has become the industry standard.

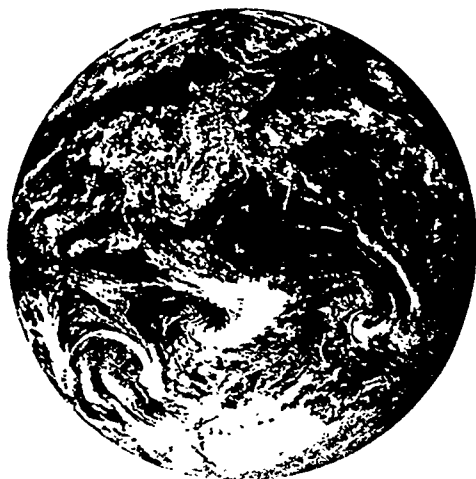
Analyses of non-homogenous bulk or asbestos-laden soil samples by different labs typically vary in four ways. The first variation is in sample preparation techniques before analysis. The different techniques include sieving samples and grinding by mortar and pestle. It is well documented in asbestos research literature that any disturbance of the ACM and asbestiform minerals causes clusters and bundles of asbestos to be broken into smaller fragments and finer fibers. Because some labs grind the samples before analysis and others do not, and because some labs sieve the samples and others do not, bias is clearly expected. However, the magnitude of the bias is unknown without standards for comparison.

The analytical technique itself reveals the second variable in PLM analysis for bulk and soil samples. The EPA method allows "point counting" or an equivalent method. Point counting divides the microscope's field of view into grids, and the microscopist counts asbestos within the grids using generalized counting rules. On the other hand, industry generally, but not always, uses the "field of view" method with other techniques as supplements. The "field of view" method is a percent area method for subjectively estimating the asbestos in the microscopist's field of view. The results of these methods offer no assurance of standardization since they are inconsistently reported as either percent area or percent volume.

Third, terminology varies greatly from lab to lab so that data results are difficult to interpret and compare. For example, some labs report concentrations of chrysotile. Others may describe the same material as "serpentine asbestos" or "elongated serpentine." These differences in terminology show that microscopists use different bases of measurement.

Finally, counting rules vary between microscopists especially for complex samples from hazardous waste sites. As with TEM, the microscopist's subjective opinion may affect the quality of data results. Since the





PLM technique is only able to indicate the presence, absence or a gross estimate of asbestos, its use is only appropriate for qualitative estimates. The technique falls short on quantitation for use in risk assessments, transport models or for setting cleanup goals.

The above is just a summary of the kinds of limitations facing asbestos analysis and quantification. Each variable in each sample or analytical technique is significant by itself; together the variables and unanswered questions become a real concern.

### **The Risk Assessment's Effect on Decisionmaking**

Once each of the hazard and exposure assessment elements are described as well as possible, the analysts perform a baseline assessment. The baseline risk assessment helps decision-makers assess what the long- and short-term risks to humans and animals would be without controls, cleanup, abatement or containment of the asbestos or hazardous material. If a hazard is determined to exist, this baseline assessment serves ideally to measure the effectiveness of the cleanup by allowing comparison of asbestos levels before and after taking action.

### **The Problem and Policy Considerations**

At hazardous waste sites, in buildings containing ACM, and on roads covered with asbestos-laden aggregate, the lack of standardized sampling techniques and regulatory criteria has led to many problems. There is great concern about the uncertainty of risks from shorter, thinner fibers and low level ambient concentrations of asbestos. Inconsistencies in sampling and analytical techniques between laboratories and between sites make comparisons of sites and data nearly impossible. These and other issues lead to concerns about the

lack of consistency for cleanup criteria, the defense of capital and maintenance costs, and the unclear risks to the public. The EPA, other regulatory agencies at the county and state levels, and private industry have made considerable effort to address these problems. Without sufficient research funds, however, questions about the risks posed by asbestos remain unanswered. Because of limited funds, problems with analytical methods, sampling methods and risk assessment protocols have been addressed as separate entities in the past. These problems are, however, very closely linked and must be addressed in a comprehensive manner to reach meaningful results.

Considering the thousands of tons of asbestos lurking in buildings and at hazardous waste and construction sites, there is an urgent need to resolve these scientific uncertainties. We also need more scientific data to support current regulatory standards. Ideally, the end-use of the sampling data, such as in risk or transport models, should determine both the sample preparation and analytical techniques. In addition to data collection, a standardized, quantitative risk assessment method would be an extremely useful tool for decision-makers. Such a standardized method would help ensure the safety of the nearby community, workers, or building occupants. It would also presumably be able to help defend a cleanup action at one site and the lack of cleanup at another.

### **Superfund: Addressing Sampling, Analytical, and Risk Problems**

The EPA, through its Superfund program, has funded a four-year research and development project to standardize air, soil, and risk assessment methodologies for hazardous waste sites. This project represents an opportunity for the federal government to use foresight and reflect on the asbestos problems of today. If successful, the project will address currently unanswered questions before more regulations are promulgated or more money is spent.

The project's results may apply to a wide range of other asbestos related problems. For example, application could extend to the construction industry's problems of determining how to assess the risks workers and community members face when working with asbestos-laden serpentine rock. This effort may also help solve some of the uncertainties involved in assessing risk from asbestos-laden aggregate on roads. Finally, the research and new techniques may offer solutions for asbestos in buildings and other situations as well.

## Conclusion

The 1988 EPA Study of Asbestos Containing Material in Public Buildings: A Report to Congress suggests that EPA should serve as a clearing house for research needed to fill the data gaps before regulating asbestos in buildings. The report clearly recognizes the size and scope of the asbestos analytical technique and risk assessment gaps. The EPA report states, "the nation's study and research program should be proportional to the magnitude of the public investment in controlling the problem which is contemplated." (2)

Consider for a moment the number of asbestos cases making their way through our court system at this time. Consider the Report to Congress estimate that 20% of all public and commercial buildings covered in their survey contain friable ACM's. The report estimates that an initial assessment in these buildings could cost over \$10 billion. The cost to clean up schools is in the billions of dollars. Known hazardous waste site evaluations and cleanups will total millions of dollars in expenses. The magnitude of the possible cost in human lives and potential expenditures to clean up asbestos warrants a national investment in research to answer the unresolved asbestos technical issues. Development of

the best possible standardized sampling, analytical, and risk assessment techniques will help identify real problem sites for future protection of the public. With this research, the nation will be able to make sound decisions based on science rather than uncertainty and fear.

## ACKNOWLEDGMENTS

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