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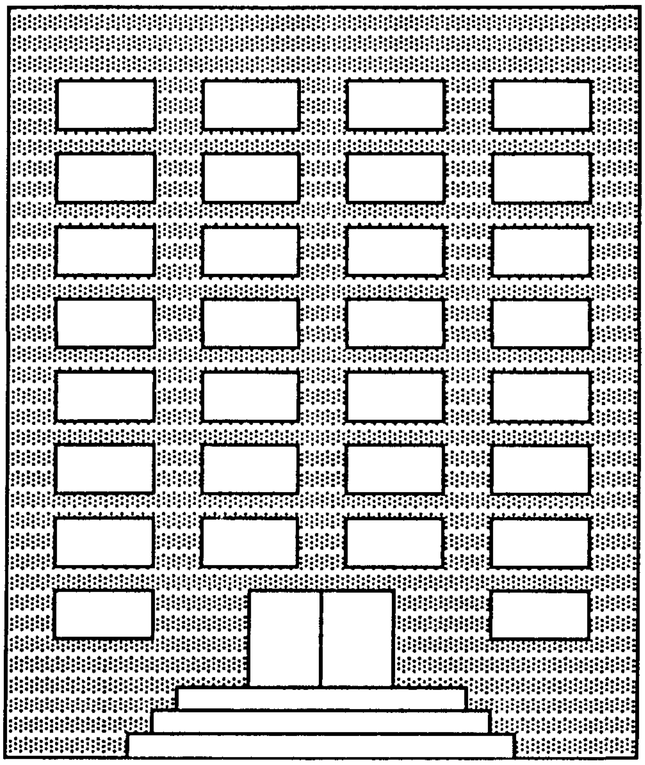
EPA STUDY OF ASBESTOS-CONTAINING MATERIALS IN PUBLIC BUILDINGS

A Report To Congress



U.S. Environmental Protection Agency
Washington, D.C.
February, 1988

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I. INTRODUCTION

A. BACKGROUND

The Asbestos Hazard Emergency Response Act (AHERA) was signed into law on October 22, 1986. AHERA requires the U.S. Environmental Protection Agency (EPA) to establish a comprehensive regulatory framework of inspection, management planning, operations and maintenance (O&M) activities and appropriate abatement responses to control asbestos-containing materials (ACM) in schools. The AHERA schools rule was signed by the EPA Administrator on October 17, 1987.

AHERA also requires that the EPA Administrator conduct a study to determine "... the extent of danger to human health posed by asbestos in public and commercial buildings and the means to respond to any such danger" (AHERA, Section 201(b)(3)). Section 213 of the Act sets forth the requirements for this study:

"Within 360 days after the date of the enactment of this title, the Administrator shall conduct and submit to the Congress the results of a study which shall--

> (1) assess the extent to which asbestos-containing materials are present in public and commercial buildings;
>
> (2) assess the condition of asbestos-containing material in commercial buildings and the likelihood that persons occupying such buildings, including service and maintenance personnel, are, or may be, exposed to asbestos fibers;
>
> (3) consider and report on whether public and commercial buildings should be subject to the same inspection and response action requirements that apply to school buildings;
>
> (4) assess whether existing Federal regulations adequately protect the general public, particularly abatement personnel, from exposure to asbestos during renovation and demolition of such buildings; and
>
> (5) include recommendations that explicitly address whether there is a need to establish standards for, and regulate asbestos exposure in, public and commercial buildings."

This report is EPA's response to that mandate.

Public and commercial buildings are defined in AHERA as all buildings other than school buildings or residential apartment buildings of fewer than 10 units. This definition includes all buildings which the "public" may typically occupy or visit--

office and apartment complexes, government facilities, museums, airports, hospitals, stores, and industrial buildings.

The EPA study consisted of a number of activities including a review and reanalysis of data previously collected by EPA during its 1984 national survey (USEPA, 1984a), a review of information on asbestos in buildings available from sources outside EPA, and new data collection efforts initiated by EPA during 1987. The activities in 1987 included a series of workshops with panelists (building owners, managers and investors, abatement contractors, State and local officials, Federal building managers) involved in asbestos management (Price, Price, 1987) and a study of airborne asbestos levels in Federal buildings (Hatfield et al., 1987).

B. REPORT ORGANIZATION

EPA has tried to make this report as useful as possible to Congress and to others who want to know more about the nature of the problem of asbestos in public and commercial buildings. The Congressional mandate for this report directed the EPA Administrator to make recommendations based on his assessment of the problem. These recommendations are presented in Section IV of this report.

In order to determine what the Agency's recommendations would be, the Administrator was presented with the entire report in its present format, except for the recommendation section. (This form is similar to the "decision memorandum" format which is routinely used inside EPA to arrive at major decisions involving the assessment and management of risk.) The Agency used this information to formulate a recommended course of action, which was incorporated into the last section of the report for submission to Congress. The "decision memorandum" format was retained to allow interested persons to follow the same analytic process used by EPA to reach its recommendations.

The report first discusses the scientific facts and uncertainties which help the reader understand the degree to which risk associated with asbestos in public and commercial buildings can be estimated. First, this "risk assessment" section of the report (Section II) addresses the hazards of asbestos in general, then discusses the limited information concerning the possible exposure of people to airborne asbestos in public and commercial buildings. Next, it summarizes the range of possible risk to workers and occupants in these buildings, which results from the combination of the hazard associated with asbestos and possible exposure to it. Because of limited exposure data, the risk assessment should be viewed with caution.

Section III of the report addresses the question of "risk management"--that is, how risk could be reduced. Several scenarios for future action to reduce the risk are examined. Attempts are made to characterize how much the risk would be reduced by these actions, and at what costs.

Finally, the report presents in Section IV the Agency's recommendations regarding what further actions should be undertaken in the near future.

As mentioned earlier, Congress directed that the Agency address five specific issues in this report. Issues 1 and 2 are addressed in Section II (Risk Assessment) of this report. Issues 3 and 4 are addressed in Section III (Risk Management). Finally, the recommendations requested under issue 5 are provided in Section IV.

II. RISK ASSESSMENT

A. HAZARD

Several life-threatening or disabling diseases, including lung cancer, mesothelioma, gastrointestinal cancer and asbestosis, can be caused by exposure to airborne asbestos, particularly at the high exposure levels experienced historically in occupational settings. In contrast to many toxic substances for which health effects are inferred from animal studies, the health effects of exposure to asbestos have been directly substantiated in epidemiological studies. The studies have been conducted for the most part on populations occupationally exposed to high airborne concentrations of asbestos for relatively long periods of time (CPSC, 1983).

Lung cancer has been associated with exposure, at occupational levels, to all of the commercial asbestos fiber types. It is responsible for the largest number of deaths from exposure to asbestos. Excess lung cancer has been documented in groups involved with the mining and milling of asbestos and the manufacture and use of asbestos products (See NRC (1984) and USEPA (1986) for summaries of studies and literature references). Cigarette smoking and asbestos have a strong synergistic interaction in the development of lung cancer; i.e., asbestos exposure appears to multiply the risk of lung cancer in smokers. Exposure to asbestos increases the lung cancer rate in non-smokers by a factor of about 5; risk is increased by a factor of about 50 for smokers exposed to asbestos (Hammond et al., 1979).

Mesothelioma, a rare cancer of the membrane that lines the chest and abdominal cavities, has been strongly associated with exposure to asbestos. An estimated 1600 cases of mesothelioma occurred in the United States in 1980 (NRC, 1984). This estimate corresponds to a cumulative mesothelioma incidence of less than 0.08 percent. Other data suggest a mesothelioma risk as low as 0.0002 percent. However, the incidence of mesothelioma is much greater among asbestos workers, approaching as high as 2 percent among asbestos miners and textile workers and as high as 10 percent among workers who manufactured asbestos-containing gas masks (Berry, 1986; NRC, 1984). The risk of contracting mesothelioma appears to be independent of smoking. Mesothelioma is usually fatal within two years of diagnosis.

Asbestosis is a serious chronic disease involving fibrosis of the lung and pleural tissues. There is no effective treatment and the disease is often disabling or fatal. Asbestosis has been observed mainly after high occupational exposures to asbestos.

Short-term occupational exposures (e.g., between one and two years) also have been shown to increase the risk of lung cancer and mesothelioma (USEPA, 1980; Seidman et al., 1979; Seidman, 1984). In addition, excess incidence of mesothelioma has been found in persons living in the households of asbestos workers (Selikoff et al., 1982) or living near asbestos mining areas, asbestos product factories, or shipyards where there was heavy use of asbestos (USEPA, 1980; NRC, 1984). As is typically done for other carcinogens, health effects associated with low level nonoccupational exposure to airborne asbestos fibers in public and commercial buildings have been inferred by extrapolating data from laboratory and occupational studies (USEPA, 1986). However, as with many other environmental pollutants, the validity of extrapolating from high level exposure to low level exposure has never been demonstrated empirically.

Summary

Asbestos is known to be extremely hazardous, based upon studies of both laboratory animals and asbestos workers and their families. Several life-threatening diseases, such as lung cancer and mesothelioma, can be caused by exposure to airborne asbestos. No safe threshold has been established for asbestos. Effects at low levels of nonoccupational exposure have been estimated by extrapolation from higher levels although the validity of this approach has not been empirically demonstrated.

B. EXPOSURE

1. INTRODUCTION

To analyze the degree of risk from asbestos in public and commercial buildings one must understand not only the inherent health hazards associated with asbestos but also the likelihood that people will actually be exposed to asbestos in these buildings. This likelihood, in turn, depends on the presence of airborne asbestos fibers and the tendency for fibers to be released into occupied areas. It must be emphasized that the presence of ACM alone does not imply exposure; fibers must be released from the material and must be inhaled. Four indicators of possible exposure are used in this report to shed light on the likelihood of actual exposure in public and commercial buildings. These indicators are:

- o Presence (summarized as the amount and type of ACM)
- o Condition of the ACM
- o Estimated airborne asbestos concentrations
- o Location of the ACM

Each of these four indicators is discussed in this section.

In the discussion which follows, asbestos-containing materials are classified as:

(1) surfacing material - ACM sprayed on or trowelled on surfaces, such as acoustical plaster on ceilings, fireproofing on structural members. Surfacing materials are usually friable (i.e., can be reduced to powder by hand pressure).

(2) thermal system insulation (TSI) - ACM applied to pipes, boilers, tanks, ducts or other structural components to prevent heat loss or gain, or water condensation; and

(3) "other" ACM - miscellaneous ACM such as ceiling and floor tiles, wallboard, or cement pipe. These materials are usually nonfriable and do not generally release fibers as readily as do friable materials, unless damaged.

Materials in the first two categories are of particular interest in determining the likelihood of exposure since they tend to be friable and may release fibers more readily than nonfriable materials in category (3). The data presented in this section refer to ACM in categories (1) and (2). Very little information is available on "other" ACM.

In assessing exposure, building occupants may be categorized into two groups. The first group consists of service and maintenance personnel ("service workers") who, without an awareness of the presence of ACM and adherence to special work practices and controls, are subject to peak episodic exposures if and when they disturb ACM. The second group ("other occupants") consists of office workers, visitors and anyone else not involved in renovation, repair, maintenance, or cleaning. Peak episodic exposure for this group is likely to be less than for service workers.

Whenever possible, public and commercial buildings are compared with school buildings since most of EPA's experience with asbestos in buildings to date has been with schools. Comparisons, however, are limited. EPA has been advised, in its discussions with school officials, building owners and managers, and other affected groups, that types of public and commercial buildings may differ from schools, as well as among themselves, in several important ways (Price, Price, 1987). For instance, the potential for damage or disturbance in schools might be greater than in many other buildings, given the nature of the occupants (children) and higher expected level of activity. In addition, schools usually have centralized ownership and management, a common activity in all areas of the building, and a period each summer when the building is vacant and available for major abatement activity. Further, schools represent a more distinct building type or category, in relation to all other public and commercial buildings. Because of these differences, it is difficult to make comparisons between schools and nonschool buildings with regard to exposure and risk.

2. PRESENCE

a. Data Sources

The estimates of presence of friable ACM in public and commercial buildings are derived primarily from data obtained in a statistically valid national survey (USEPA, 1984a). The target population consisted of Federal government buildings, rental apartment buildings with 10 or more dwelling units, and privately owned buildings used primarily for nonresidential purposes. Estimates for most types of nonfriable asbestos were excluded from the survey. The estimates provided below are for friable ACM only. Friable ACM refers to material which, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure.

The estimates of the presence of asbestos in schools were obtained in 1983 from a national telephone survey which was conducted in a statistically valid manner (USEPA, 1984b). Local education authorities provided information about the presence and amount of asbestos in schools based on inspections which they conducted to comply with the Asbestos in Schools Identification and Notification Rule, promulgated in 1982.

b. Characteristics

The 1984 building survey sampled buildings from a ta population of approximately 3.6 million public and commer buildings. It is estimated that friable ACM is present in 20 percent (733,000) of all public and commercial buildings covered by the survey. Five percent (192,000) of all buildings have sprayed- or trowelled-on asbestos surfacing material representing a total of approximately 1.2 billion square feet. A larger number of all buildings, 16 percent (563,000), contain asbestos in thermal system insulation. On the average, there appears to be a greater percentage of asbestos content in thermal system insulation than in surfacing material. Detailed tables of the results of this survey are presented in Appendix 1 and include the confidence intervals for the estimates.

Of the estimated 733,000 public and commercial buildings with friable ACM:

208,000 (28%) are residential apartment buildings with 10 or more units;

511,000 (70%) are private nonresidential buildings; and

14,000 (2%) are Federal government buildings.

The estimated 208,000 residential apartment buildings (with 10 or more units) which contain friable ACM represent approximately 59 percent of all such buildings (350,000) identified by the survey -- the highest percentage among the three categories. By comparison, Federal buildings with friable ACM represent about 39 percent of all Federal buildings (35,000) estimated by the survey, and private nonresidential buildings with friable ACM represent approximately 16 percent of the 3.2 million buildings estimated in the final category.

The results of an informal poll of members of building owners and real estate organizations conducted in 1987 are generally consistent with the results of the 1984 survey. The informal poll indicated that at least 20 percent of buildings that had been inspected contained some type of ACM.

In comparison, the national telephone school survey estimated that 35 percent (35,000) of schools in the survey contain friable ACM. From the local education agencies' inspection records, it is estimated that schools contain approximately 169 million square feet of surfacing material.

According to these data, a lower percentage of public and commercial buildings contain friable ACM than do schools (20 percent versus 35 percent).

3. CONDITION

a. Data Sources

Each area of friable material in EPA's 1984 national survey of public and commercial buildings was classified into one of three categories: good condition, moderate damage, and significant damage. This information, which did not appear in the original survey report, is tabulated in Rogers (1987). The data provide estimates of the condition of asbestos in public and commercial buildings.

b. Characteristics

Of all public and commercial buildings, an estimated 14 percent (501,000) contain damaged ACM. Five percent of all buildings (184,000) have moderately damaged ACM only, while 9 percent of all buildings (317,000) have at least some significantly damaged ACM. Overall, the incidence and severity of damaged thermal system insulation appears to be greater than the incidence and severity of damaged surfacing material.

The results of the 1984 survey are summarized below.

NATIONAL ESTIMATES OF FRIABLE ACM IN BUILDINGS
BY TYPE OF BUILDING AND CONDITION OF MATERIAL

(Numbers in 1,000's)*

	NON-RES PUB/COMM	RESI-DENTIAL	FEDERAL	TOTAL
Total Number of All Buildings**	3,221	350	35	3,600
Any ACM, Damaged or Not	511 (16%)	208 (59%)	14 (39%)	733 (20%)
Any Damaged ACM	416 (13%)	80 (23%)	5 (14%)	501 (14%)
Any Damaged ACM, Some Significant	310 (10%)	7 (2%)	<5 (1%)	317 (9%)

* Numbers are expressed in 1,000's. The percentages reflect percentages of the total number of buildings within each building type and are not additive (i.e., 416 (13%) is a subset of 511 (16%) and 310 (10%) is a subset of the 416 (13%); if these were added, double counting would occur).

** These numbers reflect the numbers of buildings in the survey target population, which included nonresidential public and commercial buildings, residential apartment buildings of 10 units of more, and Federal buildings.

4. AIRBORNE ASBESTOS LEVELS

a. Data Sources

There are relatively few data available in the public literature for estimating ambient levels of airborne asbestos inside buildings. The data assessed in this report were obtained from a variety of studies (see citations below) conducted in different types of buildings for various research purposes, and involving different types and conditions of asbestos-containing materials. As such, these airborne asbestos measurements are not based on a statistical sample of school and public buildings. To quantify these differences for the general population of buildings and schools, more extensive surveys would be needed. Therefore, comparisons using this information are limited to indications of possible differences which can serve to generate hypotheses for further research and data collection.

For prevalent building levels (i.e., levels not directly associated with maintenance or renovation activities) as measured by transmission electron microscopy (TEM)*, the most comprehensive data source is a recently conducted EPA study in 43 asbestos-containing Federal buildings (Hatfield et al., 1987). These buildings, which are covered by an asbestos management program, were selected to represent a range of material conditions but were not necessarily representative of all Federal buildings. Air samples were collected at sites containing the most seriously damaged ACM within each building. Other data were obtained from 35 buildings in the United Kingdom (Burdett and Jaffrey, 1986), 13 buildings in Ontario (Pinchin, 1982) and 3 sets of readings from Chatfield (1985). As stated earlier, the data from these 94 buildings are from diverse studies and do not represent a random sample. The values derived from them represent the best available estimates.

Direct TEM measurements are available for 6 schools studied by EPA's Office of Research and Development, 7 Canadian schools reported by Chatfield (1985), 4 British schools reported by Burdett and Jaffrey (1986), 6 schools in Ontario (Pinchin, 1982), and from reanalysis of samples collected from 18 schools in an earlier EPA study (Lee, 1987).

b. Characteristics

Prevalent airborne asbestos levels measured in the 94 non-school buildings containing ACM ranged from 0 to 0.2 fibers per cubic centimeter (f/cc) with an arithmetic mean of 0.006 f/cc.** Levels measured in the 41 schools ranged from 0 to 0.1 f/cc with an arithmetic mean of 0.03 f/cc.

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* Different analytical methods, in particular, lead to fiber concentration values that are not directly comparable. This Section's assessment is based on measurements developed using only one analytical method -- transmission electron microscopy (TEM) with a direct filter preparation technique. This method is currently recommended by EPA and has been specified, in current regulations for schools under AHERA, for "clearance testing" following a response action. A second analytical method, phase contrast microscopy (PCM), was used frequently in the past and is still in general use, although it lacks the analytic capabilities of electron microscopy, such as TEM.

** Note: To put these numbers in some context, the OSHA permissible exposure limit for occupational exposures (an 8-hour, time-weighted average) is 0.2 optical f/cc; a National Academy of Sciences study estimated that the average "background" level of airborne asbestos in the U.S. was 0.00007 optical f/cc.

Included among the data on the 94 nonschool buildings noted above are data which were collected in a 1987 EPA study of prevailing air levels in 43 Federal buildings, located in six cities across the Nation (Hatfield et al., 1987). The study's interim report indicates mean fiber concentrations in these buildings which are very low. Even in areas with significantly damaged asbestos-containing material (ACM), the mean levels measured only 0.00073 f/cc by TEM. Further, preliminary results appeared to indicate no difference between levels found in buildings with ACM and outdoor ambient levels, when compared at the 0.05 level of statistical significance. EPA is now completing its peer review of the interim report.

These data on airborne asbestos levels provide an indication of prevalent levels which may be found in schools and in non-school buildings. However, they are insufficient to support generalizations about the total population of buildings or the relative airborne concentrations in schools as contrasted with public and commercial buildings.

In addition, maintenance and cleaning activities that disturb ACM can result in elevated airborne asbestos levels of exposure for service workers (Pinchin, 1982; Sawyer, 1977; Versar, 1984).

5. LOCATION OF ACM

Information on the location of ACM was collected in the 1984 national survey (USEPA, 1984a) and reported in Rogers (1987).

An estimated 13 percent (462,000) of public and commercial buildings have friable ACM in fan and boiler rooms. These areas are frequented primarily by service and maintenance personnel. Ten percent (360,000) of buildings have some damaged material and 8 percent (282,000) have at least some significantly damaged material in these areas.

An estimated 13 percent (454,000) of public and commercial buildings have friable ACM in public areas. Eight percent of buildings (272,000) have some damaged material in public areas, and 2 percent (85,000) have at least some significantly damaged material, primarily TSI, in public areas.

Summary

Based on the results of EPA's 1984 national survey, approximately 733,000 or 20 percent of the 3.6 million public and commercial buildings in the survey contain friable asbestos. Approximately 501,000 of these buildings contain damaged material. About 317,000 of the 3.6 million buildings contain at least some significantly damaged material.

Significantly damaged material is commonly thermal system insulation (TSI), often found in nonpublic building areas, such

as boiler and machinery rooms. Because these are limited access areas for the general public or building occupants, asbestos exposures in these areas would be limited primarily to a relatively smaller number of service and maintenance workers.

Limitations in the exposure data prevent quantitative conclusions, or comparisons between schools and public and commercial buildings. Estimates of the number of persons exposed, the level of airborne asbestos exposure, the frequency or influence of episodic events which disturb asbestos, or the relative exposure levels of service workers in comparison with members of the general public are highly uncertain.

C. RISK

1. INTRODUCTION

Risk associated with exposure to asbestos can be calculated using mathematical models which translate cumulative exposure (i.e., f/cc per years of exposure) into expected number of deaths from mesothelioma and lung cancer. (Quantitative risk models for other cancers are not as well developed and the risk from these cancers is generally considered to be much lower. Asbestosis, which has been a prevalent disease among workers in asbestos mining and manufacturing, is not typically associated with nonoccupational exposure levels.) The expected number of lung cancer cases depends on cumulative exposure and age. The expected number of mesothelioma cases depends on cumulative dose and time elapsed since the onset of exposure (USEPA, 1986).

Two methods of analyzing risk are presented. Unfortunately, data limitations associated with airborne asbestos fiber levels, as discussed in the previous section, preclude any reliable estimates of risk. Instead, arbitrarily selected levels have been chosen and analyzed to demonstrate the sensitivity of the models under certain scenarios. The numerical estimates of risk associated with these arbitrary levels cannot be assumed to represent actual risk experienced in public and commercial buildings.

The first method, a proportional risk assessment, compares the percentage of total risk attributed to exposure in nonresidential public and commercial buildings with the percentage attributed to exposure in schools. The second method provides a discussion of absolute risk based on a selected exposure level, assumptions on length of exposure, and the number of people exposed.

