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Project Summary

Asbestos Concentrations Two Years after Abatement in Seventeen Schools

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Airborne asbestos concentrations were measured at 17 schools that underwent an asbestos abatement in 1988. These 17 schools, which involved 20 abatement sites, were part of a study conducted by the U.S. Environmental Protection Agency (EPA) and the New Jersey Department of Health (NJDOH) in 1988. The 1988 study showed that asbestos concentrations measured independently by the NJDOH and EPA during the clearance phase of the abatement were elevated in the abatement and perimeter areas compared with outdoor concentrations. The present study was conducted to determine the current levels of airborne asbestos under simulated occupancy conditions and to determine whether the elevated levels found during the clearance phase were still present 2 yr after abatement. In 1990, three sites showed significantly higher mean asbestos concentrations inside the building (i.e., the previously abated area and/or perimeter area) compared with those outdoors (p<0.05). In 1990, the mean asbestos concentration measured in the perimeter area at one site and in the previously abated area at two sites were significantly higher than those in 1988 (p<0.05). Variations in asbestos levels between 1988 and 1990 may be due to sampling techniques (i.e., passive and aggressive versus modified aggressive), residual air-entrainable asbestos from the 1988 abatement, or air-entrainable asbestos from operations and maintenance activities since 1988.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

In 1988, the Asbestos Control Service of the New Jersey Department of Health (ACS-NJDOH) and the Risk Reduction Engineering Laboratory (RREL) of the U.S. Environmental Protection Agency conducted a cooperative study to document Asbestos Hazard Emergency Response Act (AHERA) clearance air-sampling practices and final clearance concentrations of asbestos at 20 abatement projects in New Jersey. The 20 abatement projects involved 17 different schools. The results of this study revealed discrepancies between AHERA clearance results reported by the Asbestos Safety Control Monitoring firms employed by the building owner and those reported independently by the ACS-NJDOH and EPA-RREL. Ten of the 20 sites would not have passed the AHERA clearance test had the ACS-NJDOH and EPA-RREL clearance data been used. The 1988 study further identified cases in which elevated levels of asbestos in the perimeter areas outside the work site but inside the building would have allowed the site to pass the AHERA clearance test had the perimeter concentrations been substituted for outdoor values as allowed by AHERA.

These findings prompted a concern by ACS-NJDOH and EPA-RREL regarding the contamination levels of asbestos that may be present in the 17 schools 2 yr after abatement. Therefore, a followup

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study was conducted during the summer of 1990 to determine the airborne asbestos concentrations in these 17 schools under simulated occupancy conditions.

Study Design and Methods

This study was conducted at the same 17 schools that were involved with the 1988 ACS-NJDOH and EPA-RREL study that documented AHERA air monitoring practices and final clearance concentrations of airborne asbestos. The 17 schools involved 20 abatement sites. Access to each school was coordinated directly by ACS-NJDOH. Area airborne asbestos concentrations were measured at each site in the same three areas as in the previous study: 1) previously abated area, 2) perimeter (outside the abated area but inside the building), and 3) outdoors. It was recognized that true abatement and perimeter areas could not be separated because the containment barriers present during the 1988 abatement have been removed. It was also recognized that in the interim since 1988, other sources (e.g., routine maintenance of asbestos-containing resilient floor tile) may have contributed to the current concentrations of airborne asbestos.

Site Documentation

For each of the 17 sites, the ACS-NJDOH documented the history of the abatement activities between 1988 and 1990 and operations and maintenance (O&M) activities on any remaining asbestos-containing material (ACM) in the previously abated area and perimeter area. This information was obtained from abatement notices (N.J.A.C. 8:60-7), AHERA management plans, and information provided by the designated person and/or school officials.

Air Sampling Strategy

At each site, five area air samples were collected in each of three areas: 1) the previously abated work area, 2) the perimeter area (outside the previously abated work area but inside the building), and 3) outdoors. In addition to the area air samples, three quality assurance samples (one closed and two open field blanks) were collected at each school.