2. PROPORTIONAL RISK

In this Section, a proportional risk assessment is used to illustrate the percent of total risk attributed to exposure in nonresidential public and commercial buildings as compared to the percent attributed to exposure in schools. Since information on exposure levels in these two populations of buildings is limited and the relationship between the two is unknown, several proportional risk scenarios are examined. It is likely that the appropriate scenario for service workers will differ from the scenario for general building occupants. In one scenario, it is assumed that the level in nonschool buildings is twice the level in schools. In another, the levels are assumed to be the same. In a third scenario, air levels in public and commercial buildings are assumed to be one-tenth those in schools. These and other scenarios are analyzed in Appendix 4.

a. Approach

Lifetime risk estimates are developed representing a total exposure to asbestos in schools from age 5 to age 18 followed by exposure in public and commercial buildings for periods ranging from five years to lifetime. Risk attributable to exposure only in public and commercial buildings is calculated separately and expressed as a percentage of the risk from the total exposure. This analysis evaluates the risk attributable to exposure in public and commercial buildings that occurs after school age and obviously simplifies a complicated situation. (For instance, it is assumed that children of school age are not exposed to asbestos in any public and commercial buildings before they are 18 years of age.)

b. Results

Risk is analyzed first under scenarios in which airborne asbestos levels are assumed to be the same in public and commercial buildings as in schools. In these scenarios, elimination of asbestos exposures in schools would substantially reduce risk for populations later exposed in public and commercial buildings. For example, for mesothelioma, the proportion of total risk attributable to exposure in public and commercial buildings ranges from 19 percent for 5 years' exposure to 43 percent for lifetime exposure -- less than half the total risk. The remaining risk is attributed to exposure in schools. The analysis suggests that the elimination of asbestos exposure in schools could have a particularly pronounced effect on the risk of contracting mesothelioma. Public and commercial buildings contribute proportionately more to the total risk of lung cancer (28 percent for 5 years' exposure, 76 percent for lifetime exposure). The different results for mesothelioma and lung cancer reflect the underlying risk models. In the mesothelioma model, risk depends on the time since onset of exposure and places additional weight on exposures early in life. The relative risk model for lung cancer depends only on total exposure (concentrations multiplied by duration); therefore long post-school exposures overwhelm the effect of the 13 years of exposure in schools.

The proportion of risk attributable to exposure in public and commercial buildings declines if airborne asbestos levels in these buildings are lower than in schools. If such scenarios are realistic, controlling exposures in schools may have an even greater impact on total risk than when airborne levels are the same. Under the scenario that prevailing airborne asbestos levels are one half those in schools, a lifetime exposure in public and commercial buildings contributes 28 percent of the mesothelioma risk and 62 percent of the lung cancer risk. If levels are as little as one-tenth those in schools the contribution is 7 percent for mesothelioma and 24 percent for lung cancer. Conversely, if airborne asbestos levels in public and commercial buildings are twice those in schools, exposure in nonschool buildings contributes up to 61 percent of the mesothelioma risk and 87 percent of the lung cancer risk in the model.

Nonschool exposure will comprise a greater share of the total risk for individuals who are exposed to asbestos in their residence as well as in schools and in public and commercial buildings.

3. ABSOLUTE RISK

The absolute number of deaths attributable to the presence of asbestos-containing materials in public and commercial buildings cannot be estimated with certainty because of limited information on airborne asbestos levels in these buildings, variability among measured values, and the difficulty of quantifying the number of people exposed. An estimate has been obtained based on one exposure scenario. The scenario uses airborne asbestos fiber levels from one school system analyzed by EPA; this level was selected based on the limited data that are available and the judgment of experienced EPA personnel. In the absence of abatement activity, fiber levels are assumed to increase during the remaining useful life of the building. Details are provided in Appendix 6.

Summary

A proportional risk model developed by the Agency suggests that the elimination of asbestos exposures in schools might significantly reduce residual risk for populations later exposed in public and commercial buildings, assuming equal or higher exposures in schools. Even though the elimination of asbestos exposures in schools may significantly reduce risk, there may be significant residual risk resulting from exposure in public and commercial buildings. Service workers may encounter higher episodic exposures, particularly if their activities disturb ACM. They appear to be equally at risk, whether employed in public or commercial buildings or in schools.

Estimates of absolute risk are subject to great uncertainty primarily due to limited data on prevailing fiber levels.

III. RISK MANAGEMENT

A. FRAMEWORK FOR RISK REDUCTION

EPA has identified and analyzed a variety of major scenarios across the spectrum of possible private and public response to asbestos risks in public and commercial buildings. These scenarios range from supporting current private, State and local action to enacting a full regulatory control program, similar to the Asbestos-Containing Materials in Schools Rule ("schools rule") promulgated on October 17, 1987, under AHERA. They are listed and examined in greater detail in Section B, generally in order of increasing Federal government intervention. To discuss these scenarios meaningfully it is necessary to identify common assumptions, including a baseline against which any additional risk reduction can be judged.

1. IDENTIFICATION OF A BASELINE

For purposes of this report, the baseline will be defined as the composite of all actions or programs, voluntary or mandated by law, that are currently underway, with the abatement of risk from exposure to asbestos as their objective. Actions that are taken as a result of current market forces, or by individuals in the private sector, are already addressing risk from asbestos exposures in public and commercial buildings, in conjunction with existing State and local government activities. However, the extent and effect of this activity on actual risk is not clear. Private sector actions have increased asbestos control and abatement in public and commercial buildings in the last several years, motivated in part by public perceptions of hazard, liability, tenant pressures, lenders' concerns about property value, and Federal and State regulation, technical assistance and guidance.

State and local supervision and control programs have expanded rapidly in recent years. At least 39 States now have some type of abatement contractor certification program -- an increase from only five in early 1985. Some State and local governments, Rhode Island and New York City, for example, have comprehensive asbestos management regulations; others are now considering regulatory steps beyond certification and training programs.

Several Federal asbestos regulatory programs presently exist. (Summaries of existing Federal regulations are provided in Appendix 3.) Two Occupational Safety and Health Administration (OSHA) asbestos standards address protection for manufacturing, abatement and service workers and other private sector employees, while EPA's worker protection rule affords essentially the same protections to abatement workers in the public sector where OSHA standards do not apply. Asbestos emissions during building demolition or renovation and the transport and disposal of asbestos waste are regulated under

EPA's National Emission Standard for Hazardous Air Pollutants (NESHAP) for Asbestos. These Federal regulations, which have been recently revised or are currently being revised, afford protections to the general public and abatement personnel from exposure to asbestos during building renovation and demolition activities. The AHERA schools rule is also now part of the baseline and may provide voluntary guidelines for public and commercial building owners.

In addition, EPA's asbestos technical assistance program, initiated in 1979, has developed various guidance materials for controlling and managing asbestos in buildings. It also provides technical experts in the field to advise building owners, and offers funds to develop State programs, to promote proper training, to advance control and abatement technologies, and to improve work practices. The Agency has established asbestos information and training centers at a number of universities across the nation and developed model training materials for these centers and other training providers. As a result, thousands of abatement project supervisors and workers have received instruction on proper abatement practices and procedures.

In recent discussions, EPA has been advised by building owners and managers in the commercial sector that since 1983 the number of buildings inspected, placed under management plans, and scheduled for asbestos abatement has increased significantly, and removals have decreased the amount of asbestos remaining in public and commercial buildings (Price, Price, 1987).

In sum, States and localities are increasingly taking the initiative in establishing asbestos control programs to the extent they believe it is appropriate for their jurisdictions. Federal regulatory and technical assistance activities have increased public awareness and understanding, supported responsible marketplace action, and facilitated State and local activities.

However, this increased activity does not guarantee risk reduction in every case. Some actions may result in unnecessary or improperly conducted removals, which may increase asbestos risk rather than reduce it. In other cases no action will be taken even when abatement is necessary to protect human health and the environment.

In mandating this report on asbestos in public and commercial buildings, Congress directed the Agency to address the need for regulatory action. Any such regulatory action would be intended to provide risk reduction <u>over and above</u> that which would occur without regulation. In other words, is <u>additional</u> risk reduction necessary and appropriate?

Unfortunately, the Agency does not have the data to produce a scientifically acceptable estimate of risk due to asbestos exposure in public and commercial buildings, let alone to quantify the risk reduction now underway in public and commercial buildings as a result of private, State and local government actions. In addition, the Agency is unable to estimate how risk reduction activity might increase in coming years in the absence of further Federal intervention. Additional survey and research would be necessary to determine the level of current activity and to estimate its possible growth in future years.

2. THE ADEQUACY OF EXISTING FEDERAL REGULATIONS

Several Federal regulations serve to protect the general public, particularly abatement personnel, from exposure to asbestos during renovation and demolition. These are the OSHA asbestos standards, the EPA worker protection rule (which essentially affords OSHA-type protections to public sector abatement workers), and the EPA NESHAP for asbestos.

OSHA's worker protection program is based on numerical exposure standards: an action level and a permissible exposure level (PEL). If airborne fiber levels, measured as an eight-hour time-weighted average by phase contrast microscopy (PCM), exceed 0.1 f/cc (the action level), employee information and training, and eventually medical surveillance programs must be initiated. If the eight-hour time-weighted average measured by PCM exceeds 0.2 f/cc (the PEL), a complete workplace protection program, which includes respiratory protection, must be implemented. OSHA's standards apply to general industry and construction. The contruction standard covers abatement workers, while most of the private sector workers are covered under the general industry standard. Service workers may be protected by either the general industry or construction standard, depending on their work activities. These standards are enforced both by random inspections of workplaces and by response to worker complaints. In 1986, OSHA conducted a total of 64,100 inspections. A total of 856 citations for violation of the asbestos standards were issued during that same period. The EPA worker protection rule includes essentially the same provisions as the OSHA standards, but it currently applies to public sector abatement workers only.

The NESHAP applies to building renovation and demolition involving friable asbestos-containing materials. The building owner or operator must provide written notice to EPA of intent to renovate or demolish, and must follow basic asbestos emission control procedures (i.e., use wet methods, handle according to regulatory specifications). Transport and disposal provisions prohibit visible emissions. In 1986, EPA conducted a total of 15,060 NESHAP asbestos inspections and found 2,179 violations. EPA is currently revising the NESHAP regulation to make it more effective.

The Congressional mandate for this report directed EPA to assess whether or not the existing Federal regulations are adequate. There are two ways in which this question can be addressed. First, the existing Federal regulations set acceptable exposure levels in order to protect public health. If these levels are indeed adequate for their purposes, are the mandates stringent enough to ensure that the regulated parties actually do comply with them? Since asbestos is a human carcinogen and EPA risk models (based upon National Academy of Sciences findings) assume there is no safe level of exposure, there is inevitably some residual risk even if all the regulatory standards are met. In this instance, OSHA determined that its rules "substantially reduced" risks associated with earlier standards. At the same time OSHA acknowledged that, given considerations of feasibility, workers exposed to asbestos at the PEL level "remain at significant risk." EPA has not attempted to revisit this determination, which was promulgated by OSHA in 1986 after nearly three years of consultation, comment, and public hearings.

The second way to address this question of adequacy is to ask what the actual exposure is to workers and the public with these regulations in effect. No regulation is self-executing. What is especially difficult with regard to asbestos exposure is its episodic nature. People can go for years with little or no exposure to asbestos and then receive a significant dose because of a major disturbance to asbestos-containing material that may result from either ignorance or negligence.

To prevent many of these episodes, asbestos identification and control is required by those who are subject to these rules. Education of the regulated parties or some other means of inducing compliance with identification and control is necessary if full protection is to be achieved under the OSHA standards, and EPA worker protection and NESHAP rules.

3. THE EFFICACY OF AN "ACCEPTABLE LEVEL" STANDARD

Under the traditional approach to addressing a chemical hazard, EPA might identify and publish an "acceptable level" standard of exposure to asbestos-containing materials in buildings, based on a process such as air monitoring. The Agency would assess the risks, establish acceptable levels of exposure, require periodic monitoring, and identify proper engineering controls which would be implemented if those limits were exceeded.

Such an approach would target abatement and removal actions in those situations where such actions are clearly necessary, based on information which approximates actual exposure information. However, such an approach appears not to be practical at this time for the problem of asbestos in buildings, for the following reasons:

First, some of the exposure of persons to asbestos in buildings may result from episodic events, such as repair work, or the accidental jarring of the asbestos material by activities inside or outside the building. For air monitoring to reflect these episodes, it must continue long enough to record a "representative" period of time during which such episodes might occur. Since these types of episodes may vary widely and are hard to predict, the representative period would have to cover several days if not weeks or months. Unfortunately, EPA has insufficient data to determine whether such episodic releases contribute significantly to total risk. In addition, current exposure levels may not be representative of future levels. ACM can become damaged or deteriorated over time under certain circumstances so that an "acceptable" reading on the air monitor this year does not mean that one would get the same "acceptable" reading two years from now.

Second, the most accurate monitoring would be by transmission electron microscopy (TEM) since phase contrast microscopy (PCM) cannot distinguish between asbestos fibers and other kinds of fibers (e.g., textile fibers). The costs of a TEM monitoring program would be extremely high. At current costs of $200 to $400 per sample, a one-time monitoring program for a single commercial office building could cost several thousand dollars. For all public and commercial buildings with friable ACM, EPA estimates that the costs could exceed $10 billion for a one-time monitoring program. Clearly a one-time monitoring program would not satisfy the need to protect against deteriorating ACM which may not be releasing fibers today, but may sometime in the future.

In the face of these constraints the Agency has traditionally relied on another approach to determine when abatement and removal action is appropriate. This approach to the problem involves laboratory identification of ACM and visual assessment of its condition by trained personnel. Visual assessment of ACM also has its drawbacks because visual assessment is a subjective process. While trained raters appear to give more consistent evaluations than untrained raters, inconsistent evaluations by trained raters still occur. As techniques are developed for monitoring and determining the likelihood of exposure, EPA will continue to address how to advance the state of the art. In the meantime, the options for risk reduction in this report do not include the setting of an acceptable level of exposure to asbestos with accompanying air monitoring.

4. INFORMATIONAL DEFICIENCIES

In examining a framework for risk reduction, EPA recognizes important deficiencies in the information base which limit the Agency's present ability to assess options, draw conclusions and make recommendations concerning the regulation of asbestos in public and commercial buildings. Basic information on exposures to airborne asbestos in buildings is not fully available on key considerations which include measurements of exposure levels and validated assessment schemes for determining when to take action or for determining the efficacy of actions taken. Specifically, more information would be useful in:

1. Developing improved assessment tools for use by building owners and managers in the context of an asbestos management program that would allow them to determine what, if any, abatement activities are appropriate for a particular building. The Agency's previous efforts to develop and validate quantitative and non-quantitative assessment methods have not been successful. A research study could be undertaken to address this need and to attempt to develop a valid assessment tool. However, due to the complexities involved and technical sampling and analysis considerations, it is impossible to estimate the cost or duration of such a study or to predict its success at the present time.

2. Assessing the difference in risk between (indoor) public and commercial building exposure and outdoor ambient air exposure, which includes:

   o The levels of prevalent airborne fibers in public and commercial buildings; and

   o The number and age distribution of persons exposed to ACM in public and commercial buildings.

   This information would be needed to determine whether exposure to air in public and commercial buildings poses risk from asbestos exposure that is measurably greater than that posed by outdoor ambient levels, and if so, to what extent. (Studies 6, 7a, 8a and 8b in Appendix 7 address this limitation.)

3. Assessing whether exposure differentials exist across different types of buildings (e.g., highrises versus garden apartments) or among different areas within buildings (e.g., boiler rooms versus office space). This would allow for different technical assistance or regulatory actions to be taken for different buildings types or areas within buildings. (Study 6, study 7a and its variations, 7c, 7d, and 7e address this limitation.)

4. Assessing the presence, range and significance of elevated exposures to service workers while doing maintenance, repair, and cleaning activities as compared to prevalent level exposures for office workers and other building occupants. This would provide information on the service worker population to determine whether separate control programs should be developed for that group. (Studies 6 and 7b address this limitation.)

5. Assessing the effect of remedial action on exposure (such as O&M and other abatement activities, including removal). EPA has limited data to indicate if certain actions actually reduce exposure/risk to airborne asbestos. (Studies 2, 3, and 6 address this limitation.)

6. Assessing the full extent of private sector and State and local governmental asbestos management programs and their actual impacts on exposure and risk. This information would help develop technical assistance or regulatory programs where they are most needed. (Studies 5a and 5b address this limitation.)

This information is currently unknown and would have to be acquired through subsequent studies by EPA or other parties. It would improve the Agency's ability to estimate exposure, identify risks and recommend responsible technical assistance and regulatory options to address hazards. Any such research is complex, expensive, and time-consuming. Furthermore, serious technological difficulties may need to be overcome if some of these major asbestos research programs are undertaken.

Further descriptions and costs of possible studies to fill these gaps are provided in Appendix 7.

B. SCENARIOS: FEASIBILITY, RISKS AND COSTS, AND POLICY CONSIDERATIONS

Asbestos in public and commercial buildings is not a new issue, and considerable attention is now being given to this matter by State and local governments, building owners, lenders, and occupants. However, given the asbestos information detailed earlier in this report, the question is whether additional action, if any, is warranted at this time.

EPA examined six major risk reduction scenarios which go beyond present activity. To the extent possible, given the current data, the Agency analyzed the feasibility, risk reduction, and costs of implementation of each scenario. These scenarios are:

- **Enhanced Technical Assistance**
- **Federal Buildings as a Management Model**
- **Inspection Rule**
- **Targeted Regulation**
- **Sequential Regulation**
- **Immediate Comprehensive AHERA-Type Regulation**

The feasibility, risks and costs, and the major policy considerations associated with each scenario for risk reduction are discussed and assessed generally in the order of increasing Federal government intervention and cost.

1. ENHANCED TECHNICAL ASSISTANCE

This scenario would increase the Agency's asbestos technical assistance and guidance activities by targeting populations in particular need of protection, such as service and maintenance workers, and by concentrating Federal resources on key activities which would benefit most from EPA direction. Individual technical assistance and guidance activities that could be considered are presented below in six major categories. One, some, or all of the categories could be selected.

a. Protecting service and abatement personnel

Under this category, EPA could develop a model O&M program, including guidance and training materials, in conjunction with OSHA, unions, worker groups, building owners and managers. In particular, the Agency could promote a voluntary inspection program as well as the practice of testing suspect materials prior to a scheduled maintenance activity, as is implied but not explicitly required by the OSHA standards.

Increased compliance with existing Federal regulations (OSHA, NESHAP and EPA worker protection) might be achieved through additional education, enforcement and coordination activities (Price, Price, 1987). EPA could fund and publish O&M case studies or model management plans for major types of public and commercial buildings, such as hospitals, airports and highrise office buildings.

In addition, the Agency might provide incentives for encouraging asbestos information and training centers and other instructional programs across the Nation to offer O&M training courses, and might increase its support of O&M training programs among unions, professional associations and training organizations.

b. Advising the building owner and manager

EPA could develop and publish guidelines for inspection, management planning, hazard assessment, the completion of response actions, and other appropriate control activities, perhaps using relevant aspects of the AHERA schools rule as a model or as voluntary standards for building owners and managers. Further, EPA could establish a voluntary control program in cooperation with building owner/manager associations and provide additional grants to States for inspection and management planning programs.

c. Improving public understanding

EPA could publish a citizen's guide on asbestos hazard and risk and encourage or sponsor symposia, teleconferences, national meetings, and other similar media activities to increase public understanding of asbestos hazards and relative risks.

d. Facilitating State and local activity

EPA could develop and distribute administrative models for various types of State control programs, including inspection and management planning. (The EPA's model contractor certification program for States has provided the basis for many current State and local programs.) The Federal government could help States implement voluntary asbestos management programs which utilize existing mechanisms such as building permits or tax credits. The Agency might also help States create and implement programs which train and accredit asbestos control personnel, which support regulatory or voluntary asbestos management programs, or which provide technical or financial assistance to building owners and managers.

e. Promoting new technology and research

At this time, the Agency lacks adequate information on: the number of persons exposed to ACM in public and commercial buildings and the levels of exposure in these buildings; the effects of special O&M and other abatement activities on exposures; the extent of marketplace/private sector actions and their impacts on exposure and risk; and other factors that are important in determining what future actions are appropriate. Research in these areas would improve EPA's ability to help guide future decision-making.

EPA could also serve as a clearinghouse for evolving asbestos technical information. The Federal government could accelerate research in key developmental areas, such as air monitoring, replacement materials, sampling techniques and abatement technologies, and conduct studies of asbestos in public and commercial building situations (highrises, abatement in occupied areas, etc.). EPA could also conduct supplemental surveys to fill specific information gaps. A formal risk assessment and quantitative cost-benefit analysis of the leading regulatory scenarios for public and commercial buildings may also be useful.

f. Increasing abatement training and performance

EPA could promote the extension of accreditation programs in the States, along the lines set by the AHERA Model Accreditation Plan for schools, to persons who inspect, develop management plans, or design or conduct response actions in public and commercial buildings. The Agency could continue to support the concept of information and training centers at universities and other facilities across the Nation. The Federal government could cooperate with training organizations and professional associations to sponsor or promote training activities.

Feasibility

EPA's technical assistance programs have been well received and relatively successful in providing guidance to decision makers (Price, Price, 1987; Dietz, 1987). Further, EPA already has the framework in place to deliver increased assistance through Regional asbestos coordinators and support staff under the American Association of Retired Persons (AARP) Senior Environmental Employment Program.

Risks and Costs

Technical assistance would likely influence existing private sector incentives (market value concerns and litigation) and help guide the actions of the marketplace toward greater risk reduction. This scenario also allows the Agency to target scarce resources on the groups which may be at higher risk, such as service workers. Costs to the Federal government could range from two to three hundred thousand dollars to as much as $74 million, depending upon what elements are included in the program. Details on costs are provided in Appendix 5.

Policy Considerations

Targeted technical assistance would allow the EPA to help shape and guide the activities of the private sector by improving key private sector and State capabilities. This scenario would not impose regulation, which might be burdensome, and, given current knowledge of exposure and risk, premature. As EPA provides better information on exposure and risks (and their uncertainties), private sector judgments should result in more appropriate risk management decisions. In addition, States may continue regulatory programs at levels they deem appropriate under this option.

As the AHERA schools rule program advances, it should provide a better context for assessing the real impacts of future regulatory steps, if these are deemed necessary, for public and commercial buildings. AHERA accreditation in the States should also increase the availability of trained experts to improve the prospects for risk reduction in public and commercial buildings. In addition, voluntary standards could be established, which would benefit contractors, building investors and lenders, and worker groups, without imposing Federal regulations on building owners and managers.