Air sampling in the previously abated work area and the perimeter area was conducted in accordance with a modified aggressive sampling protocol designed to simulate normal building activity. The protocol involved sweeping only the floors with the exhaust of a 1-hp leaf blower at a rate of 5 min/1000 ft^2 of floor space. One stationary fan (18-in diameter, axial flow) per 10,000 ft^3 was positioned with the air directed toward the ceiling to maintain air movement during sampling.

Sampling Methodology

Air samples were collected on open-face, 25-mm-diameter, 0.45-µm-pore-size, mixed cellulose ester (MCE) membrane filters with a 5-µm-pore-size, MCE, backup diffusing filter and cellulose support pad contained in a three-piece cassette. The filter cassettes were positioned approximately 5 ft above the floor on tripods, with the filter face at approximately a 45° angle toward the floor. The filter assembly was attached to a 1/6-hp electric-powered vacuum pump operating at a flow rate of approximately 9 L/min. Air volumes ranged from 975 to 1545 L. At the end of the sampling period, the filters were turned upright before being disconnected from the vacuum pump and then stored in this position. The sampling pumps were calibrated with a calibrated precision rotameter both before and after sampling.

Analytical Methodology

The MCE filters were prepared and analyzed in accordance with the nonmandatory transmission electron microscopy (TEM) method, as described in the AHERA final rule (40 CFR 763). A sufficient number of grid openings were analyzed for each sample to ensure a sensitivity (the concentration represented by a single structure) of no greater than 0.005 asbestos structure per cubic centimeter (s/cm^3) of air sampled. In addition to the requirements of the nonmandatory TEM method, the specific length and width of each structure were measured and recorded. The Public Health and Environmental Laboratories of the New Jersey Department of Health performed the TEM analyses on the field samples under a separate cooperative agreement with EPA-RREL.

Statistical Analysis

All estimated concentrations were based on the number of asbestos structures counted. If no asbestos structures were counted in a sample, that sample was assigned an estimated concentration of 0 s/cm^3.

Airborne asbestos concentrations measured in each of the three sampling locations were characterized by use of descriptive statistics. Because the 20 sites were likely to differ in their abatement history and status with respect to the presence of asbestos-containing material, each site was considered separately. The descriptive statistics included the arithmetic mean and standard deviation, minimum and maximum concentration, and sample size.

Analysis of variance (ANOVA) was used to examine differences between concentrations measured in the previously abated work area, perimeter area, and outdoors at each site. When overall differences were detected among the three sampling locations, the Tukey multiple comparison procedure was used to evaluate the pairwise differences. A student's t-test was used to compare airborne asbestos concentrations measured in 1988 with those measured in 1990. The transformation $\ln(x + 0.002)$, where x is the measured airborne asbestos concentration, was applied to each measurement before the ANOVA or t-test was performed. The transformation was used to make variances more equal and to provide data that are better approximated by a normal distribution. The constant 0.002, a value chosen to be smaller than the majority of analytical sensitivities, was used because some zero values were present. The transformation was used only for the ANOVA and t-test; it was not used for any other part of the data analysis (e.g., plots or descriptive statistics).

Results and Discussion

Site Descriptions

Table 1 presents the postabatement history and the remaining ACM at the 20 sites. Post-1988 abatement occurred at 1 (Site O) of the 20 sites in the previously abated area and at 5 (Sites A, D, K, L, and N) of the 20 sites in the perimeter area. Table 1 lists the types of ACM that were abated after 1988. At 14 sites, ACM is still present in the previously abated areas; at 18 sites, ACM is still present in the perimeter areas. Resilient floor tile acounts for a major portion of the ACM.

Airborne Asbestos Levels Measured in 1990

Statistically significant differences between the three sampling locations (i.e., previously abated area, perimeter, and outdoors) were detected at 4 of the 20 sites. The average concentration in the previously abated area at Site B (0.015 s/cm^3) was significantly higher ($p<0.05$) than the average outdoor concentration (0.001 s/cm^3). Sites J and K showed average perimeter concentrations (0.003 and 0.007 s/cm^3, respectively) significantly higher ($p<0.05$) than both the average concentration in the previously abated area (0 s/cm^3 at both sites) and the average outdoor concentration (0 and 0.001 s/cm^3, respectively). The average concentration in the previously abated area at Site R (0 s/cm^3) was significantly less ($p<0.05$) than both the average perimeter concentration (0.011 s/cm^3) and the average out-