On the other hand, this option would leave decisions regarding whether and how to address the asbestos problem in buildings to unknown market forces, private initiative, and State and local regulation which may not result in consistent risk reduction.

2. FEDERAL BUILDINGS AS A MANAGEMENT MODEL

This scenario would establish Federal buildings as a model management program that could be used voluntarily in other public and commercial buildings. It could also provide a laboratory to test policies, programs and schedules for their appropriateness and to improve EPA's information on exposure and risk in buildings. The program could consist of one or more of the following activities: inspection, management planning, operations and maintenance (O&M) programs, and identifying, selecting, implementing, and completing appropriate response actions in Federal buildings.

A variety of analytical and evaluative activities could be instituted as part of the model program. Relocation and reoccupancy practices could be tested, as well as occupant awareness and notification policies. Additional research might be conducted on the effect of abatement activities on exposure, particularly in highrise buildings or near occupied space. Alternative hazard assessment schemes and emerging technologies for hazard abatement and respiratory protection could be evaluated. Results would be available to the public and guidance developed and distributed as appropriate for voluntary public and commercial building use. The Federal buildings program could also be evaluated after a fixed period, along with the AHERA schools rule program, to provide a better context for future regulatory assessment.

Feasibility

The General Service Administration (GSA), the Federal government's primary building owner and manager, already has in place a relatively comprehensive inspection and management program. Further, the Federal building universe, including about 14,000 buildings which contain asbestos, is manageable and an Executive Order might be sufficient to establish a mandatory program. However, Federal departments or agencies could find a mandatory program difficult to implement within present budgets since the costs could be high. GSA, for instance, has spent at least $35 million on inspection and abatement activity, and since 1978, the U.S. Postal Service has spent $50 million for asbestos abatement in about 800 buildings (Dietz, 1987). Also, Federal workers might object to the use of their workplace as a "testing ground" for experimental asbestos control and abatement activities.

Risks and Costs

This option should result in some risk reduction for Federal employees and other occupants of Federal buildings, particularly if appropriate response actions were identified and implemented in a timely manner. However, the extent of this risk reduction is questionable. EPA's interim report, as discussed previously in the Airborne Asbestos Levels part of Section II, did find very low prevailing asbestos fiber levels in surveyed Federal buildings and no significant difference between levels in these buildings and those taken outdoors, although these results cannot be considered representative of all Federal buildings (Hatfield et al., 1987).

EPA's analysis for this scenario indicates that a full regulatory program for approximately 35,000 Federal buildings would cost under $4 billion (discounted at 10 percent over a 30-year period). This estimate excludes costs for EPA analysis and evaluation activities. It also leaves out ongoing costs associated with GSA's current management program activities.

Policy Considerations

The scenario would provide additional exposure and risk information on a specific sector of public and commercial buildings, and deal with the practical difficulties of a mandatory control program before deciding whether to impose regulations on other public and commercial buildings. GSA's existing asbestos management program provides a good foundation on which to build. Analytic and evaluative activities in Federal buildings should improve EPA's understanding of risk in such buildings and help identify appropriate control strategies for other public and commercial buildings.

On the other hand, EPA's air monitoring study indicates that relatively low prevailing airborne asbestos levels exist in sampled Federal buildings. Further, some Federal agencies, like some public and commercial building managers, might resist a mandatory program, particularly without better information on exposure and risk, especially if costs are high. Finally, the Federal government could be criticized for protecting Federal employees before other public and private employees or the general public.

3. INSPECTION RULE

This scenario would have EPA promulgate an inspection inventory and notification requirement for public and commercial buildings that is similar to EPA's 1982 Asbestos-In-Schools Rule. Under this rule, building owners would be required to inspect for friable and nonfriable asbestos materials, sample and analyze suspect materials, document results and provide notification.

An inspection component (locating and testing suspect materials) is the first critical step in a proper asbestos management plan. The location of ACM must be determined before appropriate worker protection and work practices can be implemented or before appropriate response actions can be identified to control or eliminate exposure. To inspect, one may either:

- Conduct a complete inspection of the building to develop an inventory of ACM at the time the management program is initiated, as is contemplated by this option; or

- Test suspect material prior to a scheduled activity (such as maintenance, repair, renovation) that may disturb the material.

A comprehensive building inspection inventory consists of four components: (1) reviewing building records for references to asbestos used in construction or repairs; (2) inspecting materials throughout the building to identify those which may contain asbestos; (3) sampling suspect materials for laboratory confirmation that asbestos is present; and (4) mapping the locations of all confirmed or suspected asbestos. Relevant documents should be retained. If asbestos is not present, no action beyond proper documentation is necessary.

<u>Feasibility</u>

The scale of the undertaking would be considerable, as an estimated 3.6 million buildings are involved. For comparison, compliance with the 1982 school inspection rule, which included approximately 100,000 schools, has reached about 60 percent after five years. While protocols for bulk sampling and analysis are standard and costs are low ($35 per sample) for this option, the availability of qualified inspectors, bulk sampling laboratories and other support capabilities would be insufficient at least in the near future to meet demands, in part due to the ongoing implementation of the AHERA schools rule.

Risk and Costs

Risk is not reduced by virtue of an inspection alone. Subsequent voluntary measures, such as management planning, maintenance practices and scheduled abatement activities, would have to follow in order to reduce risk in actuality. (OSHA and EPA NESHAP rules would govern some of these activities.)

EPA's cost analysis for this scenario indicates that an inspection program, as outlined above, for public and commercial buildings would cost nearly $2 billion. Inspection costs per building range from $150 to more than $2,500, depending upon building size and other factors.

Policy Considerations

An inspection, either voluntary or mandatory, is necessary to set a proper foundation for management planning, O&M programs and the selection and implementation of other appropriate response actions to reduce exposure and risk. A prior inspection rule, in association with private sector incentives, did compel many schools to identify asbestos hazards and implement appropriate response actions. It is conceivable, therefore, that an inspection rule alone might achieve a fair degree of activity. Inspection documentation and worker/occupant notification enable knowledgeable occupants to "enforce" responsible manager behavior.

On the other hand, an inspection inventory program appropriate for schools may not be appropriate for public and commercial buildings. First, these buildings, unlike schools, are often characterized by multiple managers and diverse, individual occupant agreements. An inspection inventory would involve negotiations and agreements with individual tenants addressing issues such as notification, education, cost, lost productivity, and liability for damage. Perhaps more important, current NESHAP and OSHA rules already presume that suspect buildings materials are identified, sampled and tested before disturbance, although this presumption may not be supported by actual practice.

4. TARGETED REGULATION

This scenario would have EPA promulgate a rule which would go beyond requiring inspection but which would stop short of a full AHERA-type regulation in public and commercial buildings.

The major activities, in order of normal precedence, which might be part of a targeted regulation are:

° **Inspection Inventory**, as described and discussed in Option 3 above.

° **Management planning.** Management planning is a decision process which includes an assessment of the need, timing and method of any control or abatement action required beyond O&M. It generally involves the coordination and documentation of all steps in the asbestos control process, from initial inspection to the completion of response actions. Policies and procedures for establishing an O&M plan, ensuring worker protection and safe work practices, training in-house staff, conducting reinspection and periodic surveillance, offering notification, and keeping records can also be considered aspects of management planning.

° **Operations and maintenance (O&M) activities.** An O&M program is designed to (1) clean up asbestos fibers previously released; (2) prevent future release by minimizing asbestos disturbance or damage; and (3) monitor the condition of asbestos. The training of service and maintenance workers is necessary. A good program consists of both worker protection and safe work practices. O&M should be continued until all asbestos is removed from a building.

Examples of targeted regulation follow:

- EPA might promulgate a rule which would require inspection and management planning in public and commercial buildings. In this case, buildings owners and managers would be free to determine the appropriateness of O&M activities and response actions for themselves. The focus of such a rule would be on identification and planning rather than control or abatement activities.

- The Agency might instead require O&M programs as well as inspections and management plans, leaving only the selection of other proper response actions to the responsible persons. This approach would mandate an active control program for keeping materials in place, as well as identification and comprehensive planning.

- A third approach might be a requirement for inspection and O&M programming. In this instance, greater emphasis would be placed on asbestos control (as opposed to asbestos management planning) than in the first approach. With this approach, EPA would place a premium on O&M and allow building owners and managers to make their own judgments on whether to implement a management plan or take additional actions.

Feasibility

Targeted regulation is appealing in theory, but the Agency currently lacks information on how it might choose the appropriate blend of regulatory activities. For example, EPA lacks the information to determine whether O&M is the next logical or most effective regulatory step after inspection. Further, this option, like other regulatory options, may draw limited near-term resources away from activities already mandated in the AHERA schools rule program.

Risks and Costs

The Agency lacks basic information on overall exposure, such as the effect of O&M activities on airborne fiber levels, to make estimates of the risk which would be reduced in each combination of regulatory actions.

EPA's cost analyses for several regulatory packages are listed below.

- A rule that required inspection and development of management plans would cost an estimated $3 billion for all public and commercial buildings.

- A rule that mandated inspection, management plans (development and implementation) and an O&M program would cost an estimated $50 billion (discounted at 10 percent over 30 years).

- An inspection and O&M program regulation would cost an estimated $31 billion (again discounted at 10 percent over a 30-year period).

Policy Considerations

With additional information, this scenario would presumably allow EPA to require only those planning, management or control activities which are most effective in reducing exposure and risk in public and commercial buildings.

However, the Agency lacks information necessary to make these judgments and determine the most appropriate targeted regulation. It is also uncertain whether one activity, such as planning, could be determined to represent a generally preferable approach to another, such as control, in all public and commercial buildings. In addition, costs associated with the alternatives are substantial and support capabilities (e.g., accredited experts, laboratories) may not be available in the short run without jeopardizing compliance with the AHERA schools rule.

5. SEQUENTIAL REGULATION

This scenario would have EPA promulgate a rule or series of rules which would, through a sequential process, gradually extend the Agency's regulatory reach to appropriate categories of public and commercial buildings, with Federal buildings as a potential pilot program. Because of current gaps in information, EPA would need to study representative building types so that an appropriate ranking system could be developed.

In this scenario, EPA would publish a schedule identifying and designating, by category, type, or class, public and commercial buildings that would be subject to AHERA-type regulations. Procedures would need to be established for revisions and regular additions to the schedule. In making the determination of any such category, type, or class of building for inclusion on a schedule, EPA could consider, among other items or matters --

- the typical size of a building;
- average building age and condition;
- likelihood that the building contains ACM;
- availability of technical experts and personnel and analytical resources;
- whether the determination is likely to adversely affect or impede the inspection for, or response to, hazardous asbestos in school buildings;
- number of occupants and visitors utilizing such buildings; and
- likelihood of use by children.

Essentially, regulatory scope would be gradually expanded from one category of buildings, such as Federal buildings, airports, highrises or shopping malls, to others on a scheduled basis, based upon criteria such as those listed above. Gradual additions to the category of buildings regulated by EPA could allow the EPA to assess the marginal impact and effects of regulation without full, immediate application of a rule to all buildings.

Feasibility

Again, scope and timing are critical considerations. EPA would be able to schedule building inclusions based upon feasibility considerations. However, the lack of information on the decision criteria listed above might pose serious practical problems for EPA to accomplish building selection, ranking and scheduling.

Risks and Costs

Risk reduction would presumably increase with regulatory scope, as greater levels of regulatory controls were reasonably applied to new categories of buildings.

EPA's cost analysis for this scenario indicates that an AHERA-type regulatory program for one public and commercial building category, hospitals, would cost an estimated $674 million. (Costs for hospitals are provided purely for illustrative purposes.)

Policy Considerations

The sequential approach, much like the selective approach, would allow EPA to focus and scale its regulatory activity to a more manageable level than would be the case under an immediate, comprehensive AHERA-type rule. Under this scenario EPA would extend standards to reduce exposure first in the buildings with greatest exposure and risk, as determined by research studies.

On the other hand, EPA currently lacks information on key building selection, ranking and scheduling criteria, including exposure and risk, which would be necessary for the Agency to properly identify categories of public and commercial buildings for regulation.

6. IMMEDIATE, COMPREHENSIVE AHERA-TYPE REGULATION

This scenario would have EPA promulgate a full regulatory standard for all public and commercial buildings with major components similar to those of the AHERA schools rule.

The rule would include standards for building owner responsibilities, inspection and reinspection, sampling and analysis, hazard assessment, response actions, operations and maintenance, training and periodic surveillance, management planning, recordkeeping, warning labels, compliance and enforcement activities, waivers and exclusions, and use of accredited personnel.

It would allow building owners to select, within an acceptable range of alternatives, appropriate response actions to address particular asbestos hazards. Least burdensome methods of response could be selected by the building owner among those actions which adequately protect human health and the environment.

Feasibility

The regulation would be applied to the full range of public and commercial buildings, which are considerably more diverse than schools and outnumber schools by approximately 20 times.

Similar regulatory standards for schools were recently developed, primarily through the AHERA schools rule regulatory negotiation, but the appropriateness of these standards in a public and commercial buildings context cannot be very well assessed due to a lack of exposure and risk data on these buildings.

The scope of the regulation would require a substantial public mobilization, greater than for any other scenario discussed in this section. Support capabilities, such as accredited experts and TEM labs, are not now available to meet a demand of this scale.

Risk and Costs

This scenario has the potential to reduce the greatest risk, as it would require, unlike most other scenarios, appropriate abatement activities by building owners across the nation. EPA's cost analysis for this scenario estimates that full regulation of public and commercial buildings, on the scale of the AHERA schools rule, would cost approximately $51 billion (discounted over a 30-year period).

Policy Considerations

This scenario is assumed to be most protective of public health, since it responds to the risks of asbestos exposures in essentially all buildings. The regulation would provide a uniform comprehensive national standard and require that public health hazards are abated.

On the other hand, practical obstacles associated with the regulatory scale appear so substantial that the intended results might be jeopardized. The scenario requires the nation to apply its asbestos control resources equally among all building categories regardless of possible differences in exposure and risk reduction. Costs are extremely high and the private sector resources required for proper inspection, management planning, O&M programs, and the conduct of response actions do not appear available to meet demand in the near term. Further, the Agency's compliance assistance and enforcement capabilities would be severely strained by the demands of such an option.

IV. RECOMMENDATIONS

The Administrator's responses to the findings of this report are contained in the following letter to the Honorable George Bush, President of the Senate, and the Honorable James C. Wright, Jr., Speaker of the House of Representatives:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D C 20460

FEB 26 1988

THE ADMINISTRATOR

Honorable George Bush
President of the Senate
Washington, DC 20510

Honorable James C. Wright Jr.
Speaker of the House
of Representatives
Washington, DC 20515

Dear Mr. President and Mr. Speaker:

On October 22, 1986 the Congress passed the Asbestos Hazard Emergency Response Act (AHERA) which required this Agency to conduct a study to determine "...the extent of danger to human health posed by asbestos in public and commercial buildings and the means to respond to any such danger." This letter transmits that report and contains my recommendations.

The Congressional mandate for this report focused our attention on two major lines of inquiry:

(1) The extent and condition of asbestos in public and commercial buildings; and

(2) Whether public and commercial buildings should be subject to the same inspection and response action requirements that apply to school buildings under the AHERA school rule.

To no one's surprise, our study determined that friable asbestos-containing materials can be found in about one fifth of the public and commercial buildings in this country. Two thirds of these asbestos-containing buildings have at least some asbestos which is already damaged.

The asbestos present in approximately 730,000 of the public and commercial buildings in this country represents a potential health hazard which deserves our careful attention. However, it is not the mere presence of asbestos which poses a health risk to building occupants; the true hazard is presented by damage and disturbance of that asbestos which releases fibers to the air that are inhaled by people.

Removal of asbestos from buildings, although attractive in concept, is not always the best alternative from a public health perspective. In fact, improperly performed removal of asbestos can result in a very high level of exposure for the occupants of that building and perhaps others as well. Response actions short of removal, such as encapsulation, and good housekeeping procedures during the life of the building can be safer in some circumstances. This is why the AHERA school regulations, promulgated last October for asbestos in schools, established a carefully structured process by which case-by-case determinations are to be made by trained professionals about the proper solution to the presence of asbestos in particular schools. Where removal is deemed appropriate, careful procedures to prevent exposure to the public both during and after the removal are mandated.

If we are not careful we will stimulate more asbestos removal actions in public and commercial buildings during the next few years than the infrastructure of accredited professionals and governmental enforcement can effectively handle. For example, as public and commercial buildings are sold, investors are increasingly insisting that the asbestos in the buildings be removed, as a condition of the purchase. Unless such removals are done correctly, exposure of asbestos to the public may actually be increased. We already have anecdotal information which leads us to believe that irresponsible and potentially dangerous removal action is taking place outside of carefully monitored programs, and we do not want to exacerbate this problem by our actions.

I therefore strongly recommend that we take steps now to focus our attention on assessing and improving the QUALITY of the asbestos-related actions that currently take place in public and commercial buildings. I recommend that the following steps be taken over a three-year period:

(1) Enhance the Nation's Technical Capability.

Ideally, owners of public and commercial buildings should use trained and accredited professionals, just as the schools are required to do for inspection and abatement activities. Under the AHERA school rule, States are now establishing accreditation programs for asbestos control professionals. Since we do not want to divert the limited supply of these professionals from the implementation of AHERA, we need to encourage an increase in the supply of these qualified professionals.

Assistance to building owners could shape, guide, and enhance the present private sector activity. For instance, identification of proper operations and maintenance activities should result in immediate risk reduction for that segment of the population which may be receiving the largest exposure--the custodial staffs in these buildings. It may also prevent accidental damage or extensive deterioration which could expose other building occupants. Guidance on how to avoid imminent hazard conditions should greatly reduce the risks from asbestos in these buildings.

Based on our experience with a variety of activities conducted under the Asbestos School Hazard Abatement Act and AHERA we believe that $2 million a year for three years would be sufficient to complete this goal.

(2) Focus attention on thermal system insulation asbestos.

This report indicates that more public and commercial buildings contain thermal system insulation asbestos than other kinds of friable asbestos. In addition, this thermal system insulation is generally in worse condition and in higher concentrations than the other asbestos found in public and commercial buildings. This asbestos represents a potentially serious health hazard to the custodial and maintenance staff, who work with and around this material on a regular basis. Finally, in contrast to other kinds of asbestos, thermal system insulation is usually easier to repair, encapsulate, or, where appropriate, remove. A $600,000 investment for each of three years should be sufficient to complete the task of developing and providing proper guidance for dealing with thermal system insulation.

(3) Improved integration of activities to reduce imminent hazards.

More can be done to avoid high peak exposures associated with improper or poorly timed asbestos removal activities. It is clear that the recent attention on asbestos in buildings has increased the number of removals, the number of resulting NESHAPs notifications, and the need for additional compliance assistance.

There is a need to develop additional ways to coordinate asbestos-related programs in order to increase the effectiveness and efficiency of our existing asbestos control efforts and address legitimate imminent hazards. In particular, we could institute a field program in which notification and inspection information is regularly integrated across EPA programs and perhaps OSHA. Further, the NESHAP notification procedure can be utilized to provide guidance and direction on good work practices to building owners and contractors BEFORE work commences. Within our own Agency, a regional pilot project to better coordinate various asbestos programs--NESHAP, technical assistance, the ASHAA and AHERA schools programs--can be expanded.

A combination of additional Federal inspection personnel and increased State grant money in States with delegated enforcement programs could dramatically improve compliance with existing regulations. Limited increases in Regional staff devoted to coordinating programs, and delivering technical assistance and guidance to building owners and other affected parties, would provide the critical mass to eliminate duplication and inefficiencies. The total cost of this increased program would be approximately $4 million per year. After three years the effectiveness of these efforts should be assessed and future needs determined at that time.

(4) <u>Objectively assess the effectiveness of the AHERA school rules and other current activities</u>.

There are approximately 35,000 school buildings which contain friable asbestos, as compared to more than 730,000 public and commercial buildings. The total cost of the AHERA program is about $3 billion compared to approximately $51 billion for a similar regulatory program in public and commercial buildings. Federal agencies, States, localities, and the private sector are already active in the assessment and control of asbestos in many of these buildings. These facts emphasize the need to assure that the Federal government's intervention in society on behalf of public and commercial buildings is a sound one based on an objective assessment of activities which have only recently been begun.

I do not believe that a comprehensive regulatory inspection and abatement program such as was recently implemented for the Nation's schools under the AHERA school rule is appropriate at this time. I do recommend that studies be conducted on a priority basis, focused on the effectiveness of the AHERA school rule, and the level and effectiveness of the current activities of the States and private sector.

It would be foolish for the country to consider a large new program of asbestos control without first asking basic questions which could improve our response to asbestos in public and commercial buildings and probably provide public health protection at a lower cost. The nation's study and research program should be proportional to the magnitude of the public investment in controlling the problem which is contemplated, especially when so little is actually known, as this report indicates. Some of these studies could cost many millions of dollars to conduct on a scientifically credible basis. Yet their impact on future abatement programs which carry cost estimates in the tens of billions of dollars could be profound. Perhaps a cooperative effort between industry and the government for these studies should be explored with principal funding by the private sector. I could envision the actual studies being conducted by a third party.

In conclusion, asbestos in commercial buildings, like asbestos in schools, represents a potential health hazard that deserves careful attention. However, we need to continue to place our primary focus on asbestos in schools. This report highlights the wisdom of this priority attention. Children, since they have the longest life expectancy would appear to incur the greatest risk, particularly to contracting mesothelioma. Children also spend a great deal of time in school where any asbestos is especially susceptible to disturbance by the occupants. We have only recently put in place the comprehensive AHERA school regulations which call for inspections and the development of management plans by October 1988. The implementation of these plans must begin no later than July 1989. The successful implementation of this school program should remain our first concern, and we all have much to learn from it. In addition, until the necessary national infrastructure to manage asbestos problems on a much larger scale exists, I fear a major initiative in other buildings could do more harm than good.

It has taken a great effort over six years to put the school asbestos program in place. We should be very careful not to take steps which undermine its completion. During the next several years, AHERA school rule activities will stretch the resources of this country, in terms of trained and accredited inspectors, planners, removal contractors, and laboratories, as well as compliance assistance and enforcement capabilities among Federal, State, tribal and local governments. Although we expect the supply of accredited professionals and laboratories to expand in response to the demand for increased services, any significant additional demand imposed by new and immediate regulation could pose a serious obstacle to the success of the schools program.

This should not be interpreted as ruling out an inspection rule or even greater Federal regulation of these public and commercial buildings at some later time. This is a question we should address in about three years after we have had more experience with the AHERA school rule, have dealt with the large surge of demand for trained professionals, and have completed the important studies I have outlined above.

I hope that you will find these recommendations useful, and I look forward to a constructive dialogue with the Congress in the days ahead.

Sincerely,

Lee M. Thomas

APPENDICES

1. 1984 EPA Asbestos In Buildings National Survey
2. Summary of Other Major Support Studies
3. Existing Federal Regulations
4. Proportional Risk Assessment
5. Summary Economic Analysis
6. Absolute Risk Sensitivity Analysis
7. Possible Studies to Address Informational Deficiencies
8. References

APPENDIX 1

1984 EPA ASBESTOS IN BUILDINGS NATIONAL SURVEY OF ASBESTOS-CONTAINING FRIABLE MATERIALS

A. Initial Analysis

- **USEPA, 1984a.** U.S. Environmental Protection Agency. Asbestos in buildings: a national survey of asbestos-containing friable materials. Washington, DC: Office of Toxic Substances, USEPA. EPA 560/5-84-006.

The U.S. Environmental Protection Agency's Office of Toxic Substances (OTS) has an ongoing program concerning asbestos in buildings. As part of this program, a national survey of materials in buildings was conducted. The survey was an effort to deal with the broad problem of public exposure to asbestos-containing friable materials (ACFM). Previous estimates of the number of buildings that contain asbestos ranged from 5 to 45 percent with an unknown degree of accuracy because they were based on anecdotal information or expert opinion. No valid national estimates had been generated and this wide range did not satisfy the Agency's information needs. Thus, a national survey was undertaken to produce more precise and statistically valid estimates with a known degree of accuracy that can be used to support OTS' technical assistance and regulatory programs.

The survey's primary objective was to determine the extent of the use of friable asbestos-containing materials in buildings and the amount of asbestos in them. A secondary objective was to determine how many buildings have asbestos-containing floor and ceiling tiles and the approximate square footage of each. To accomplish these objectives, the survey was designed to: (1) estimate the number and percent of buildings with asbestos-containing friable material; (2) estimate the square footage of such material; and (3) estimate the percent asbestos content of the material. The estimates were to be made at specified levels of accuracy, and estimates of their precision were also to be made. These estimates were made for three types of buildings: Federal government (owned or operated by a civilian agency); residential (with 10 or more rental units); and private nonresidential (largely commercial--office, retail and other). Additional information was gathered including data on ceiling tile, pipe or boiler insulation, floor tile and building characteristics.

The survey involved five major areas of work: the development of a survey design, the design and implementation of a quality assurance program, the execution of a field survey, the laboratory analysis of field samples, and the statistical analysis and interpretation of the data.

The study was conducted in 10 sites (cities or groups of counties) chosen with probability sampling to represent the continental U.S. A total of 231 buildings was inspected, with about half being private nonresidential, one-quarter residential, and one-quarter Federal government. A total of 1,514 bulk samples was taken. The sample of buildings was chosen so that separate estimates could be made for each type of building. Although survey participation was not mandatory, a high rate of cooperation was achieved -- 88 percent of initially sampled eligible buildings were inspected. Replacements for those buildings that did not participate were identified and substituted.

Each sampled building was thoroughly inspected for the presence of friable materials which might contain asbestos: sprayed- or trowelled-on materials, ceiling tile, and pipe and boiler insulation. A bulk sample was taken of any such material found, and all bulk samples were analyzed for asbestos content. Pipe wrap was sampled at elbows, pipe ends and damaged spots, to estimate asbestos content of exposed material. Undamaged material not at elbows or valves may have lower percent asbestos content. The chemical analysis was carried out using Polarized Light Microscopy (PLM); the identity of the fibers was determined by optical characteristics according to an established protocol.

Vinyl floor tile was also sampled whenever found. The results of these analyses were presented in a separate publication, "Use of Asbestos-Containing Friable Materials and Vinyl-Asbestos Floor Tiles in Public and Commercial Buildings," EPA/OTS Asbestos-in-Buildings Technical Bulletin Series, March 12, 1985.

The major study findings are summarized below. The term "asbestos-containing friable material" (ACFM) refers collectively to sprayed- or trowelled-on friable material, ceiling tile, and/or pipe and boiler insulation. Results pertaining to one of these types of material specifically reference the particular material type. The term "all buildings" refers to estimates based on survey data appropriately weighted to the defined target universe. There are several important exclusions from this universe. One consists of primary and secondary schools, which are studied and regulated under a separate EPA program. Other excluded buildings are those owned or occupied primarily by agencies of State or local governments, which may be a sizable number of buildings (there are no published estimates of the exact number), and residential buildings with fewer than 10 units.

The figures given here are estimates and, as such, are imperfect measures. In general, survey estimates are subject to sampling error and nonsampling error. Ranges given in parentheses following the estimates represent the 95 percent confidence limits for the estimates due to sampling error. This means that there is only a five percent chance that actual values fall outside of this range.

- About 20 percent (14-27 percent) of all buildings have some type of asbestos-containing friable material. This represents 733,000 (499,000-966,000) buildings.

- Five percent (0.5-10 percent) of buildings have asbestos-containing sprayed- or trowelled-on friable material, accounting for 192,000 (18,000-365,000) buildings.

- Sixteen percent (6-25 percent) of buildings, or 563,000 (239,000-888,000) buildings have asbestos-containing pipe and boiler insulation. This material is generally limited to closed, restricted-access areas rather than offices or other highly-used space.

- The amount of sprayed- or trowelled-on asbestos-containing material is estimated at 1,184 million square feet (406-1,961 million square feet).

- The average percent of asbestos content (weighted by square footage of material) in asbestos-containing sprayed- or trowelled-on friable material was 14 percent (7-21 percent). For asbestos-containing pipe and boiler insulation material, the average percent asbestos content was 70 percent (66-74 percent).

- Rental residential and Federal government buildings had a higher incidence of asbestos-containing friable materials than private nonresidential buildings. These two types of buildings account for 11 percent of the total population of buildings.

- Very few buildings had asbestos-containing ceiling tile (less than 0.5 percent of buildings). The square footage of asbestos-containing ceiling tile is also low, an estimated 3.6 million square feet (less than 7.8 million square feet), and the average asbestos content of the asbestos-containing ceiling tile that was found was quite low, averaging three percent (less than 8 percent).

- Buildings built in the sixties are more likely to have asbestos-containing sprayed- or trowelled-on friable material (15 percent of such buildings do), than other buildings. It appears that the extensive use of asbestos-containing sprayed-on friable material would have continued and perhaps increased in the 1970's had not the EPA banned the use of those materials for all but decorative purposes in 1973. In 1978, the EPA banned all other uses of these materials. Older buildings are more likely than newer ones to have asbestos-containing pipe and boiler insulation.

- No significant differences in percent of asbestos content were found by building height or construction type (masonry, frame or steel beam).

- An estimated 1,526,000 buildings, or 42 percent of buildings in the survey, are estimated to have asbestos-containing floor tile.

Table 1. Estimated number of buildings with asbestos-containing friable materials by type of material and type of building (in 1,000's) (95 percent confidence limits are provided for each estimate)

Type of building (universe total)	Type of asbestos-containing friable material			
	Sprayed- or trowelled-on	Ceiling tile	Pipe/boiler insulation[c]	Any material
Federal government 35	5 (<10)	1 (<2)	9 (<18)	14 (8-20)
Residential (10+ rental units) 350	64 (34-94)	2 (<6)	155 (66-243)	208 (119-297)
Private nonresidential 3,221	122 (<275)	0[a]	400 (76-724)	511 (274-748)
All buildings[b] combined 3,606	192 (18-365)	2 (<6)	563 (239-888)	733 (499-966)

[a]Of 110 sampled buildings in this category, none had asbestos-containing ceiling tile. However, some small number of buildings in this category may have asbestos-containing ceiling tile.

[b]May not equal sum of the columns due to rounding.

[c]Sampled damaged or exposed material.

Table 2. Estimated percent[a] of buildings with asbestos-containing friable materials by type of material and type of building (95 percent confidence limits in parentheses)

Type of building	Type of asbestos-containing friable material			
	Sprayed- or trowelled-on	Ceiling tile	Pipe/boiler insulation[c]	Any material
Federal government	16% (<33%)	2.0 (0.3-3.6%)	25% (8-41%)	39% (28-48%)
Residential (10+ rental units)	18% (10-27%)	0.5% (<1.7%)	44% (26-62%)	59% (45-74%)
Private nonresidential	4% (<9%)	0[b]	12% (2-22%)	16% (9-23%)
All buildings combined	5% (0.5-10%)	0.1% (<0.2%)	16% (7-25%)	20% (14-27%)

[a]May not equal percentages calculated directly from Table 1 due to rounding in Table 1 and in this table.

[b]Of 110 sampled buildings in this category, none had asbestos-containing ceiling tile. However, some small number of buildings in this category may have asbestos-containing ceiling tile.

[c]Sampled damaged or exposed material.

B. Additional Analysis

- **Rogers, J. 1987.** Final Report: Additional analysis of data collected in the asbestos in buildings survey. Westat: Rockville, MD. Prepared for the Office of Toxic Substances, U.S. Environmental Protection Agency.

The data collection for the 1984 EPA National Survey included a code describing the physical condition of the ACFM. These condition codes have not been previously analyzed. The Asbestos Hazard Emergency Response Act (AHERA) of 1986 requires EPA to report to Congress on the condition of asbestos-containing materials in commercial buildings and the likelihood that persons occupying such buildings are, or might be, exposed to asbestos fibers. An analysis of the asbestos in buildings survey data by condition code can be used to support EPA's report to Congress in response to AHERA.

The objective of the additional analysis of the survey data was to provide estimates for the number of buildings, floor area of buildings, and surface area of ACFM in buildings with either: a) any ACFM, b) damaged ACFM, or c) significantly damaged ACFM. These estimates are broken down into categories by type of asbestos-containing material, type of building, and height of building.

The condition codes from the survey are defined on a relative scale from 1 (Best) to 5 (Worst), with the damaged ACFM defined as having condition codes 3, 4, or 5, and significantly damaged asbestos having condition code 5.

The major findings are summarized below. As used in this report, the term asbestos-containing friable material refers collectively to sprayed-on or trowelled-on friable material, ceiling tile, and/or pipe and boiler insulation. Results pertaining to one of these types of material specifically reference the particular material type. The term "all buildings" refers to estimates based on survey data appropriately weighted to the defined target universe. There are several important exclusions from this universe. One is primary and secondary schools, which are studied and regulated under a separate EPA program. Other excluded buildings are those owned or occupied primarily by agencies of State and local governments or residences with fewer than 10 units.

The figures given here are estimates and, as such, are imperfect measures. In general, survey estimates are subject to sampling error and non-sampling error. Ranges given in parentheses following the estimates represent 95 percent confidence intervals for the estimates based on the sampling error. This means that there is only a five percent chance that the actual values fall outside this range.

SUMMARY OF MAJOR FINDINGS

Sprayed- or Trowelled-on ACFM

- The percentage of buildings with asbestos-containing sprayed- or trowelled-on friable material by condition of material is:

All material	5%	(0.5-10%)
Damaged material	2%	(<4%)
Significantly damaged material	0%	(<0.5%)

- Most of the buildings with asbestos-containing sprayed- or trowelled-on friable material have one or two floors or are commercial/private nonresidential, reflecting the overall distribution of buildings.

- Most of the floor area associated with buildings with asbestos-containing sprayed- or trowelled-on friable material is in highrise buildings (8 or more floors).

- For buildings with asbestos-containing sprayed- or trowelled-on friable material the ratio of surface area of material to floor area of the buildings decreases with building height.

Pipewrap or Boiler Insulation

- The percentage of buildings with asbestos-containing pipe wrap and boiler insulation by condition of material is:

All material	16%	(7-25%)
Damaged material	13%	(3-22%)
Significantly damaged material	9%	(<19%)

- Asbestos-containing pipe wrap or boiler insulation was found in the sample in almost all building categories and conditions.

- Fifty-eight percent of buildings with pipe wrap or boiler insulation have asbestos-containing pipe wrap or boiler insulation.

- All highrise buildings (8 or more floors) in the sample had asbestos-containing pipe wrap or boiler insulation.

ACFM in Public Areas

- The percentage of buildings with ACFM in public areas by condition of material is:

All material	13%	(10-15%)
Damaged material	8%	(4-11%)
Significantly damaged material	2%	(<7%)

- The ACFM in public areas occurs mostly in private non-residential buildings with one or two floors, reflecting the overall distribution of buildings.

- Buildings with friable material in public areas are more likely to be highrises rather than buildings with one or two floors.

<u>ACFM in Fan and Boiler Rooms</u>

- The percentage of buildings with asbestos-containing friable material in fan/boiler rooms by condition of material is:

All material	13%	(4-22%)
Damaged material	10%	(1-19%)
Significantly damaged material	8%	(<18%)

- Taller buildings are more likely to have asbestos-containing friable material in fan/boiler rooms regardless of condition of the material.

- Most of the buildings with asbestos-containing friable material in fan/boiler rooms have three or more floors, unlike the overall distribution of buildings.

- Often ACFM in fan/boiler rooms is significantly damaged.

- Most friable material (damaged or not) in fan/boiler rooms contains asbestos.

- Percentage of buildings with asbestos-containing friable material by condition of material is:

All material	20%	(14-27%)
Damaged material	14%	(6-22%)
Significantly damaged material	9%	(<19%)

- Most buildings with asbestos-containing friable material are private nonresidential buildings or have one to seven floors, following the distribution of all buildings.

- Taller buildings are more likely to have asbestos-containing friable material regardless of condition of the material.

Table 3. Estimated **number of buildings** (in 1,000's) in the continental U.S. with **any asbestos-containing friable material,** by condition of the asbestos-containing friable material (ACFM) and **by type of building.** (See notes below.)

(95% confidence intervals are shown in parentheses)

	Condition of ACFM		
Building Type (Total in 1,000's)	Any	Damaged	Significantly Damaged
Federal (35)	14 (8-20)	5	<0.5
Residential (10+ rental units) (350)	208 (119-297)	80	7
Commercial Nonresidential (3,221)	511 (274-748)	416	310
All Buildings (3,606)	733 (499-966)	501 (201-801)	317 (<679)

Notes:

Asbestos-containing friable material has more than 1% asbestos.
Damaged is defined by condition codes of 3, 4, or 5.
Significantly damaged is defined by a condition code of 5.
Missing condition codes have been imputed to get national totals.
Columns may not add due to rounding.
<0.5 indicates few or no occurrences in the sample; the actual value in the universe is small and cannot be estimated from the survey data.

Table 4. Estimated **percentage of buildings** in the continental U.S. with **any asbestos-containing friable material** with the condition indicated, by condition of the asbestos-containing friable material (ACFM) and **by type of building.** (See notes below.)

(95% confidence intervals are shown in parentheses)

	Condition of ACFM		
Building Type	Any	Damaged	Significantly Damaged
Federal (100%)	39% (29-48%)	14%	1%
Residential (10+ rental units) (100%)	59% (45-74%)	23%	2%
Commercial Nonresidential (100%)	16% (9-23%)	13%	10%
All Buildings (100%)	20% (14-27%)	14% (6-22%)	9% (<19%)

Notes:

Asbestos-containing friable material has more than 1% asbestos.
Damaged is defined by condition codes of 3, 4, or 5.
Significantly damaged is defined by a condition code of 5.
Missing condition codes have been imputed to get national totals.
Columns will not add.

APPENDIX 2

SUMMARIES OF OTHER MAJOR SUPPORT STUDIES

- **Hatfield, J., Stockrahm, J., Chesson, J. 1987.** Draft report for task 2-31: Preliminary analysis of asbestos air monitoring data. Washington, DC: Office of Toxic Substances, U.S. Environmental Protection Agency.

  Interim report of prevailing air levels in 43 Federal buildings in six cities across the Nation found asbestos levels to be very low (mean values between 0.00059 to 0.00073 f/cc as measured by TEM). Further, preliminary results appeared to indicate no difference between levels found in buildings with ACM and outdoor ambient levels, when compared at the 0.05 level of statistical significance. EPA is now completing its peer review of the interim report.

- **Dietz, S. 1987.** Asbestos focus group: a report from a focus group on asbestos in buildings with federal government agency program managers. Westat: Rockville, MD. Prepared for the Office of Toxic Substances, U.S. Environmental Protection Agency.

  Roundtable discussion of a seven Federal managers who summarize their asbestos programs, identify the problems of controlling asbestos in their facilities, assess existing Federal regulations and guidance, and recommend activities to EPA for appropriately addressing the asbestos hazard in public buildings.

- **Price, A., Price, B. 1987.** Report on workshops regarding AHERA section 213: a study to assess the need for asbestos regulations in public and commercial buildings. Price Associates: Washington, DC. Prepared for the Office of Toxic Substances, U.S. Environmental Protection Agency.

  Proceedings of two workshops to examine current asbestos management practices, discuss control problems and identify ways to reduce asbestos hazards in public buildings. The first panel consisted of approximately 17 buildings owners, investors and consultants, primarily contractors; the second, about 19 State and local government officials, some with experience in regulating public and commercial buildings.

- **USEPA. 1986.** U.S. Environmental Protection Agency. Airborne asbestos health assessment update. Washington, DC: Office of Health and Environmental Assessment, USEPA EPA/600/8-84/003F.

  Health assessment summary, developed by the EPA Office of Health and Environmental Assessment and reviewed by the EPA Science Advisory Board, provides a scientific basis for review and revision, as appropriate, of the Agency's NESHAP asbestos standard. The effects of occupational exposure are clear and some high nonoccupational levels have been found. Extrapolations of cancer risks from occupational circumstances can be made for nonoccupational exposure, but only with great uncertainty.

APPENDIX 3

EXISTING FEDERAL REGULATIONS

Four Federal asbestos regulations bear primary responsibility for protecting the general public and abatement personnel during renovation or demolition of buildings:

- National Emission Standard for Hazardous Air Pollutants (NESHAP): Asbestos Regulations, U.S. Environmental Protection Agency Title 40 CFR Part 61.

  The NESHAP applies to building renovation and demolition involving friable asbestos-containing materials. The building owner or operator must provide written notice of intention to renovate or demolish to EPA and follow basic asbestos emission control procedures (i.e., use wet methods, handle carefully). Transport and disposal practices prohibit visible emissions into the air.

  The NESHAP, first published in 1973, was amended last on April 5, 1984, and is currently being revised.

- Occupational Exposure to Asbestos: Occupational Safety and Health Administration Title 29 CFR Part 1926.58 (Construction Standard).

  The construction standard applies to private sector workers engaged in demolition or salvage of structures, asbestos abatement, renovation, emergency cleanup and transportation and disposal. It establishes a permissible exposure limit (PEL), currently 0.2 fibers per cubic centimeter; defines a "regulated area"; and provides standards for exposure monitoring, achieving compliance with the PEL, proper respiratory protection, protective clothing, hygiene facilities and practices, communication of hazard to employees, medical surveillance and recordkeeping.

  The construction standard became effective on July 20, 1986, after a lengthy rulemaking process.

- Toxic Substances; Asbestos Abatement Projects, U.S. Environmental Protection Agency Title 40 CFR Part 763 Subpart G (Worker Protection Rule).

  The worker protection rule essentially extends the protections of the OSHA construction standard to public sector employees.

  The current rule became effective on March 27, 1987, replacing a prior rule first effective on July 12, 1985, and issued as final on April 26, 1986.

- Occupational Exposure to Asbestos: Occupational Safety and Health Administration Title 29 CFR 1910.1001 (General Industry Standard).

  The general industry standard, which affects all private sector workers in occupations other than construction, establishes provisions similar to those of the construction standard.

  The standard also became effective on July 20, 1986.

APPENDIX 4

CALCULATION OF PROPORTIONAL RISK

METHODS

This appendix presents a model which formulates and compares the percentage of total risk which might be attributed to asbestos exposure in nonresidential public and commercial buildings with the percentage which might be attributed to exposure in schools. Arbitrarily selected levels of airborne asbestos fibers are applied to illustrate the sensitivity of the model.

The percentage of mesothelioma and lung cancer risk attributable to exposure to asbestos in public and commercial buildings is estimated from Table 6-3 of the Airborne Asbestos Health Assessment Update (USEPA, 1986). Using an arbitrarily chosen exposure level, Table 6-3 gives the lifetime risks per 100,000 persons of death from mesothelioma and lung cancer from continuous asbestos exposures according to age and duration of exposure. These lifetime risks were calculated using a lifetable approach with U.S. general population death rates and the absolute risk model developed by Nicholson (USEPA, 1986) for mesothelioma and relative risk model for lung cancer.

The Health Assessment Update table was expanded here (Table 1) to include two additional ages at onset of exposure (age 5 and age 18), and three additional durations of exposure (18, 23, and 33 years). The new values, which are approximations obtained by linear interpolation, were plotted with the original tabulated values to check that they were sufficiently accurate for the proportional analysis.

Proportional risk is calculated by determining the risk due to exposure in public and commercial buildings and dividing it by the total risk due to the combined exposure in schools plus public and commercial buildings. The resulting percentage represents the proportion of total risk that would remain if exposure in schools were completely eliminated and exposure occurred only in public and commercial buildings. The result does not depend on the absolute level of airborne asbestos, only on the level in public and commercial buildings relative to the level in schools. Proportional risk does not measure the absolute magnitude of the risk (i.e., number of deaths). Instead, it indicates which exposure sources contribute most to total risk. Proportional risk may be useful in helping to determine priorities for reducing exposure.

Using this sensitivity analysis, if exposure levels in public and commercial buildings are the same as exposure levels in schools, then the values needed for the proportional risk calculation can be read directly from Table 1. (See the example below.) If exposure levels in public and commercial buildings

Table 1. LIFETIME RISKS PER 100,000 MALES OF DEATH FROM MESOTHELIOMA AND LUNG CANCER FROM CONTINUOUS ASBESTOS EXPOSURE OF 0.01 f/cc ACCORDING TO AGE AND DURATION OF EXPOSURE. DERIVED FROM AIRBORNE ASBESTOS HEALTH ASSESSMENT UPDATE, JUNE 1986, TABLE 6-3, PAGE 165. (USEPA, 1986) THE LEVEL OF 0.01 f/cc IS ARBITRARY.