Table 1. *Post-1988 Abatement History and Remaining Asbestos- Containing Material (ACM) at the 20 Sites*

	Abatement after 1988			*Remaining ACM*	
Site	*Abatement area*	*Perimeter area*	*Material abated*[a]	*Abatement area*	*Perimeter area*
A	*No*	*Yes*	*AP, PB-TSI*	*FT*	*FT*
B	*No*	*No*	-	*FT*	*FT*
C	*No*	*No*	-	*None*	*None*
D	*No*	*Yes*	*PB-TSI*	*CEM-TSI*	*CEM,TSI,FT*
E	*No*	*No*	-	*FT*	*FT*
F	*No*	*No*	-	*None*	*FT*
G	*No*	*No*	-	*None*	*FT*
H	*No*	*No*	-	*FT*	*FT, AP*
I	*No*	*No*	-	*None*	*FT*
J	*No*	*No*	-	*CEM-TSI*	*FT*
K	*No*	*No*	-	*None*	*FT*
L	*No*	*Yes*	*FT, TR*	*FT, TR*	*FT*
M	*No*	*No*	-	*None*	*None*
N	*No*	*Yes*	*AP*	*None*	*FT*
O	*Yes*	*No*	*CEM-TSI*	*TR*	*FT*
P	*No*	*No*	-	*FT*	*FT*
Q	*No*	*No*	-	*FT*	*FT*
R	*No*	*No*	-	*FT*	*FT*
S	*No*	*No*	-	*FT*	*FT*
T	*No*	*No*	-	*None*	*FT,CT*

a *AP* = *Acoustical Plaster*
PB-TSI = *Preformed Block Thermal System Insulation*
FT = *Floor Tile*
CEM-TSI = *Cementitious Thermal System Insulation*
TR = *Transite*
CT = *Ceiling Tile*

door concentration (0.013 s/cm^3). In all other cases the numerical differences were not statistically significant.

Structure and Morphology and Length Distributions of 1990 Samples

The TEM analysis of 100 samples collected in the previously abated area, 95 samples collected in the perimeter area, and 85 samples collected outdoors yielded a total of 196 asbestos structures. Of these, 95% were chrysotile and 5% were amphibole. Approximately 85% of the structures observed on the samples collected in the previously abated area and 95% of the structures observed on the perimeter area samples were less than 5 µm in length. Ninety-two % of the asbestos structures observed on the outdoor samples were less than 5 µm in length.

Comparison of 1988 and 1990 Airborne Asbestos Levels

Table 2 presents the mean arithmetic concentrations of airborne asbestos measured in the previously abated area, perimeter area, and outdoors in 1988 and 1990. Figure 1 presents a comparison of mean work area concentrations measured in 1988 and 1990; Figure 2 presents a like comparison of mean perimeter concentrations. The diagonal line in each figure represents concentrations that were the same for both sampling locations. Sites that fall above the line indicate that concentrations, on the average, were higher in the sampling location represented on the vertical axis. Similarly, sites falling below the line indicate that concentrations, on the average, were higher in the sampling location represented on the horizontal axis.

Abatement Area

Three sites (Sites A, E, and I) showed higher mean asbestos concentrations in 1990; the increase was statistically significant ($p<0.05$) at Site E. Sixteen sites (Sites B - D, F - H, J - O, and Q - T) showed lower mean asbestos concentrations in 1990; the decrease was statistically significant ($p<0.05$) at 11 sites (Sites C, D, F, H, K - O, Q, and T). The asbestos concentration at one site (Site P) did not change.

Perimeter Area

Nine sites (Sites A, B, E, F, I, J, N, O, and R) showed higher mean asbestos concentrations in 1990; the increase was statistically significant ($p<0.05$) at Sites E and R. As noted in the preceding subsection, Site E also showed a statistically significant increase in the asbestos concentration in the abatement area. Eleven sites (Sites C, D, G, H, K, L, M, P, Q, S, and T) showed a lower mean asbestos concentration in 1990; the decrease was statistically significant ($p<0.05$) at six sites (Sites D, H, L, P, R, and T).