Mesothelioma

Age of onset of exposure	Years of Exposure: 1	5	10	13	18	20	23	33	Life
0	11.2	51.0	91.1	107.5	134.8	145.7	147.6	153.9	192.8
5	9.1	41.1	74.7	86.8	107.1	115.2	116.7	121.6	149.8
10	7.0	31.2	58.2	66.2	79.4	84.7	85.7	89.1	106.8
18	4.7	20.2	35.7	40.8	49.2	52.5	53.1	54.9	62.7
20	4.1	17.5	30.1	34.4	41.6	44.5	44.9	46.2	51.7
30	2.1	8.8	14.6	16.3	19.2	20.4	20.5	20.9	22.3
50	0.3	1.1	1.8	1.9	2.0	2.0	2.0	2.1	2.1

Lung Cancer

Age of onset of exposure	Years of Exposure: 1	5	10	13	18	20	23	33	Life
0	2.9	14.8	29.7	38.6	53.3	59.2	68.1	97.7	170.5
5	2.9	14.9	29.8	38.6	53.4	59.4	68.3	97.9	156.3
10	2.9	14.9	29.8	38.7	53.6	59.5	68.4	98.2	142.0
18	3.1	15.0	30.0	38.8	53.5	59.4	68.3	98.0	118.8
20	3.1	15.0	30.0	38.8	53.5	59.4	68.3	98.0	113.0
30	3.1	14.9	29.8	37.8	51.2	56.6	65.1	93.4	84.8
50	2.5	11.5	20.3	22.9	27.3	29.1	33.5	48.0	30.2

Note: The proportional risk analysis does not depend on absolute exposure level, nor sex. The choice of males and 0.01 f/cc is arbitrary.

are not the same as exposure levels in schools, then risk should be calculated from first principles using the lifetable approach and incorporating the change of exposure level at age 18. However, for the purposes of this analysis, an estimate relying on the approximate additivity of risk is adequate.

The approximation is introduced by assuming that the new total risk (due to exposure in schools plus exposure in public and commercial buildings) will be this number plus the portion of the old total risk (i.e., total risk when exposure levels are the same) contributed by schools.

Proportional risk, for purposes of illustrating the sensitivity of the model, is calculated for several arbitrarily selected airborne asbestos levels for public and commercial buildings: twice, the same, one half, one sixth and one tenth of those in schools. It is not possible to determine with any certainty which, if any, of these scenarios is most appropriate. The levels are provided merely to indicate the relative contributions to total risk of exposure in public and commercial buildings and in schools, as computed by the model.

EXAMPLE

Consider an individual who spends 13 years from age 5 to age 18 in school buildings containing asbestos followed by 10 years of exposure in asbestos-containing public and commercial buildings. If airborne asbestos levels are the same in schools and in public and commercial buildings, the exposure experience is 23 years starting at age 5. The total mesothelioma risk (117) can be read directly from Table 1. (Note that the absolute risk value has no significance here; only relative values are of interest. The numbers are based on an exposure level of 0.01 f/cc to maximize accuracy, since in the Health Assessment Update, these values have the highest number of significant digits. If another exposure level were chosen, the results would be the same.)

Now consider an individual who is not exposed at school, but who is exposed for 10 years in public and commercial buildings beginning at age 18. The mesothelioma risk read from Table 1 is 36. Expressing this risk as a percentage of the total risk (36/117 = 31%) provides a measure of the contribution of exposure in public and commercial buildings.

For scenarios in which exposure levels in public and commercial buildings are not the same as those in schools, a new total risk must be calculated by separating the original total risk of 117 into its two components, and modifying the public and commercial building component. For example, if exposure levels in public and commercial buildings were one half those in schools, the new total risk would be approximately 99 (81 from schools plus 36/2 from public and commercial buildings). The proportion of total risk attributable to exposure in public and commercial buildings would be 18 percent (18/99).

RESULTS

Table 2 shows that the percentage of total mesothelioma risk attributable to exposure in public and commercial buildings ranges from 61 percent for a lifetime post-school exposure at levels twice those in schools, to 2 percent for a 5 year post-school exposure at levels one tenth those in schools. When airborne asbestos levels in public and commercial buildings are no higher than those in schools, exposure in public and commercial buildings contributes less than half of the mesothelioma risk. This finding is consistent with the risk model for mesothelioma since incidence increases with time from onset of exposure, placing additional weight on exposures early in life.

Exposure in public and commercial buildings contributes more to lung cancer risk than to mesothelioma risk. A lifetime exposure in public and commercial buildings at twice the exposure level in schools contributes 87 percent of the risk. The contribution is reduced to 5 percent for a 5 year post-school exposure at levels one tenth those in schools. The risk model for lung cancer depends only on total exposure (concentrations multiplied by duration), therefore long post-school exposures dominate the 13 years of exposure in schools.

The results in Table 2 do not consider exposure in residential buildings which could occur concurrently with exposure in schools and/or nonresidential public and commercial buildings. Residential exposure is discussed separately below.

Table 2. THE PROPORTION OF LIFETIME RISK ATTRIBUTABLE TO EXPOSURE TO AIRBORNE ASBESTOS IN PUBLIC AND COMMERCIAL BUILDINGS RELATIVE TO TOTAL RISK FROM EXPOSURE IN BUILDINGS FOLLOWING 13 YEARS OF EXPOSURE IN SCHOOLS

Exposure Experience	Airborne Asbestos Levels in Public and Commercial Buildings Relative to Levels in Schools				
	Twice	Same	One half	One sixth	One tenth
	Percent Risk Attributable to Public and Commercial Buildings				
Mesothelioma					
13 years at school plus:					
lifetime in other buildings	61	43	28	11	7
20 years in other buildings	61	43	28	11	7
10 years in other buildings	47	31	18	7	4
5 years in other buildings	31	19	10	4	2
Lung Cancer					
13 years at school plus:					
lifetime in other buildings	87	76	62	35	24
20 years in other buildings	75	60	43	20	13
10 years in other buildings	61	44	28	12	7
5 years in other buildings	44	28	16	6	4

RESIDENTIAL EXPOSURE

The preceding analysis does not consider exposure to asbestos in residences. AHERA defines public and commercial buildings to include residential buildings of 10 units or more. The number of people who are exposed to asbestos in residential buildings and the level and length of exposure are not known. U.S. Census data indicate that residential buildings of 10 units or more house approximately 7 percent of the population. Schools and nonresidential public and commercial buildings are occupied by a much larger proportion of the population.

For individuals who are exposed to asbestos in residences in addition to schools and nonresidential buildings, the proportion of total risk attributable to nonschool buildings is increased. The extreme case is an individual who is exposed throughout life to asbestos in residences. Table 3 shows the proportion of total risk contributed by nonschool buildings when an individual is exposed in both residence and school from age 5 to 18, and in both residence and nonresidential public and commercial buildings from age 18 until death. The time spent per day in residences is assumed to be twice the time spent per day in schools or in nonresidential public and commercial buildings. For mesothelioma, the contribution from nonschool buildings ranges from 89 percent, if airborne asbestos levels in nonschool buildings are assumed to be twice those in schools, to 30 percent if airborne asbestos levels in nonschool buildings are assumed to be one tenth those in schools. For lung cancer the corresponding contributions are 96 percent and 52 percent.

The percentages in Table 3 do not include exposure in the period from birth to age 5 because, as stated above, the proportional risk calculations are based on risk estimates for constant exposure levels. The calculations in Table 3 already rely on an approximation to incorporate a change in exposure level from the period of age 5 to age 18 to the period after age 18. A second approximation to incorporate birth to age 5 would provide estimates of questionable validity. The special case where exposure levels are assumed to be the same in all types of buildings does not require additional assumptions. In this case including exposure in residences from birth to age 5 increases the proportion of total risk of mesothelioma attributable to non-school buildings from 81 percent to 85 percent. For lung cancer, the proportion of total risk remains at 92 percent.

Table 3. THE PROPORTION OF LIFETIME RISK ATTRIBUTABLE TO EXPOSURE IN PUBLIC AND COMMERCIAL BUILDINGS RELATIVE TO TOTAL RISK FOR INDIVIDUALS WHO HAVE A LIFETIME EXPOSURE IN RESIDENCES FROM AGE 5, AN EXPOSURE IN SCHOOLS FROM AGE 5 TO AGE 18, AND A LIFETIME EXPOSURE IN NONRESIDENTIAL BUILDINGS FROM AGE 18.

Airborne Asbestos Levels in Nonschool Buildings Relative to Schools	Percent Risk Attributable to Nonschool buildings	
	Mesothelioma	Lung Cancer
Twice	89	96
Same	81	92
One half	68	85
One sixth	41	65
One tenth	30	52

APPENDIX 5

SUMMARY ECONOMIC ANALYSIS

I. Introduction

This appendix contains a description of the economic analysis conducted to estimate the costs of the various scenarios considered with regard to the inspection for and abatement of asbestos in public buildings. The cost estimates for a particular scenario focus not only on the absolute magnitude of those costs, but also on what group incurs those costs and how those costs are distributed over time. Costs attributable to a particular scenario are incremental from a baseline which assumes that no abatement is currently taking place.

II. Methodology

A. Preliminary Steps

In most respects, the costs estimated for the scenarios discussed below were developed with the same set of assumptions, unit costs, and calculations used for the final AHERA schools rule's Regulatory Impact Analysis (RIA).

Information on the three classes of public buildings (Federal, residential, and commercial) was gathered from the EPA's 1984 Asbestos In Buildings Study (AIBS). This information, plus information gathered from the EPA's Regional Asbestos Coordinators (RACs), was used to construct a "model" building representing each building type. These models were developed in the same manner as those developed for the schools rule RIA. The models are not intended to describe any one specific building but are rather intended to represent the similarities in the building classes. The models established for this analysis were a Federal building of 42,000 square feet, a residential building of 27,601 square feet, and a commercial building of 24,094 square feet. An additional model for hospitals was 37,328 square feet.

The AIBS did not provide estimates of the amounts of most of the ACM types found in public buildings. The revised versions of the AIBS provided estimated amounts for only the asbestos-containing surfacing materials and ceiling tiles. No firm estimates were provided for the amount of thermal systems insulation (TSI) or other, miscellaneous forms of ACM.

To calculate the amount of thermal systems insulation in public buildings, model public buildings were matched with model schools that were close in size. For example, the model residential building, at 27,601 square feet, was matched with the model public primary school (at about 31,000 square feet). The amount of thermal systems ACM per model school was then applied to the matched model public building. Thus, the model residential building was estimated to have 472 square feet of TSI. These TSI amounts per model building were then multiplied by the number of public buildings (of each building type) estimated by the AIBS to have friable asbestos-containing TSI. This yielded an estimate of some 280 million square feet of friable TSI in public buildings.

This analysis did not estimate costs for asbestos-containing ceiling tile or miscellaneous types of ACM. Costs for both ACM categories are expected to be quite small. Consequently, their exclusion is expected to result in only a minor underestimate of costs. Asbestos-containing ceiling tile was found in very few buildings, and total amounts were quite small, especially for friable tile. No data were presented on the quantities of miscellaneous ACM, but the nonfriable, sturdy nature of most miscellaneous ACM implies that few costs beyond an inspection would be incurred. Thus, aside from an inspection cost, any costs incurred for these ACM will be likely be the result of NESHAPs and other existing regulations, and not the scenarios considered in this report.

The AIBS used a set of five condition codes to illustrate the level of damage to friable ACM (ACFM). Condition code 1 was for ACM in the best condition, and condition code 5 was for ACM in the worst condition. Damaged ACFM was defined as having codes 3, 4, or 5, and significantly damaged ACFM had condition code 5. Even though some of the damage labels were not mutually exclusive with respect to condition codes, this analysis assumed that these condition codes were roughly comparable to the damage/hazard categories used in the final schools rule RIA. The categories used in the RIA were: significant damage, moderate damage, good condition with the potential for significant damage, and good condition with the potential for damage.

Use of these hazard categories allowed the use of the response action timelines developed for the RIA. The timelines shown in Figures One and Two present the types and timing of response actions considered suitable for asbestos-containing surfacing material and thermal systems insulation, respectively, in different damage categories.

The term "project area" is used to denote a homogeneous expanse of ACM, such that the ACM (and the space in which it is enclosed) could be efficiently treated with one abatement project. The sizes of the model buildings derived from the AIBS are quite close to those of the model schools used in the final schools rule's RIA. Thus, it was assumed that the range of model asbestos projects developed for the RIA could also be used for this study.

The AIBS noted that most buildings in the survey have only one to two floors. To simplify the analysis, it was assumed that all asbestos project areas would be based on one floor. Although this is an accurate representation of most project areas, this assumption tends to underestimate unit costs for a limited number of abatement projects in multi-story buildings.

Figure One
Response Action Timeline for Surfacing ACM

Response Category	Year	1	2	3	4	5	10	20	30
Significant Damage									
Option 1		Remove							
Moderate Damage									
Option 1		O&M	Remove						
Option 2		O&M	Encap			Remove			
Option 3		O&M	Enclose					Remove	
Option 4		O&M	Repair			Remove			
Good Condition (Potential Significant Damage)									
Option 1		O&M	Remove						
Option 2		O&M	Enclose						Remove
Good Condition (Potential Damage)									
Option 1		O&M	O&M	O&M	O&M	O&M	O&M	O&M	Remove
Option 2		O&M	O&M	O&M	O&M	Encap			Remove

Figure Two
Response Action Timeline for Thermal ACM

Response Category	Year	1	2	3	4	5	10	20	30
Significant and Moderate Damage									
Option 1		Remove							
Option 2		Repair					Remove		
Good Condition (Potential Significant Damage)									
Option 1		O&M	Remove						
Option 2		O&M	Enclose						Remove
Good Condition (Potential Damage)									
Option 1		O&M	O&M	O&M	O&M	O&M	O&M	O&M	Remove
Option 2		O&M	O&M	O&M	O&M	Encap			Remove

The number of project areas per model building is dependent on the total quantity of ACM, the type of ACM, and the location and configuration of ACM in a building. Average amounts of asbestos-containing surfacing materials (SM) per model building were calculated by dividing the total amount of SM in each building class by the number of buildings in the class. The AIBS provided estimates of the surfacing ACM found in each building class. The estimated TSI amount per building was, as noted above, derived from the matched model schools. Once average ACFM amounts per building were established, a range of model projects was used to develop a building project mix that best approximated each model building's ACFM amount. The model projects are shown in Figure Three.

Figure Three
Model Buildings and Their ACM Projects

Type of Model Building	# of Projects	Project Description	Project Sq. Feet
Surfacing Materials:			
Federal	8	3 4,000 SF[a/] spray-on 5 400 SF spray-on	14,000
Residential	3	2 4,000 SF spray-on 1 400 SF spray-on	8,400
Commercial	3	1 4000 SF spray-on 2 400 SF spray-on	4,800
Thermal Systems Insulation:			
Federal	4	1 900 SF boiler wrap 3 100 LF pipe wrap b/	1,254
Residential	4	4 100 LF pipe wrap b/	472
Commercial	4	4 100 LF pipe wrap b/	472

a/ Square feet.
b/ 100 LF (linear feet) pipe wrap = about 118 SF pipe wrap.

The cost estimates developed for this analysis were based on the assumption that outside consultants and contractors would be used for all work except training, recordkeeping, and O&M cleaning. Unless otherwise noted, the costs shown in the following figures are weighted averages of the costs estimated for buildings with only friable TSI, buildings with only friable SM, and buildings with both friable TSI and SM. Generally, costs are lowest for buildings with only TSI and highest for buildings with both types of ACM. Based on AIBS data, it was estimated that 76.8% of all public buildings with friable ACM have TSI, 26.2% have SM, and about 3% have both types.

B. Appendix Format

The remainder of this appendix presents the cost estimates developed for most of the asbestos assessment and control scenarios considered in the report. All of the major scenarios, regulatory and non-regulatory, presented by the report were addressed in the economic analysis. However, some specific action items listed in such scenarios as enhanced, targeted technical assistance do not have cost estimates, as data limitations prevented the estimation of a cost.

This appendix presents a set of figures containing the results of the various cost estimation scenarios considered in the report. Most of the figures present separate cost columns for the three building types (Federal, residential, and commercial). In addition, the figures present a distinct cost column for hospitals for use in the sequential regulation scenario. This illustrates the possible cost of various asbestos control scenarios on a specific building set. The total cost column on the far right of all figures is the sum of the costs in the Federal, residential, and commercial columns. The hospital case is actually a subset of the population of commercial buildings, so these costs should not be double counted when reading the data in the figures.

The final section of the appendix presents a summary of the limitations of the economic analysis.

III. Cost Estimates

A. Air Monitoring Cost Estimation

Several steps were followed to cost out air sampling as a risk management tool. The first step was to establish a unit cost for the collection and analysis of a sample. Sample analysis can currently be performed by either Phase Contrast

Microscopy (PCM) or Transmission Electron Microscopy (TEM). The per sample cost using PCM analysis is roughly $30, while the cost using TEM analysis is about $400 per sample. These costs were established by EPA during the final AHERA schools rule preparation. (It should be noted that PCM does not actually measure asbestos fibers, but rather all fibers. Furthermore, it does not measure thin or small fibers.) The analysis recognized that TEM analysis of an air sample makes up almost all of the cost of collecting and analyzing an air sample.

The second step was to determine the number of air samples taken per building. No data were available to allow an empirical estimate of the required number. Based on expert judgment, it was concluded that five air samples per project area per building was the most reasonable sampling rate to use. In order to estimate the cost of alternate sampling rates, it was also decided to use sampling rates of one sample per project area and one sample per building.

The three sampling rates were then multiplied by the number of project areas per model building (shown in Figure Three) to yield the total number of samples per building. Using the highest sampling rate as an illustration, a Federal building, with twelve project areas, would require 60 air samples. A model residential building, with seven project areas, would require 35 air samples. A model commercial building, at seven ACM project areas, would require 35 samples.

The resulting sample counts per building were then multiplied by the PCM- and TEM-based unit costs to estimate the cost per building. The per building costs were then multiplied by the estimated number of public buildings, by building class, with friable asbestos-containing materials. This yielded the total estimated cost of a one-time air sampling and analysis effort. Depending on whether PCM or TEM is used, the total cost of a one-time sampling effort would be either $25 million or $336 million for all Federal buildings, $218 million or just under $3 billion for all residential buildings, and $537 million or just over $7 billion for all commercial buildings. These estimates are rounded to the nearest unit.

Figure Four shows the estimated cost of this analysis: some $780 million using PCM and over $10 billion using TEM. The total cost of sampling all buildings with ACM (friable or nonfriable) would be three times as high. Should air sampling occur semi-annually, with five samples per ACM area, costs for each type of analysis would be doubled. Reducing the sampling rate to one sample per ACM area would yield one-time and annual TEM analysis costs of $2 billion and $4 billion, respectively, for public and commercial buildings. At these low sampling rates, the resulting data would be statistically unreliable and still extremely expensive.

Figure Four
Costs of One-Time Air Monitoring Effort

	Fed	Res	Comm	All Bldgs
#Bldgs.	14,000	208,000	511,000	733,000
#Samples/Bldg.	60	35	35	
$/PCM Sample	$30	$30	$30	
$/Bldg.(PCM)	$1,800	$1,050	$1,050	
*Total Cost	$25	$218	$537	$780
$/TEM Sample	$400	$400	$400	
$/Bldg.(TEM)	$24,000	$14,000	$14,000	
*Total Cost	$336	$2,912	$7,154	$10,402

* In Millions

B. The Cost of Acquisition of Needed Information

A good deal of the basic information required for the Agency to best address the asbestos hazard in public buildings is presently unavailable. Better risk reduction decisions would be possible if the information were acquired by EPA. The report discussed several useful data collection efforts that EPA could undertake. Appendix 7 describes in detail a number of studies designed to collect this information and the costs associated with each.

C. Cost of Enhanced, Targeted Technical Assistance

One approach to risk management would be non-regulatory in nature: providing enhanced technical assistance to target populations with the greatest needs. The report presented six major categories of technical assistance, all of which are briefly discussed below. These estimates are based on the most recent experience of EPA in providing schools with technical assistance quite similar to that under consideration in the report. Estimates of the approximate costs of providing enhanced technical assistance are presented in Figure Five.

The costs in Figure Five and in the following text are costs incurred by the Federal government only. Costs incurred by State and local governments, and by building owners and managers, are not presented for several reasons. Most important, these costs were not estimated due to a lack of reliable data with which to quantify these costs.

The first type of assistance attempts to ensure that building maintenance and asbestos abatement personnel are better protected when working with or around asbestos. Developing model O&M practice programs and providing and promoting guidelines for the sampling of suspect materials for asbestos is estimated to cost approximately $500,000 in total. Funding case studies of asbestos management plans for various building types would cost roughly $150,000 for every four case studies. Finally, helping various groups establish and offer approved training courses would cost roughly $50,000 per course. Costs were not estimated for a voluntary inspection program or for additional compliance enforcement activities.

Figure Five
Costs of Providing Technical Assistance

Assistance Categories and Tasks	Estimated Cost
1. Protect Service Personnel	
o develop model programs	$500,000 each
o publish case studies	$150,000 for 4 studies
2. Advise Building Owners	
o develop voluntary standards	$250,000 each
3. Improve Public Understanding	
o publish citizen's guide	$100,000 each
o conduct symposia	$50,000 each
4. Facilitate State and Local Activity	
o set up contractor certification and other models	up to $100,000 each
5. Improve Asbestos Control Information	
o conduct new studies	up to $61 million
o establish and run clearinghouse	up to $5 million/year
6. Increase Abatement Training	
o set up extra training centers	up to $550,000 per center
o set up extra courses	$50,000 each

A second assistance category involves the development and publication of voluntary standards for asbestos activities (such as inspections). Such standards would be intended for use by building owners and managers. Current experience with similar activities yields an estimated cost of about $250,000 to develop each standard, including testing and peer review. Costs were not estimated for the grants EPA might provide to states for inspection and management planning programs.

A third assistance category would attempt to improve public understanding of the presence of asbestos in buildings. Developing and publishing a citizen's guide to the hazards and risks associated with asbestos could cost about $100,000. Sponsoring a symposium on this subject would cost about $50,000. Costs were not estimated for other forms of information dissemination.

As a fourth form of assistance, EPA could develop, distribute and encourage State and local use of such model asbestos administration programs as a contractor certification program or a management planning program. Past Agency experience with such programs indicates that the development and distribution of each new model would cost from $50,000 to $100,000. Costs were not estimated for asbestos management assistance programs `stablished with states using such existing mechanisms as tax credits.

A fifth form of assistance would have EPA promote the development and public release of new asbestos-related information and technology. The types of surveys required to address the information deficiencies listed in the report would cost an estimated $33 million to $61 million. Additional detail on the costs of these studies is provided in Appendix 7. Further EPA action to serve as an information clearinghouse would cost up to $5 million on an annual basis. Costs were not estimated for attempts to accelerate research in key areas or to perform a formal cost-benefit analysis of the leading regulatory scenarios.

A sixth and final form of assistance would have EPA expand the set of abatement training and accreditation programs around the nation. That would cost the Agency an estimated $50,000 per course. It would also likely involve an expansion of the number of asbestos information and training centers (AITCs) and satellite training centers. Each AITC receives a total of $550,000 from the Agency over its first three years. Likewise, each satellite training center receives $125,000 from the Agency over its first two and a half years of operation. Most of the states that house AITCs and satellite training centers provide cost sharing support equivalent to 5% to 7.5% of annual operating budgets. Some states also provide free office space for the centers. Each of the 25 state training programs assisted by the

EPA received between $100,000 and $200,000 at its inception. The total cost for this approach was not estimated because the required number of courses, training centers, and training programs is unknown.

D. Cost Estimation For Regulatory Scenarios

This section presents the steps followed in estimating the costs of regulatory risk management scenarios. The economic analysis addressed a series of successively more comprehensive regulatory environments involving greater levels of response to the risk posed by ACM in buildings. This approach provides a set of cost estimates that can be combined to illustrate the likely total cost of any of a variety of regulatory approaches. The first section to follow describes the general cost estimating scheme. The next six sections present the estimated costs of the six regulatory risk management scenarios discussed in the report.

1. General Cost Estimating Scheme

The economic analysis was structured in such a way that the costs associated with performing different types of asbestos activities could be estimated for each of the three building types (Federal, residential, commercial) identified in the AIBS. The analysis developed costs sequentially using an activity scheme identical to that identified in section 203 of the Asbestos Hazard Emergency Response Act. That is, the analysis estimated costs for: (1) inspections; (2) inspections and the development of management plans; (3) the preceding item plus operations and maintenance (O&M); and (4) item (3) plus a range of appropriate abatement actions.

Costs for the first activity, building inspections and notifications, were estimated via the following steps. First, the count of 733,000 public buildings with friable ACM was obtained from the AIBS. The initial estimate of buildings with nonfriable ACM derived from AIBS data was then adjusted. EPA's technical asbestos consultants provided the analysts with their latest estimate of the proportion of all public buildings that contained nonfriable ACM (NFACM). Applying this proportion to the AIBS data resulted in an estimate of just under 1.5 million buildings with NFACM.

The second step was to estimate the likely inspection cost for a building that had ACFM, NFACM, or no ACM at all. This was accomplished by adjusting the inspection cost estimates developed for the schools rule RIA to the sizes of the various model public buildings. The inspection costs developed for the RIA were based on estimates of the time needed to perform the different inspection tasks: a building walkthrough and visual assessment, bulk sampling and analysis, assessment, mapping, and reporting.

The time estimates were based primarily on the size of the school; its ACM mix was a secondary factor. Inspection hours for public buildings were established by comparing the size of the model public buildings with the size of the model schools developed for the schools rule RIA. If a public building model reasonably matched a school model in terms of size measured in square feet, the estimated school inspection time was applied to the public building model. Thus, the Federal building model used the time estimates developed for the public secondary school. The residential and commercial building models, on the other hand, used the time estimates from the public primary school. Appendix F of the schools rule RIA presents details on the development of the time estimates.

The time estimates were then slightly decreased to account for the fact that the public building models were somewhat smaller than the school models they were matched with. As an illustration, the time estimate for a public secondary school (of some 80,000 square feet) was 15.5 hours, exclusive of time spent collecting bulk samples. The Federal building model, at 42,000 square feet, was slightly over half the size of the school model. Reducing the Federal building's inspection time requirements by a ratio of 42:80 (for thousands of square feet of model size) did not seem appropriate given the increased complexity of the Federal building's tenant mix and tenant activities. Thus, it was decided that 9.5 hours was a reasonable estimate of the time required for all inspection activities (save collection of bulk samples) in the Federal building.

Once inspection hours were developed, the inspection cost was calculated by simply multiplying hours by unit labor rates. The estimated inspection cost for buildings with both types of ACFM is from $1,904 to $3,354 per building, depending on building type. The cost for buildings with NFACM ranges from $359 to $583 per building. For buildings with no ACM, the cost ranges from $135 to $224.

Once unit inspection costs were developed for buildings of each building type and with different combinations of ACM, these costs were multiplied by the appropriate number of buildings to yield a total inspection cost. The total cost estimate of under $2 billion is shown in Figure Six. Compared with the total cost for all public buildings, the costs of only subjecting Federal buildings or hospitals to the regulation are significantly lower. The costs for Federal buildings and hospitals are about $37 million and $31 million, respectively.

Figure Six
Costs for Inspection and Notification

		All Bldgs.			
	Hospitals	Fed	Res	Comm	Total
Bldg w/ SM&TSI					
* $Insp/Bldg	$2,208	$3,354	$2,026	$1,904	
#Bldg	208	0	11,000	11,000	22,000
** Subtotal	$0.5	$0	$22.3	$20.9	$43.2
Bldg w/ SM					
* $Insp/Bldg	$1,648	$2,626	$1,298	$1,176	
#Bldg	2,098	5,000	53,000	111,000	170,000
** Subtotal	$3.5	$13.1	$68.8	$130.5	$212.5
Bldg w/ TSI					
* $Insp/Bldg	$1,104	$1,534	$1,237	$1,237	
#Bldg	7,352	9,000	144,000	389,000	541,000
** Subtotal	$8.1	$13.8	$178.1	$481.2	$673.1
Bldg w/ NFACM					
* $Insp/Bldg	$540	$583	$359	$359	
#Bldg	25,816	14,802	98,804	1,363,023	1,476,629
** Subtotal	$13.9	$8.6	$35.5	$489.4	$533.5
Bldg w/ no ACM					
* $Insp/Bldg	$180	$224	$135	$135	
#Bldg	25,509	6,198	43,196	1,346,977	1,396,371
** Subtotal	$4.6	$1.4	$5.8	$181.8	$189.1
** Total	$30.6	$36.9	$310.5	$1,303.9	$1,651.4

* Includes Inspection and Notification
** In Millions

The second activity adds to the inspection requirement an additional requirement that building owners have asbestos management plans developed for their buildings. As was done with the inspection cost estimates, the cost of developing a management plan for a public building was determined using a procedure quite similar to that used for the schools rule RIA. Appendix G of the RIA presents further details on this work.

First, the model public buildings were once again matched with model schools on the basis of size. The hour estimates from the matched model schools were used as a baseline estimate of the public building's management plan hours. Second, the hour estimates were decreased to reflect the fact that public building models were smaller than their school matches. Third, the hour estimates were adjusted to reflect the differences between the project mixes in model schools and in model public buildings.

To illustrate, the public secondary school (using an outside consultant) required 19 hours to prepare a management plan. The Federal building, with its smaller size and different project mix, was estimated to require 15.9 hours.

The estimated cost of developing an asbestos management plan ranges from $1,080 to $1,350 per building with ACFM. (These costs are rounded off to the nearest ten dollars.) The plan development costs for buildings with only NFACM are considerably lower, between $540 and $720.

The total cost is estimated to be over $3 billion for all public buildings. The cost for the class of Federal buildings is about $67 million. The cost is roughly $62 million if only hospitals must meet this requirement. Figure Seven presents the costs for inspection and management plan development for all public buildings.

The third activity adds to the preceding approach a requirement for the use of operations and maintenance (O&M) programs. Once again, O&M costs developed for the schools rule RIA were adjusted for the public buildings study on the basis of model building size and model project mix.

Figure Seven
Costs for Inspection and Management Plan Development

	Hospitals	All Bldgs. Fed	Res	Comm	Total
Bldg w/ ACFM					
* Insp/Bldg	$1,592	$1,959	$1,297	$1,239	
$Mgmt Plan/Bldg.	$1,200	$1,350	$1,080	$1,080	
#Bldg	9,675	14,000	208,000	511,000	733,000
**Subtotal	$27.0	$46.3	$494.3	$1,184.8	$1,726.9
Bldg w/ NFACM					
* $Insp/Bldg	$540	$583	$359	$359	
$Mgmt Plan/Bldg.	$640	$720	$540	$540	
#Bldg	25,816	14,802	98,804	1,363,023	1,476,629
**Subtotal	$30.5	$19.3	$88.8	$1,225.4	$1,334.0
Bldg w/ no ACM					
** Insp Subtotal	$4.6	$1.4	$5.8	$181.8	$189.1
**Total	$62.1	$67.0	$589.0	$2,592.0	$3,250.1

* Includes Inspection and Notification Costs. Costs for buildings with ACFM are averages of costs for each possible ACM mix per building.
** In Millions. Totals may not equal due to rounding.

The cost of implementing an O&M program in the first year ranges from $12,283 to $14,898 for buildings with ACFM. These costs include expenditures for durable equipment such as HEPA vacuums, a quantity of disposable dusting and mopping tools, and labor costs associated with the actual cleaning effort. Annual O&M costs are considerably lower in following years, from $3,746 to $5,181 for cleaning procedures.

The estimated costs for this activity are presented in Figure Eight. It was assumed that all buildings will be used for 30 more years, and O&M cleaning activities, training, periodic surveillance and reinspection will continue throughout that time. The resulting cost, discounted at 10% over 30 years, is roughly $50 billion. The total cost breakdown is: Federal buildings, over $1 billion; hospitals, $690 million; residential buildings, just under $12 billion; and commercial buildings, over $36 billion. (As noted above, hospital-related costs are subsumed by the cost estimates for all commercial buildings.)

Figure Eight
Costs for Inspections, Management Plans and O&M Programs

	Hospitals	All Bldgs. Fed	Res	Comm	Total
Bldg w/ ACFM					
* $Insp/Bldg	$1,592	$1,959	$1,297	$1,239	
$Mngmt Plan/Dev	$1,200	$1,350	$1,080	$1,080	
$O&M/Yr. 1	$12,537	$13,191	$11,650	$11,228	
$O&M, each yr	$4,186	$4,612	$3,792	$3,333	
$Mngmt Plan Imp.	$2,900	$2,083	$1,714	$1,714	
$Per. Surv.	$45	$45	$45	$45	
$Reinsp.	$80	$80	$48	$48	
#Bldg.	9,675	14,000	208,000	511,000	733,000
**Subtotal	$463	$1,359	$11,015	$24,550	$35,255
Bldg w/ NFACM					
* $Insp/Bldg	$540	$583	$359	$359	
$Mngmt Plan/Dev	$640	$720	$540	$540	
$O&M/Yr. 1	$0	$0	$0	$0	
$Mngmt Plan Imp.	$1,525	$1,649	$1,408	$1,408	
$Per. Surv.	$45	$45	$45	$45	
$Reinsp.	$80	$80	$48	$48	
#Bldg.	25,816	14,802	98,804	1,363,023	1,476,629
**Subtotal	$222	$132	$755	$11,763	$12,650
Bldg w/ no ACM					
**Insp Subtotal	$4.6	$1.4	$5.8	$181.8	$189.0
**Total	$689.8	$1,492	$11,776	$36,495	$49,763

* Includes Inspection and Notification
** In Millions

Periodic surveillance and reinspection of ACM are generally viewed as part of an O&M program. However, these activities must also be conducted for buildings with only nonfriable ACM, i.e., those buildings that do not require O&M cleaning. Therefore, costs for periodic surveillance and reinspection were considered separately from O&M expenses in this analysis. The final schools rule requires that periodic surveillance occur semi-annually. It was estimated to cost $45 per public building. Reinspection of the ACM is to take place every three years. One-time costs vary from $48 to $80. It was assumed that the timing of periodic surveillance and reinspections was the same for all buildings.

A variation of the preceding activity includes only requirements for inspections and operations and maintenance programs. It does not require management plans. Figure Nine presents the costs for inspections and O&M programs. Once again, the analysis assumed that O&M programs would continue for thirty years. The estimated cost, discounted at 10%, is under $31 billion for all public buildings with friable ACM. Federal buildings and hospitals would incur a cost of over $1 billion and $395 million, respectively. Residential buildings and commercial buildings would incur costs of approximately $9 billion and $21 billion, respectively.

The final activity requires that building owners perform the same actions that are required of schools under the final AHERA schools rule. In other words, this activity incorporates inspections, management plans, O&M, and all appropriate abatement actions.

The abatement activity that is appropriate for a given area of ACM depends on the type and condition of that ACM. Those activities considered in the final schools rule include repairs, encapsulation, enclosure and removal. The distribution of ACM by type (surfacing material (SM) and/or thermal systems insulation (TSI)) was estimated with information from the AIBS. The proportion of ACM in each possible condition, or "damage", category was also estimated with information gathered from the AIBS.

Figure Nine
Costs for Inspections and O&M Programs

		All Bldgs.			
	Hospitals	**Fed**	**Res**	**Comm**	**Total**
Bldg w/ ACFM					
* $Insp/Bldg.	$1,592	$1,959	$1,297	$1,239	
$O&M/Yr. 1	$12,537	$13,191	$11,650	$11,228	
$O&M, each later yr	$4,186	$4,612	$3,792	$3,333	
$Per. Surv.	$45	$45	$45	$45	
$Reinsp.	$80	$80	$48	$48	
#Bldg.	9,675	14,000	208,000	511,000	733,000
**Subtotal	$378	$1,068	$8,776	$19,975	$29,819
Bldg w/ NFACM					
* $Insp/Bldg.	$540	$583	$359	$359	
$O&M/Yr. 1	$0	$0	$0	$0	
$Per. Surv.	$45	$45	$45	$45	
$Reinsp.	$80	$80	$48	$48	
#Bldg.	25,816	14,802	98,804	1,363,023	1,476,629
**Subtotal	$14	$10	$58	$758	$826
Bldg w/ no ACM					
**Insp Subtotal	$4.6	$1.4	$5.8	$181.8	$189.0
**Total	$395.3	$1,079.3	$8,840.0	$20,915.1	$30,834.4

* Includes Inspection and Notification
** In Millions

Figure Ten presents the possible costs of this approach. Discounted at 10%, the total cost is over $51 billion. This analysis assumed that all buildings will be used for 30 more years. The timing and number of response actions assumed to occur in this time period was based on the model response action timelines developed for the final AHERA schools rule RIA. The discounted cost for this scenario is under $4 billion for Federal buildings, $674 million for hospitals, over $12 billion for residential buildings, and almost $36 billion for commercial buildings.

Figure Ten
Costs of Full (AHERA) Regulatory Approach

	Hospitals	All Bldgs. Fed	Res	Comm	Total
Bldg w/ ACFM					
$Insp/Bldg	$1,592	$1,959	$1,297	$1,239	
$Mngmt Plan/Bldg	$4,100	$3,433	$2,794	$2,794	
#Bldg	9,675	14,000	208,000	511,000	733,000
$O&M/Bldg	$16,723	$36,295	$18,857	$16,176	
#Bldg	9,675	8,800	142,852	149,860	
$Repair/Bldg	$4,125	$18,811	$1,892	$3,087	
#Bldg	929	7,251	70,709	73,725	
$ Removal/Bldg	$87,471	$110,686	$15,147	$23,962	
# Bldg	9,675	14,000	208,000	511,000	
$Encaps/Bldg	$58,236	$101,892	$30,810	$35,147	
#Bldg	2,416	4,650	35,713	37,465	
$Enclosure/Bldg.	$73,869	$145,419	$44,827	$53,319	
#Bldg	2,416	4,650	35,713	37,465	
**Subtotal	$447.0	$3,471.6	$11,271.2	$23,631.2	$38,361.0
Bldg w/ NFACM					
$Insp/Bldg	$540	$583	$359	$359	
$Mngmt Plan/Bldg	$2,165	$2,369	$1,948	$1,948	
$O&M	$125	$125	$93	$93	
#Bldg	25,816	14,802	98,804	1,363,023	1,476,629
**Subtotal	$222	$132	$755	$11,763	$12,650.0
Bldg w/ no ACM					
**Insp Subtotal	$4.6	$1.4	$5.8	$181.6	$189.0
**Total	$673.6	$3,605.0	$12,032.0	$35,576.0	$51,200.0

* O&M costs include any required cleaning, periodic surveillance and reinspection.
** Costs are in millions of dollars.

The costs shown in Figure Ten incorporate the cost of asbestos-containing waste disposal. This cost was based on the proposed revisions to the NESHAP asbestos disposal standards. This cost assumed that asbestos waste would be disposed of in regular landfills as well as some hazardous waste landfills. Should only hazardous waste landfills accept asbestos-containing waste, the total discounted cost would increase by under $2 billion. Thus, the total cost would be an estimated $53 billion.

2. Federal Buildings As A Management Model

The first regulatory scenario considered in the report would establish an asbestos management model of Federal buildings. A variety of activities were considered as possible components of this model. The economic analysis estimated costs for those activities included in the full regulatory approach used for the final AHERA schools rule. (The activities were inspections, management plans, periodic surveillance, reinspection, response actions, O&M, and transport and disposal of asbestos waste.)

These costs, shown in Figure Eleven, are discounted at 10% over 30 years. If Federal buildings were used as a management model, the total estimated cost would be under $4 billion. The GSA and U.S. Postal Service have already undertaken some asbestos identification and abatement activities. The expenses for these activities have not been subtracted from this cost estimate.

In addition, Figure Eleven does not present cost estimates for such activities as relocation and reoccupancy studies, evaluation of the efficacy of different abatement techniques, or the development and analysis of new abatement and respiratory protection schemes. It was not possible to precisely determine costs for these activities. However, the preceding section on enhanced, targeted technical assistance provides at least approximations of the cost of some of these activities.

3. Inspection Rule

The second regulatory scenario discussed in the report would require that all public buildings inspect for ACM and notify occupants of any discoveries. This scenario would be modeled after the 1982 Asbestos-In-Schools Rule. In the economic analysis, the costs were estimated by multiplying the expected unit inspection cost per building type by the number of buildings in each public building class. The expected unit costs and building counts are shown in Figure Ten. To illustrate, 14,000 Federal buildings estimated to have ACFM would incur an average inspection expense of $1,959 for a total cost of roughly $27 million. The inspection of buildings with NFACM would cost under $9 million, and the inspections performed on buildings with no ACM would cost an estimated one and a half million dollars.

The resulting total inspection cost for all Federal buildings of $37 million is shown in Figure Eleven. Residential inspections would cost an estimated $311 million. Finally, commercial building inspections would cost an estimated $1.3 billion. Costs are, again, discounted at 10% over 30 years.

Figure Eleven
Total Cost by Building Type and Activity
(in millions of dollars)

	Building Type			
Cost Item	**Federal**	**Resident**	**Commercial**	**Total Cost**
Inspection	$36.9	$310.5	$1,303.9	$1,651.4
Mgmt Plan	$388.0	$2,862.6	$15,013.7	$18,264.3
O&M	$319.4	$2,693.7	$2,424.1	$5,437.2
Periodic Surveillance	$16.2	$134.0	$794.8	$945.0
Reinspect	$8.6	$45.4	$252.9	$306.9
Repairs	$136.4	$133.8	$227.6	$497.8
Encapsulation	$473.8	$1,100.3	$1,316.8	$2,890.9
Enclosure	$676.2	$1,600.9	$1,997.6	$4,274.7
Removal	$1,549.6	$3,150.7	$12,244.6	$16,944.9
Total	$3,605.3	$12,031.8	$35,576.1	$51,213.1

Note: Totals may not add exactly due to rounding.

4. Targeted Regulation

As discussed in the report, this scenario would allow EPA to selectively issue regulations to address the key ACM areas or materials where exposure and risk are greatest. The Agency could effectively issue regulations on any combination of asbestos activities and/or building types shown in Figure Eleven. One possible rule would be the inspection rule discussed immediately above.

Another rule, requiring the performance of O&M work, would cost an estimated $29 billion if all public buildings with friable ACM performed O&M for the next 30 years. If this rule applied only to residential buildings, for example, the cost would be an estimated $9 billion. These costs are taken from Figure Nine, and are derived by subtracting the inspection costs from the total costs.

5. Sequential Regulation

As opposed to the targeted regulation scenario, the sequential regulation scenario involves a gradual extension over time of the types of public buildings subject to an asbestos regulation. As an illustration, Federal buildings could be the first building set required to act under a new rule. As described earlier in this appendix, the estimated Federal building cost of a full regulatory response to asbestos, i.e., from inspection through removals, would be just under $4 billion.

The next building set to be regulated could perhaps be hospitals. The total count of these buildings is relatively small, so it would be fairly easy to determine the long-term effect of the regulations. The cost of a full regulatory program for hospitals would be roughly $700 million.

6. Immediate AHERA-Type Regulation

This scenario is identical in nature to the final AHERA schools rule in terms of the requirements made of building owners and managers. Such a scenario would require the full set of activity items shown in the first column of Figure Eleven and would cost an estimated $51 billion. This cost does not attempt to subtract the value of ongoing Federal building abatements or the value of ongoing private sector abatement work. The costs of this regulatory approach, by both building type and type of activity, are shown in Figure Eleven. The derivation of these costs is described above in the General Cost Estimation Scheme section.

IV. Limitations of the Analysis

Data limitations of many different types somewhat restrict the confidence in this analysis. This section briefly describes those data most likely to yield substantial changes in the results of this analysis, given a change in the data themselves.

The first data limitation concerns the number of public buildings with ACM, the quantity of ACM, and the level of damage of the ACM. The AIBS-supplied estimates for the first two items are probably low. The AIBS building data set does not account for buildings constructed after 1979, some of which are likely to contain ACM. The AIBS and its revisions also failed to estimate the amount of thermal systems insulation and such types of miscellaneous ACM as vinyl-asbestos floor tile. It is possible that the TSI estimate developed for this analysis on the basis of schools data is high. However, any overestimate of costs based on this estimate may be overshadowed by an underestimate caused by the lack of data on miscellaneous ACM types.

The AIBS damage estimates are not directly comparable to those used in the schools rule RIA; thus, the cost estimates derived by using the RIA's response action timelines may be off. It is not possible to determine if this caused an underestimate or overestimate of costs for public buildings.

The second limitation is the paucity of data on the current level of market-driven asbestos identification and abatement activities in public buildings. Because the level of currently ongoing identification and abatement activities was not estimated in this analysis (due to a lack of data), the costs developed in this analysis may be somewhat high.

The third limitation concerns the estimates of hours required to perform such activities as an asbestos inspection. It is likely that the estimates developed in this analysis are low. These estimates were derived from, and are often somewhat lower than, the estimates developed in the schools rule RIA. (This is because the public building models are smaller than most of the school models.) However, in terms of scheduling and performing asbestos-related work, many classes of public buildings are likely to require more time than schools. This is due to a variety of factors ranging from a more complex tenant mix to a more varied tenant work schedule mix. Unfortunately, the data do not yet exist that would allow a revised estimate of both the time required to perform these activities and the resultant change in costs. It is expected that the revisions would yield some increase in both hours and costs.

In total, the set of data limitations described above are expected to result in a moderate underestimate of total costs.

APPENDIX 6

ABSOLUTE RISK SENSITIVITY ANALYSIS

I. INTRODUCTION

This appendix will illustrate the relationship between fiber levels and asbestos-related mortality which could be attributed to the presence of asbestos-containing material in public and commercial buildings. These scenarios cover deaths occurring over the next 130 years as a result of exposure to asbestos-containing material within the next 60 years.

As was discussed in the main report, many data which would strengthen this risk sensitivity analysis do not exist. The fiber levels which are prevalent in public and commercial buildings comprise a major source of uncertainty in the production of absolute risk numbers. In addition, EPA has applied necessarily broad assumptions about the person-hours of occupancy used in these scenarios, as well as the ages of their exposed populations.

A further reason to examine the scenarios with caution is the lack of any information on current abatement actions which are occurring in the absence of specific Federal regulations. These abatement actions, driven by considerations (*inter alia*) of legal liability and State and local regulation, may reduce a significant proportion of the risk from asbestos currently located in public and commercial buildings.

The risks of lung cancer are estimated using Nicholson's relative risk model, while those of mesothelioma are estimated using Nicholson's absolute risk model.[1] These models have been used by both OSHA and CPSC in rulemakings, and are used by EPA in proposed rules for other asbestos products. These are the standard models for estimating risks resulting from asbestos exposure. Although the models are standard, peer-reviewed, models, the fiber level selected for use with the models is that found in an EPA study of one school district.[2] This particular level was selected to indicate the results of the model when a specific fiber level is chosen, and is not meant to suggest which fiber levels are actually present in public and commercial buildings. The results of this analysis are, therefore, purely illustrative.

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1 U.S. EPA, Office of Health and Environmental Assessment. **Airborne Asbestos Health Assessment Update**. June 1986.

2 **Airborne Asbestos Levels in Schools**, Office of Toxic Substances, U.S.E.P.A., June 1983. EPA 560/5-83-003.

II. INDIVIDUAL EXPOSURE ESTIMATION

Since the precision of the risk assessment is enhanced by the analysis of exposure to various categories of populations, separate estimates of exposure to asbestos are used for the occupants of residential buildings of ten or more units, the occupants of government buildings[3], and for the occupants of nonresidential commercial buildings.

Unfortunately, data on air monitoring to determine asbestos concentrations in buildings with friable, asbestos-containing material (ACFM) before and after abatement action are limited to those from a few studies only. These studies used different methods of analysis and interpretation. The results from several of these studies were compiled by EPA staff and are presented in Appendix C of "Cost and Effectiveness of Abatement of Asbestos in Schools".[4] The estimates from these studies are not used here since they represent a wide variety of sampling methods, and it would be extremely difficult to adjust data based on sampling conditions and procedures that are unknown or were derived for purposes other than the intent of this study.

An essential component of the risk analysis for asbestos would be the actual fiber levels to which persons are exposed. Unfortunately, EPA does not have fiber level estimates for either schools or public buildings which can validly be extended to the general population of buildings. In this analysis, the airborne concentration is assumed to be the mean concentration found in a 1981 EPA study conducted in a single school district[5], or 0.0021 optical fibers per cc. The weighted average concentration found in that district of 70 ng/m^3 (or 0.0021 optical f/cc) was derived by assuming that approximately 15% of the building contains asbestos. We do not know whether this number can be extended to other schools, nor do we know whether it is representative of fiber levels in public and commercial buildings.

We chose the figure of 0.0021 f/cc for the purpose of this sensitivity analysis, as opposed to the figure of 0.03 f/cc used in Section II.B. of the main report, for the following reason: the figure of 0.03 f/cc and other exposure data which appear in

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3 Government buildings are defined as those buildings either owned by the U.S. Government or leased by the U.S. General Services Administration (GSA), in which more than half of the occupants are Federal workers.

4 U.S. EPA, Office of Toxic Substances. **Cost and Effectiveness of Abatement of Asbestos in Schools**. August 1984.

5 Op. Cit. USEPA 1983 (June).

the main body of this study are fiber counts derived using direct Transmission Electron Microscopy (TEM). This method counts fibers much smaller than those counted using light (optical) microscopes, and thus produce a much higher total fiber count. The risk models were developed from optical fiber data, which counts only the larger fibers, and at present there is no accepted method for converting direct TEM measurements into optical fiber data. The data from EPA's school study were collected by a particular method (indirect TEM), which can be converted into light microscope units.[6] This allows us to use the fiber levels generated in the school study as input to the previously developed health models, which enables us to predict mortality.

Despite the paucity of the data on fiber levels, this sensitivity analysis was considered a useful exercise, since both the health models and population estimates are well developed.

III. ESTIMATES OF TOTAL POPULATION EXPOSED

A. Non-custodial Occupants of Government and Nonresidential Buildings

In this analysis it is assumed that non-custodial occupants of government and nonresidential buildings are exposed to the same levels of airborne asbestos. The range of airborne concentrations currently in nonresidential public buildings with ACFM prior to abatement are adjusted here to account for the deterioration of asbestos-containing building materials caused by vibration, vandalism, age, and moisture damage over time. Using the standard economic assumption that a building has a useful life of fifty years before requiring major renovation or replacement, and further assuming that no major cycles have occurred in building construction, the average age of public buildings can be assumed to be 20 to 30 years. On average these buildings can be expected to last an additional 20 to 30 years.[7] For this analysis, a remaining building life of 30 years has been assumed.

Assuming that building materials deteriorate proportionately with building age,[8] by the end of the building life, the airborne

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6 Op. Cit. USEPA 1986 (June).

7 This assumption is consistent with the assumption made for the asbestos-in-schools rule. U.S. EPA, Office of Toxic Substances. **Final Schools Rule: Asbestos Hazard Emergency Response Act Regulatory Impact Analysis.** September 1987.

8 This assumption of proportional deterioration with building age has been used in other EPA reports. See Op. Cit. USEPA 1984 (August).

asbestos concentration will slightly more than double from today's level. Therefore, this analysis assumes that the mean airborne asbestos level over the remaining building life would be about 60 percent above the current estimated airborne concentration.

Additional assumptions are listed below.

- Non-custodial occupants of nonresidential public buildings are assumed to have the age, race, and sex distribution of the U.S. occupational population. This distribution is reported in Table 1. The proportion of smokers by age, sex, and race is assumed to be the same as the current distribution of U.S. smokers. For this analysis, the proportion of the U.S. population who smoke is held constant over time, although the actual proportion may be declining. The population is assumed to be exposed to airborne asbestos for 8 hours a day, 250 days per year and to have a breathing rate of 1 m^3/hr.

- The "average" nonresidential building is assumed to be an office building. This assumption probably provides reasonably close results for the population of government (GSA) buildings but may be inaccurate for the population of non-GSA buildings. Non-GSA buildings would include churches, hospitals, and stores, in addition to more office buildings.

- Using Census-derived estimates of 30 occupants per office building, 637,000 persons are assumed to occupy Federal buildings which contain asbestos and 23,250,500 persons are assumed to occupy other nonresidential public buildings which contain asbestos.

TABLE 1

SEX, RACE, AND AGE DISTRIBUTION OF EXPOSED POPULATIONS

Characteristic	Proportion of Population (Decimal Share) Occupational	Nonoccupational
SEX		
Male	.79	.49
Female	.21	.51
RACE		
White	.88	.88
Nonwhite	.12	.12
AGE		
0 - 9	0	.146
10 - 19	.1	.174
20 - 29	.205	.176
30 - 39	.210	.139
40 - 49	.193	.108
50 - 59	.175	.099
60 - 69	.117	.083
70 - 79	0	.055
80 - 89	0	.020

Sources: For occupational: Research Triangle Institute, 1985 (August). Regulatory Impact Analysis of Controls on Asbestos and Asbestos Products. Prepared for the Office of Pesticides and Toxic Substances, USEPA, Washington, D.C., Appendix B. For nonoccupational: U.S.DOC. 1980. U.S. Department of Commerce. Statistical Abstract of the United States. Washington, D.C.: Bureau of the Census. Table taken from "Regulatory Impact of Controls on Asbestos and Asbestos Products. Volume I: Technical Report." Draft report prepared for the Office of Toxic Substances, USEPA, Washington, D.C., August 1987.

B. **Non-custodial Occupants of Residential Buildings**

Since it is not possible to determine whether, on average, different levels of airborne asbestos are prevalent in the various types of buildings, it is assumed that non-custodial occupants of residential buildings are exposed to the same level of airborne asbestos fibers as are occupants of nonresidential buildings. As in the previous section, it is assumed in this analysis that these residential structures have a 30-year remaining life and that, in the absence of abatement activity, the average airborne asbestos fiber level will more than double from the current level, during the remaining useful life of the building.

Additional assumptions are as follows:

- Non-custodial occupants of residential buildings of 10 or more units are assumed to have age, race, sex, and proportion smoking distribution of the U.S. population as a whole. They are assumed to be exposed to building asbestos fiber levels for 14 hours a day, 365 days a year. A breathing rate of 1 m^3/hr is assumed. The population distribution is presented in Table 1.
- According to the 1980 census, there are 19,815,448 occupants of such buildings.
- Assuming that the proportion of residents of buildings of ten or more units who are exposed to airborne asbestos is the same as the proportion of such buildings which contain asbestos, 59%, or 11,691,114 persons, would be exposed.

C. Custodians of Public and Commercial Buildings

This analysis assumes that custodians of buildings potentially face a higher level of exposure to fibers than do other occupants of the same buildings. This assumption is based on the facts that much of the asbestos is located in areas frequented by custodians, such as boiler rooms, and that custodians are engaged in activities, e.g., changing light bulbs or dry sweeping, which disturb asbestos in their vicinity.

The OSHA regulation on occupational exposure found that routine maintenance in commercial and public buildings produced a mean exposure of 0.29 f/cc on an eight-hour, time-weighted average[9]. Finding that this level presented an unacceptable risk, OSHA promulgated a Permissible Exposure Limit (PEL) of 0.2 fibers per cubic centimeter. It is not always a straightforward task for a building owner to comply with this OSHA PEL. Consequently, to bound the estimates of risk to custodians, this analysis assumes for the high end of the range that custodians are exposed to the 0.29 f/cc today, and that conditions deteriorate over the 30-year remaining life of these buildings, so that the average exposure level over the 30-year period is 0.46 f/cc. For the low end of the range, this analysis assumes that workers are exposed to an average concentration of 0.01 f/cc, the lowest level measured by Phase Contrast Microscopy (PCM) that is used in practice. This level, in practice, would

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9 Department of Labor, Occupational Safety and Health Administration. 29 CFR Parts 1910 and 1926, **Occupational Exposure to Asbestos, Tremolite, Anthophyllite, and Actinolite; Final Rules.** June 20, 1986, Washington, D.C.

be used as the clearance level in buildings after a response action. Estimates are also shown for the assumption that workers are exposed to an average of 0.2 f/cc, the OSHA PEL, and 0.1 f/cc, the action level under the OSHA regulation. All of the fiber levels selected for the sensitivity analysis (displayed in Table 3) are taken from the OSHA RIA of June 20, 1986.[10] In particular, the choice of 0.01 f/cc is similar to the weighted average fiber level that OSHA estimated for routine maintenance in commercial and residential buildings.

Additional assumptions are as follows:

- Custodians are assumed to have the age, race, and proportion smoking distribution of the population of U.S. workers in the manufacturing sector (blue collar). The sex distribution, derived from Census data, is 80% male and 20% female. They are assumed to be exposed for 8 hours a day, 250 days per year. Their breathing rate is assumed to be 1 m^3/hr.

- According to the 1980 Census, 1,846,000 persons are employed as custodians or other cleaners in buildings, not including education-related buildings. (Education-related buildings include public and private elementary and secondary schools, colleges and universities, and libraries.)

- Assuming that the proportion of custodial personnel exposed to airborne asbestos is the same as the proportion of buildings which contain asbestos, i.e., 20% or 369,200 custodians are exposed.

- The data source used to estimate custodians' exposure is different from, and consequently not necessarily consistent with, the data source used to estimate the exposures of non-custodial building occupants.

IV. RISK ANALYSIS METHODOLOGY

The effects of the presence of airborne asbestos in public and commercial buildings are estimated in terms of the number of lung cancer, gastrointestinal (GI) cancer and mesothelioma deaths avoided. These figures understate the effects since they exclude statistical cases of cancer which do not result in death. The

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10 U.S. DOL, Occupational Safety and Health Administration. **Quantitative Risk Assessment for Asbestos-Related Cancers.** Washington, D.C., 1983.

cure rates assumed for this paper are approximately 10% for lung cancer and GI cancer, and approximately 2% for mesothelioma.

The Nicholson relative risk model is used to estimate the number of lung cancer cases avoided, and Nicholson's absolute risk model is used to estimate the number of mesothelioma cases avoided (USDOL, 1983)[11]. The GI cancer rate is assumed to be 10% of the lung cancer rate, which is the lower end of the range found in studies, and the value adopted by OSHA in its rulemaking. Dose-response constants used in these models were estimated by Selikoff in a study of asbestos insulation workers (Selikoff et al., 1979).[12] These models are also being used to estimate deaths and cases of lung cancer, GI cancer and mesothelioma for other EPA asbestos (proposed) regulations and have been used in prior rulemaking by both OSHA and the Consumer Product Safety Commission.

A number of epidemiological studies have estimated dose-response constants for asbestos-related diseases. Estimates vary by as much as an order of magnitude. The Selikoff estimates fall approximately in the middle of the ranges of dose-response estimates for lung cancer and mesothelioma. In addition, the Selikoff estimates have the lowest variance among all of the estimates. These models and dose-response constants are those recommended by the Chronic Hazard Advisory Panel on Asbestos and were used by OSHA in doing asbestos risk assessment. The risk analysis methodology is discussed in more detail in Appendix A of "Cost and Effectiveness of Abatement of Asbestos in Schools."[13]

V. RESULTS

The results derived from the assumptions outlined in the previous sections are presented in Tables 2 and 3. In each table, the illustrative number of cases and deaths assumes that no additional regulations are promulgated for public buildings. As mentioned earlier in this Appendix, ongoing activities to abate asbestos in public and commercial buildings have not been estimated, so that the number of cases for each exposure level may be overstated.

A. Non-custodial Occupants

In Table 2, the exposure level is based on a weighted average concentration found by EPA in one school district. This value

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11 Op. Cit. USDOL 1986 (June).

12 Selikoff, et al. "Mortality Experience in Insulation Workers in the United States and Canada." **Annals of the New York Academy of Sciences.** 330:91-116. New York, 1979.

13 Op. Cit. USEPA 1984 (August).

was chosen to provide a reference point; since the risk of all three types of cancers are directly proportional to the exposure concentration, it is a simple matter to determine what the expected cancer deaths might be in any other scenarios. It should be stressed that the numbers generated by the model are based on estimated fiber levels and estimated population exposed. Since fiber levels are uncertain, the estimate of deaths provided by the model is also uncertain. The number of cases and deaths predicted by the model occur between 1988 and 2118 (130 years) and are the result of exposure to asbestos in buildings between 1988 and 2048 (60 years).

As described earlier, the models used to estimate cancer cases and deaths are Nicholson's absolute risk model (for mesothelioma) and Nicholson's relative risk model (for lung cancer). The model's results are directly proportional to fiber concentrations so that determination of the statistical deaths associated with higher- or lower-level asbestos concentrations is a straightforward process. For example, if the fiber levels were as low as one-tenth the mean of the school district study, we would expect a total of 430 total deaths due to lung cancer, GI cancer and mesothelioma. On the other hand, if the fiber levels were as high as twice the mean of the school district study, we would expect 8,540 deaths due to lung cancer, GI cancer and mesothelioma.

TABLE 2

NON-CUSTODIAL OCCUPANTS

		Government Buildings	Commercial Buildings	Residential Buildings (10 or more units)	Total*
CASES**	(1988 - 2118)	70	2650	1850	4570
DEATHS	(1988 - 2118)				
	Lung Cancer	30	1160	570	1750
	G.I. Cancer	0	120	60	180
	Mesothelioma	30	1190	1120	2340
TOTAL*		70	2460	1750	4280

* Columns may not add exactly due to rounding. All numbers have been rounded to the nearest ten.
** Assumes fiber exposure of 0.0021 optical f/cc.

Given this illustrative range of exposure for non-custodial occupants of public and commercial buildings among 35.6 million people exposed, the lifetime (30 years of exposure) risk to individuals would range from 10^{-5} to 10^{-4}. This is equivalent to between 7 and 143 deaths per year of exposure over the up to sixty year remaining building life. Alternatively, this is equivalent to between 3 and 66 deaths per year over the 130 years that these deaths may occur. The distribution of these deaths is not uniform so that in any one year more or fewer than the average number of deaths may occur. No deaths are estimated to occur beyond 130 years. This estimate of the number of deaths assumes that no medical advances are made over the next 130 years to reduce cancer mortality.

If the airborne concentrations of asbestos fibers can be brought down to the median fiber concentration in ambient air, 2.3 nanograms per cubic meter or 0.00007 fibers per cubic centimeter[14] then most of these deaths could be avoided. Assuming that this could be accomplished in a relatively short period of time (i.e., most of the abatement occurs in the first 5 years), the number of deaths resulting from 60 years of occupancy in these buildings could be kept to around 100.[15]

The issue of abatement is a complicated one. At the present time EPA does not have information which allows the Agency to assess the efficacy of abatement techniques. Sufficient data regarding post-abatement fiber levels are not available. EPA has anecdotal evidence which indicates that not all abatement actions are conducted in a manner that would preclude the release of asbestos. Improperly conducted abatement actions may cause an increase, rather than a decrease, in the fiber levels to which building occupants are exposed. Even well-conducted abatement actions may increase exposure in the short term for an unknown length of time. For the purposes of this analysis, no assumption is made that abatement activities will reduce building fiber levels to average ambient fiber levels.

Finally, this appendix has not attempted to assess the risk to building occupants from exposure to materials which are used as replacement materials for the asbestos. A report issued by the National Research Council states, "In the studies conducted to date, man-made mineral fibers have not presented the same magnitude of health hazard to humans as has asbestos."[16]

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14 The median asbestos fiber concentration of the air of U.S. cities is reported to be 2.3 ng/m^3 or 0.00007 f/cc using a conversion factor of 30 fibers per nanogram. See **Asbestiform Fibers: Nonoccupational Health Risks.** National Research Council, Washington, D.C. 1984.

15 This calculation used the timing of abatement action used in Appendix 5 for estimating the costs of an AHERA-type regulation. It is beyond the scope of this appendix to speculate whether in fact an AHERA-type regulation would achieve such an airborne concentration level.

16 Op. Cit. National Research Council (1984) p. 145.

Although the risk posed by substitute materials appears to be lower than the risk posed by asbestos, the substitutes are unlikely to be completely risk free.

B. Custodians

Table 3 presents estimates for the number of deaths among custodians working in asbestos-containing buildings. The first column assumes pre-OSHA rule fiber levels and that over the 30-year remaining life of the buildings, the airborne concentration will rise to an average level of 0.46 f/cc. The estimated number of deaths among this group, 3,730, out of an exposure population of 369,200, implies a lifetime risk to individuals of 10^{-2} if no OSHA rule had been implemented.

The second column assumes that the OSHA PEL of 0.2 f/cc is, on the average, just met in each and every building. The resulting 1,665 deaths out of 369,200 exposed implies a lifetime risk to individuals of 10^{-3}. This differs from the OSHA reported risk of 10^{-2} because OSHA has estimated mortality from asbestosis and included these deaths with the cancer deaths. EPA has not estimated asbestosis deaths in this report.

TABLE 3

SENSITIVITY ANALYSIS: CUSTODIANS (ALL ASBESTOS-CONTAINING BUILDINGS)

		Pre OSHA Rule	At average of 0.2 f/cc	At average of 0.1 f/cc	At average of 0.01 f/cc
CASES	(1988 - 2118)	4060	1810	905	91
DEATHS	(1988 - 2118)				
	Lung Cancer	2055	920	460	46
	G.I. Cancer	205	90	45	5
	Mesothelioma	1470	655	327	33
TOTAL*		3730	1665	832	84

* Columns may not add exactly due to rounding. All numbers have been rounded to the nearest ten.

The third column assumes that all custodians are exposed to an average of 0.1 f/cc, the action level under the OSHA regulation, and the fourth column assumes an exposure at 0.01 f/cc, the practical limit of detection for PCM.

The resulting deaths out of 369,200 exposed implies a lifetime risk to individuals of 10^{-4}. If the levels in these buildings could be brought down over a reasonably short time to the ambient air concentration of 0.00007 f/cc, these deaths could be held to near zero.[17]

VI. LIMITATIONS OF THE ANALYSIS

Any analysis is only as strong as the data which support it. As mentioned at the beginning of this appendix, many data which would have improved this analysis simply do not exist. In addition to the limitations discussed in each section, several other assumptions should be pointed out.

Smoking and exposure to asbestos react synergistically to produce lung cancer. That is, persons who both smoke and are exposed to asbestos have lung cancer rates that are 50 times those of persons who neither smoke nor are exposed to asbestos. Smoking multiplies one's chance of developing lung cancer by a factor of 10, regardless of whether one is or is not exposed to asbestos. Thus, the majority of the cases of lung cancer described in the report will occur to smokers.

For the relative risk (lung cancer) portion of this analysis, U.S. 1977 lung cancer rates were assumed. Because lung cancer rates have been increasing at approximately three percent per year since the 1950's, this assumption, taken by itself, will understate lung cancer rates. Smoking rates, however, are currently declining. We can therefore expect that lung cancer rates will also decline, with a 30 or 40 year lag. The choice of 1977 lung cancer rates is an attempt to select a rate which represents the average rate over the 130-year period of analysis. Whether or not this choice is indeed the appropriate average, the deaths predicted by the model will occur later in time than will the actual deaths.

As mentioned earlier, deaths from asbestosis are not included in this analysis. OSHA estimates that at the PEL of 0.2 f/cc, a lifetime exposure will result in five deaths from asbestosis out of every thousand lifetime exposures.

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[17] This calculation used the timing of abatement action used in Appendix 5 for estimating the costs of an AHERA-type regulation. It is beyond the scope of this appendix to speculate whether in fact an AHERA-type regulation would achieve such an airborne concentration level.

For every population group modeled, the assumption was made that the proportion of people exposed to asbestos (out of total persons potentially exposed in that building type) was equal to the proportion of buildings of that type which contained asbestos. If large buildings are more likely to contain asbestos than small buildings, the number of people assumed exposed will be understated by the methodology employed here. Conversely, if the asbestos-containing buildings are smaller than average, this methodology will overestimate the number of people exposed.

One final assumption which requires discussion is the derivation of average fiber levels. For the purposes of estimation, buildings were not 'retired' until the end of the 30-year estimation period. If buildings which contain asbestos are taken out of service within the 30-year estimation period -- for example, if they are replaced with non-asbestos-containing buildings -- the fiber levels will not increase as rapidly as projected by this appendix. This failure to retire buildings, however, is balanced by the fact that although the average age of buildings is assumed to be 25 years, so that in this analysis all asbestos-containing buildings will be out of service in 30 years, approximately one-half of the buildings are in fact newer and will continue to expose the inhabitants to asbestos for 50 to 60 years. Since the analysis uses a linear, no-threshold model, as long as total fiber emissions have been adequately captured, the resulting mortality estimates will be approximately accurate. As in the case of the lung cancer rates, however, the timing of modeled deaths will differ from the timing of actual deaths.

VII. SUMMARY

This appendix demonstrates a method of estimating the deaths which can be attributed to the presence of airborne asbestos fibers in public and commercial buildings. A wide range of estimates is used because of limited data on the actual airborne asbestos levels in this set of buildings.

APPENDIX 7

POSSIBLE STUDIES TO ADDRESS INFORMATIONAL DEFICIENCIES

The following studies are means for addressing the informational limitations listed in Part 4 of Section III.A.

STUDY 1: EVALUATION OF THE IMPLEMENTATION OF AHERA SCHOOLS RULE

STUDY OBJECTIVE: To identify efficiencies and difficulties experienced by schools in attempting to achieve full compliance with AHERA regulations.

RATIONALE: Before proceeding with a regulatory program for public and commercial buildings, technical implementation problems and potential resource constraints associated with the regulations promulgated for schools under AHERA should be identified. The "lessons" learned in the program for schools should provide a basis for proceeding with regulatory programs for the public and commercial buildings sector.

APPROACH: This information would be obtained in a national telephone survey of Local Education Agencies (LEAs) similar to the EPA survey conducted previously to assess compliance with the 1982 Asbestos Identification and Notification regulation. On-site quality assurance checks would be implemented at a subsample of LEAs to verify the survey respondent information. The survey would be planned during the last quarter of fiscal year 1988 and conducted during 1989 and 1990. Interim results would be available in March 1989, September 1989, and March 1990. Final results would be available in September 1990.

COST ESTIMATE: $1,500,000

TIME ESTIMATE: 2.5 years

STUDY 2: OPERATIONS AND MAINTENANCE PROCEDURES EFFICACY

STUDY OBJECTIVE: To evaluate the efficacy of particular operations and maintenance (O&M) procedures, such as special cleaning techniques.

RATIONALE: Most of the information that exists regarding these objectives is anecdotal in nature. A valid study would provide careful evaluations of various O&M procedures and strengthen the Agency's technical guidance and regulatory programs.

APPROACH: Air monitoring would be conducted over time in buildings selected on the basis of function, construction and engineering systems, and existing asbestos management/O&M/ abatement programs. Standard asbestos sampling and analysis methods would be employed. It is anticipated that the study might have to bear the costs of special cleaning operations in some of the study buildings to ensure uniformity and to provide incentives for cooperation and participation. It is proposed that a few O&M procedures be evaluated at a unit cost of approximately $1,000,000 for each special study.

COST ESTIMATE: $2,000,000 (two procedures @ $1,000,000 each)

TIME ESTIMATE: 2 years

LIMITATIONS/DISADVANTAGES: This study does not directly determine absolute airborne concentrations without O&M, but rather examines potential for reducing levels in certain buildings.

STUDY 3: LONG-TERM EFFICACY OF ASBESTOS CONTROL

STUDY OBJECTIVE:

Phase 1: To monitor airborne asbestos levels after a removal action and determine the need for and effectiveness of special cleaning procedures or followup O&M.

Phase 2: To compare the reduction in airborne asbestos levels after asbestos removal to the reduction through implementation of special operations and maintenance procedures.

RATIONALE:

Phase 1: Anecdotal evidence indicates that the removal of ACM may not completely eliminate asbestos exposures due to residual contamination of the building. Since increased EPA regulatory activity (i.e., AHERA) will undoubtedly result in additional asbestos removal activities, it is important to collect information on how well they are being conducted and whether or not long-term O&M procedures are necessary.

Phase 2: This study option would supplement Phase 1 by collecting information to document the efficacy of leaving ACM in place and implementing special O&M procedures as opposed to the removal of the ACM. There is no information on the relative effectiveness of special O&M versus ACM removal. If O&M is as effective in controlling airborne asbestos levels as properly conducted removal actions, then building managers/owners could defer costly removal jobs and factor them into planned changes in building use.

The results of Studies 2 and 3 would serve in part as the basis for guidance to building owners on the efficacy and implementation of O&M programs and the need for continued O&M after removal.

APPROACH:

Phase 1: Forty buildings would be selected for air monitoring before and after removal actions. Special cleaning procedures (wet mopping, HEPA vacuuming, etc.) would be implemented in half the buildings. Normal cleaning procedures would be followed in the remaining half. Airborne asbestos levels will be measured 3, 6 and 12 months after removal. Standard asbestos sampling and analysis methods would be employed.

Phase 2: A second set of buildings would be selected for air monitoring before and during the implementation of a special O&M program over an extended period of time.

COST ESTIMATE:

Phase 1: $8,000,000

Phase 2: $8,000,000

TIME ESTIMATE: 2-3 years

LIMITATIONS/DISADVANTAGES: This study does not directly determine whether or not there are significant asbestos levels without removal and O&M, but rather looks at potential for reducing levels in certain buildings.

STUDY 4a: PROBLEM CHARACTERIZATION STUDY 1: "PEAK" EXPOSURE LEVELS

STUDY OBJECTIVE: To characterize "peak" asbestos fiber releases from specific disturbances of ACM.

RATIONALE: The Agency has long been concerned about building occupants and service workers receiving "peak" exposures to airborne asbestos fibers during incidents that disturb the ACM. Many of these disturbances occur in the course of routine maintenance and repair activities. There are virtually no data on "peak" exposures. These incidents occur as a result of routine maintenance and repair activities as well as through vandalism and inadvertent damage to the material (e.g., a leaking roof). This study would provide the Agency with estimates of "peak" exposures and will provide the Agency with information to consider in regulatory decisions about the utility of special operations and maintenance programs for preventing "peak" exposures.

APPROACH: To conserve funds, this study would be carried out using an experimental design approach. Typical maintenance and repair activities that involve disturbing in-place ACM would be staged in selected buildings in order to simulate real world activities. Air monitoring would be conducted during these activities to characterize the fiber releases associated with them. The cost estimate reflects the Agency bearing the expense of the activities in order to ensure monitored activities are conducted properly and so that expensive monitoring can be done only at times that will yield the most information.

COST ESTIMATE: $5,000,000

TIME ESTIMATE: 1.5 years

STUDY 4b: PROBLEM CHARACTERIZATION STUDY 2: THE INCIDENCE OF "PEAK" EXPOSURE LEVELS AND THEIR IMPACT ON AVERAGE BUILDING LEVELS

STUDY OBJECTIVE: To estimate the incidence of "peak" fiber releases and their contribution to overall asbestos levels in buildings.

RATIONALE: EPA has no data on the contribution of incident-related releases to overall building asbestos fiber levels. This study will investigate fiber emissions from specific disturbances and will provide an estimate of the frequency of occurrence of these "peak" exposures. Measured airborne asbestos levels in public and commercial buildings are generally low. The frequency of "peak" exposures and their impact on overall building fiber levels is unknown. This study would provide the Agency with valid data upon which to base regulatory decisions about the utility of special operations and maintenance programs for in-place asbestos control.

APPROACH: In order to measure "peak" exposures, a large number of air samples would need to be collected. Air monitoring would be conducted daily and weekly over a six month period in a number of buildings sufficient to ensure detection of "peak" incidents. A subset of samples will be analyzed by transmission electron microscopy.

COST ESTIMATE: $30,000,000

TIME ESTIMATE: 2-3 years

STUDY 5a: PRIVATE SECTOR ASBESTOS MANAGEMENT ACTIVITIES AND STATE AND LOCAL GOVERNMENT PROGRAMS

STUDY OBJECTIVES: To characterize and document current asbestos management programs in public and commercial buildings (non-school buildings owned privately or by State and local governments).

RATIONALE: To determine the extent of the need for Federal regulations regarding inspection and response actions to control asbestos exposure in these buildings. For example, if voluntary management activities are successfully in place in the commercial sector and if State and local government regulatory programs are effective, EPA's regulatory risk management efforts could emphasize technical assistance rather than requirements similar to the AHERA schools regulations for the commercial sector.

APPROACH: A national survey of building owners and managers, including State and local government officials, to identify and characterize asbestos management programs that are in place. A combination of survey methods would be employed (telephone, personal interview, mail) with on-site followup visits to verify respondents' report information.

COST ESTIMATE: $850,000

TIME ESTIMATE: 1.5 years

LIMITATIONS/DISADVANTAGES: This does not address the question of risk in buildings without management programs. It is also very difficult to determine the "before" situation necessary to evaluate the impact of private sector programs. In addition, buildings are likely to have different sets of circumstances and control mechanisms which would not necessarily be reproducible. For example, education/awareness training, O&M, and removal would not necessarily be separable activities.

STUDY 5b: EVALUATE IMPACT OF PRIVATE SECTOR/STATE AND LOCAL ASBESTOS MANAGEMENT PROGRAMS

STUDY OBJECTIVE: To determine the impact of private sector asbestos management activities and State and local government asbestos control programs on prevalent airborne asbestos levels in these buildings.

RATIONALE: To determine the extent of the need for Federal regulations regarding inspection and response actions to control asbestos exposure in these buildings. For example, if voluntary management activities are successfully in place in the commercial sector and if State and local government regulatory programs are effective, EPA's regulatory risk management efforts could emphasize technical assistance rather than requirements similar to the AHERA schools regulations for the commercial sector. Air monitoring would be utilized to evaluate the effectiveness of asbestos control programs.

APPROACH: The objective would be met by an air monitoring study which would be conducted over the next four years, the first sampling period to be accomplished now with a followup period in three years in order to compare prevalent levels and assess the reduction in exposure, if any, as a result of the asbestos management programs taking effect.

COST ESTIMATE: $15,000,000

TIME ESTIMATE: 5 years

LIMITATIONS/DISADVANTAGES: Essentially the same as Study 5a above.

STUDY 6: EXPOSURE-RISK INTERPRETATION

STUDY OBJECTIVE: To establish a standard method for using TEM exposure estimates to calculate risks of lung cancer and mesothelioma.

RATIONALE: The models for lung cancer and mesothelioma relating risk to exposure were developed from data reflecting exposure measurements based on PCM. A formal method for applying these models directly to fiber concentrations measured by TEM has not been developed. Previous risk calculations where TEM was used to measure exposure have relied on a conversion from mass to fibers, typically using 30 fibers per nanogram. The conversion factor was developed using assumptions concerning the size distribution of fibers visible by PCM and limited data directly comparing PCM and TEM measurements. Differences between direct and indirect filter preparation methods were not considered.

APPROACH: This study will consist of a thorough review of the measurements used to establish current exposure-risk relationships for lung cancer and mesothelioma. Special emphasis will be placed on summarizing fiber size distributions. These findings will be analyzed in conjunction with summaries of fiber size distributions associated with Method 7400 (PCM), "direct" TEM, and "indirect" TEM. The results of the analysis will be summarized in a report that will indicate the assumptions underlying risk calculations based on exposure measurements obtained by different methods. The report will also suggest a standard EPA approach for using asbestos exposure data to evaluate risk.

COST ESTIMATE: $75,000

TIME ESTIMATE: 6 months

STUDY 7a: PREVALENT LEVELS OF AIRBORNE ASBESTOS FIBERS IN PUBLIC AND COMMERCIAL BUILDINGS

STUDY OBJECTIVE: To establish national estimates of prevalent airborne asbestos levels in nonschool buildings.

RATIONALE: Valid national estimates of prevalent airborne asbestos levels in these building populations would allow EPA and other Federal agencies to have an exposure basis for Federal regulatory programs. These estimates would allow EPA to better determine whether there is a need for regulations or other programs to control exposure levels experienced by typical building occupants in public and commercial buildings, and whether these activities should be similar to those for schools.

APPROACH: Select a probability sample of U.S. public and commercial buildings for air monitoring. The survey design will be similar to the EPA 1984 survey and will include residential apartment buildings, office buildings and other public facilities (theaters, airports, restaurants, sports facilities). Federal buildings are excluded from this project description and cost estimates. It is anticipated that approximately 1,250 public and commercial buildings would be inspected in order to select buildings for air monitoring. Air monitoring would be conducted in 250 public and commercial buildings. An average of 10 indoor and 2 outdoor samples would be collected over a one-week period in each of the 250 buildings. The samples would be analyzed by TEM. The data collected would be used to estimate prevalent levels in public and commercial buildings.

COST ESTIMATE: $14,000,000

TIME ESTIMATE: 2 to 3 years

LIMITATIONS/DISADVANTAGES: Although this study will help determine whether or not there is a "problem" in the building types (i.e., it will allow for risk estimates to be calculated), it will not suggest specific regulatory or other program options if a "problem" is found. That is, the efficacy of any potential regulatory options would not be explicitly addressed by this study. Also, it would only indirectly suggest how many buildings have an airborne asbestos problem and would not necessarily suggest which particular buildings present a significant hazard.

STUDY 7b: SERVICE WORKERS' EXPOSURE TO AIRBORNE ASBESTOS IN PUBLIC AND COMMERCIAL BUILDINGS

STUDY OBJECTIVE: To estimate exposure to airborne asbestos levels experienced by service workers during maintenance, repair and cleaning activities, and to compare service worker exposure levels to prevalent building levels.

RATIONALE: The Agency would have better information to determine if regulations or other program options governing activities and exposure of service workers to airborne asbestos in public and commercial buildings are necessary and justified in addition to or in place of regulations or other programs that address exposure levels experienced by other building occupants.

APPROACH: First, estimates of prevalent levels of airborne asbestos would need to be obtained by conducting a national survey of public and commercial buildings. Since it is estimated that 20 percent of all buildings contain ACM (1984 EPA Survey), approximately 1,250 buildings would be inspected for ACM in order to select 250 buildings for air monitoring. An average of 10 indoor and 2 outdoor samples would be collected over a one-week period in each building and analyzed using TEM. This would establish background levels and complement Study 7a.

The service worker exposures would be measured in public and commercial buildings by collecting an average of 10 additional air samples, both area and personal, to be analyzed by TEM. A subset of these samples will be identified with episodic or peak exposure based on the work activity involved.

COST ESTIMATE:	\$14,000,000	If prevalent levels have not been established by a separate study such as Study #7a.
	\$ 6,000,000	Worker exposures only, i.e., if prevalent levels study is done separately or not done at all
	\$20,000,000	

TIME ESTIMATE: 2 to 3 years

LIMITATIONS/DISADVANTAGES: Again, although this study will help determine whether or not there is a "problem" in the building types (i.e., it will allow for risk estimates to be calculated), it will not suggest specific regulatory or other program options if a "problem" is found.

STUDY 7c: RESIDENTIAL APARTMENT BUILDING EXPOSURES

STUDY OBJECTIVE: To provide national estimates of prevalent airborne asbestos levels in residential apartment buildings and to characterize populations exposed.

RATIONALE: In the 1984 survey, EPA estimated that 59 percent of all residential apartment buildings (of 10 units or more) contain some type of ACM, 18 percent have sprayed- or trowelled-on ACM and 44 percent contain asbestos TSI. Residential exposures may be of particular concern due to relatively long times spent in residential buildings and since much of indoor time during childhood, outside of school, is spent in residential areas. The risk model for mesothelioma depends on time from onset of exposures and cumulative exposure. The risk model for lung cancer depends on cumulative exposure and age. Prevalent airborne asbestos levels and the numbers of people and age distributions in residential apartment buildings would be collected in order to determine appropriate action concerning this building population.

APPROACH: Air monitoring and collection of data on occupant characteristics would occur in 100 residential apartment buildings. To identify a proper sample, approximately 500 residential apartment buildings would have to be inspected for the presence of ACM. A small subset of the buildings would have followup monitoring samples to assist in determining the consistency of measured concentrations over time.

COST ESTIMATE: $6,000,000

TIME ESTIMATE: 2 years

LIMITATIONS/DISADVANTAGES: Again, although this study will help determine whether or not there is a "problem" in the building types (i.e., it will allow for risk estimates to be calculated), it will not suggest specific regulatory or other program options if a "problem" is found.

STUDY 7d: SURVEY OF FEDERALLY SUBSIDIZED PUBLIC HOUSING UNITS FOR ASBESTOS EXTENT AND AIR LEVELS

STUDY OBJECTIVE: To determine exposures of occupants to ACM and to airborne asbestos levels.

RATIONALE: There are approximately 1.2 million public housing units supported by the Federal government. These buildings contain asbestos materials, some in damaged condition, and there is no asbestos control program in place. Typical public housing units contain many children who spend much of their nonschool time at home. Investigating these buildings would be consistent with the current EPA/GSA effort to offer Federally owned and operated buildings as a "model" asbestos management program.

APPROACH: To inspect and bulk sample in 250 additional buildings in order to identify 50 additional buildings for air monitoring. The standard approach is described in Study 7a.

COST ESTIMATE: $2,000,000 (in addition to $14,000,000 of study 7a, for a total of $16,000,000)

TIME ESTIMATE: 2 years

LIMITATIONS/DISADVANTAGES: Same as Studies 7a, 7b, and 7c above.

STUDY 7e: PREVALENT LEVELS OF AIRBORNE ASBESTOS FIBERS IN SCHOOLS

STUDY OBJECTIVE: To establish national estimates of prevalent airborne asbestos levels in schools to compare to levels in non-school buildings and help determine the need for AHERA-type regulation of nonschool buildings.

RATIONALE: Valid national estimates of prevalent airborne asbestos levels in these building populations would allow the EPA and other Federal agencies to have an exposure basis for Federal regulatory programs.

APPROACH: Select a probability sample of U.S. school buildings for air monitoring. It is anticipated that approximately 250 schools would be inspected in order to select buildings for air monitoring. Air monitoring would be conducted in 50 schools. An average of 10 indoor and 2 outdoor samples would be collected over a one-week period in each building. The samples would be analyzed by TEM. The data collected would be used to estimate prevalent levels in schools and to compare to levels in non-school buildings.

COST ESTIMATE: $4,000,000

TIME ESTIMATE: 2 to 3 years (can be done concurrently with 7a)

LIMITATIONS/DISADVANTAGES: This does not directly assess absolute risk due to airborne asbestos levels in schools, but rather provides only a relative risk and would only be done to provide reference for study 7a of prevalent levels of asbestos in public and commercial buildings. Further, it will not suggest specific regulatory or other program options or efficacy of options already in place.

STUDY 8a: CHARACTERIZATION OF POPULATION EXPOSED TO AIRBORNE ASBESTOS IN PUBLIC AND COMMERCIAL BUILDINGS

STUDY OBJECTIVE: To determine the number, sex, and age distribution of people exposed to ACM in public and commercial buildings. Ancillary information on occupation, smoking habits, etc., would also be collected, if possible.

RATIONALE: The risk model for mesothelioma depends on time from onset of exposure and cumulative exposure. The risk model for lung cancer depends on cumulative exposure and age. Numbers of people and age distributions in different types of buildings are needed to estimate risk using these models.

APPROACH: This can be accomplished in several ways with various levels of accuracy and cost. One method, a "paper analysis" based on existing data (e.g., census information, results of EPA surveys), would be used to estimate the number of people exposed to asbestos in public and commercial buildings.

COST ESTIMATE: $75,000

TIME ESTIMATE: 8 months

STUDY 8b: SURVEY OF POPULATIONS EXPOSED TO AIRBORNE ASBESTOS IN PUBLIC AND COMMERCIAL BUILDINGS

STUDY OBJECTIVE: To determine the number, sex, and age distribution of people exposed to ACM in public and commercial buildings. Ancillary information on occupation, smoking habits, etc., would also be collected, if possible.

RATIONALE: The risk model for mesothelioma depends on time from onset of exposure and cumulative exposure. The risk model for lung cancer depends on cumulative exposure and age. Numbers of people and age distributions in different types of buildings are needed to estimate risk using these models.

APPROACH: This can be accomplished in several ways with various levels of accuracy and cost.

A survey similar to EPA's 1984 survey would be conducted. Buildings would be inspected for asbestos and information on building occupants and visitors would be obtained through on-site interviews. Approximately 1,250 buildings would have to be inspected to identify 250 with ACM for the survey.

COST ESTIMATE: $4,000,000

TIME ESTIMATE: 2 years

STUDY 9: DEVELOPMENT OF A DECISION TOOL FOR DETERMINING WHETHER A RESPONSE ACTION IS WARRANTED FOR A PARTICULAR BUILDING

STUDY OBJECTIVE: To develop an assessment tool for use by building owners and managers in the context of an asbestos management progam that would allow them to determine what, if any, abatement activities are appropriate for a particular building.

RATIONALE: Due to a variety of technical sampling and analysis considerations, air monitoring has not been demonstrated to be a valid exposure assessment tool. In addition, none of the Agency's previous efforts to develop and validate quantitative and non-quantitative assessment methods have been successful. A research study could be undertaken to address this need and attempt to develop such a tool.

APPROACH: This study would consist of obtaining expert input from the scientific community on current assessment methodologies including short-term air monitoring. Several possible overall assessment approaches would be identified and tested through long-term air monitoring. Several phases of testing would probably be necessary before identifying one or two specific assessment tools for extensive testing in a variety of building situations. There are a number of technical sampling and analysis methods that would need to be further refined prior to the field aspects of this study.

COST ESTIMATE: Precise estimates are impossible since it is an exploratory study with an unpredictable likelihood of success. However, due to the numerous technical complexities, it would take a multi-million dollar effort to make worthwhile progress on the problem.

TIME ESTIMATE: Uncertain, since the results from any phase of the study are unpredictable.

LIMITATIONS/DISADVANTAGES: It is uncertain that such a mechanism could be found. Limited and unsuccessful attempts have been made in the past to predict exposures by virtue of the condition of ACM and other subjective criteria, although these studies have never been adequately funded. Further, no risk reduction strategies would be obtained from this study even if it were successful.

APPENDIX 8

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