The reasons for the variation in asbestos concentrations between 1988 and 1990 are not discernible. The decrease in asbestos concentrations in the previously abated area may be due to the reduction of air-entrainable asbestos or to the sampling technique. Regarding the latter, the 1988 measurements were made under aggressive sampling conditions during the AHERA clearance phase of the abatement, whereas the 1990 measurements were made under less aggressive sampling conditions. The increase in asbestos concentrations measured at Site E in 1990 may be due to maintenance activities (such as buffing and stripping of the resilient floor tile) rather than the sampling technique. Subsequent to the 1988 abatement, which involved the removal of asbestos-containing suspended ceiling panels, Site E did not undergo any abatement. The building contains no ACM other than the resilient floor tile (Table 1).

The increase in asbestos concentrations in the perimeter areas in 1990 may be due to the presence of residual asbestos-containing dust resulting from the 1988 abatement action or subsequent operations and maintenance activities (e.g., maintenance activities on resilient floor tile) or to some nontypical simulated activity. If the asbestos-containing dust was present in 1988, the passive sampling protocol used may not have been adequate to

Table 2. Mean Concentrations of Airborne Asbestos Measured in 1988 and 1990 at 20 Sites

	Mean asbestos concentration, s/cm³					
	Abatement area		Perimeter		Outdoors	
Site	1988	1990	1988	1990	1988	1990
A	0.002	0.007	0.001	0.011	0	0
B	0.016	0.015	0.008	0.010	0.001	0.001
C	0.060	0.001	0.002	0.001	0.004	0
D	0.079	0.001	0.062	0.001	0.052	0
E	0	0.004	0	0.006	0	0
F	0.024	0.001	0.002	0.005	0.001	0
G	0.007	0.001	0.010	0.001	0	0.001
H	0.016	0	0.062	0	0.003	0
I	0	0.001	0	0.011	0.006	0.001
J	0.004	0	0.001	0.003	0.001	0
K	0.063	0	0.008	0.007	0	0.001
L	0.118	0.002	0.060	0.001	0.004	0
M	0.322	0	0.002	0	0.002	0
N	0.100	0.007	0.003	0.004	0.004	0.001
O	0.004	0.001	0.003	0.018	0.001	0.001
P	0.005	0.005	0.007	0	0.003	0
Q	0.099	0.019	0.055	0.010	0.007	0.001
R	0.002	0	0	0.011	0	0.013
S	0.012	0.003	0.003	0.001	0	0
T	0.049	0.001	0.030	0.001	0.015	0.005

reentrain the asbestos into the air. Conversely, a decrease in concentration at some sites suggests that air-entrainable asbestos was not as prevalent.

Conclusions

The following are the principal conclusions reached during this study:

- Four of the 20 sites sampled in 1990 under simulated occupancy conditions showed significantly higher airborne asbestos concentrations in the previously abated area and/or perimeter area than outdoors. None of the four sites underwent an asbestos abatement action after 1988, and the asbestos-containing material remaining in the sites was primarily resilient floor tile.
- Three of the 20 sites showed significantly higher airborne asbestos concentrations in the previously abated area and/or perimeter area in 1990 than in 1988. Variations in asbestos levels between 1988 and 1990 may be due to sampling techniques, residual air-entrainable asbestos from the 1988 abatement action, or air-entrainable asbestos from operations and maintenance activities since 1988.

Recommendations

- Although these data provide valuable information regarding the residual levels of asbestos under simulated conditions of occupancy 2 yr after abatement, they may not be representative of concentrations measured during actual conditions of occupancy. Followup air monitoring should be conducted to determine their representativeness. The results of this sampling may help to direct future research efforts aimed at characterizing the effectiveness of asbestos abatement programs and at evaluating the need for EPA guidance on postabatement management practices.
- The four sites showing elevated asbestos concentrations should be evaluated to determine the sources of asbestos and to identify appropriate corrective measures.

The full report was submitted in fulfillment of Contract No. 68-CO-0016 by IT Environmental Programs, Inc., under the sponsorship of the U.S. Environmental Protection Agency.

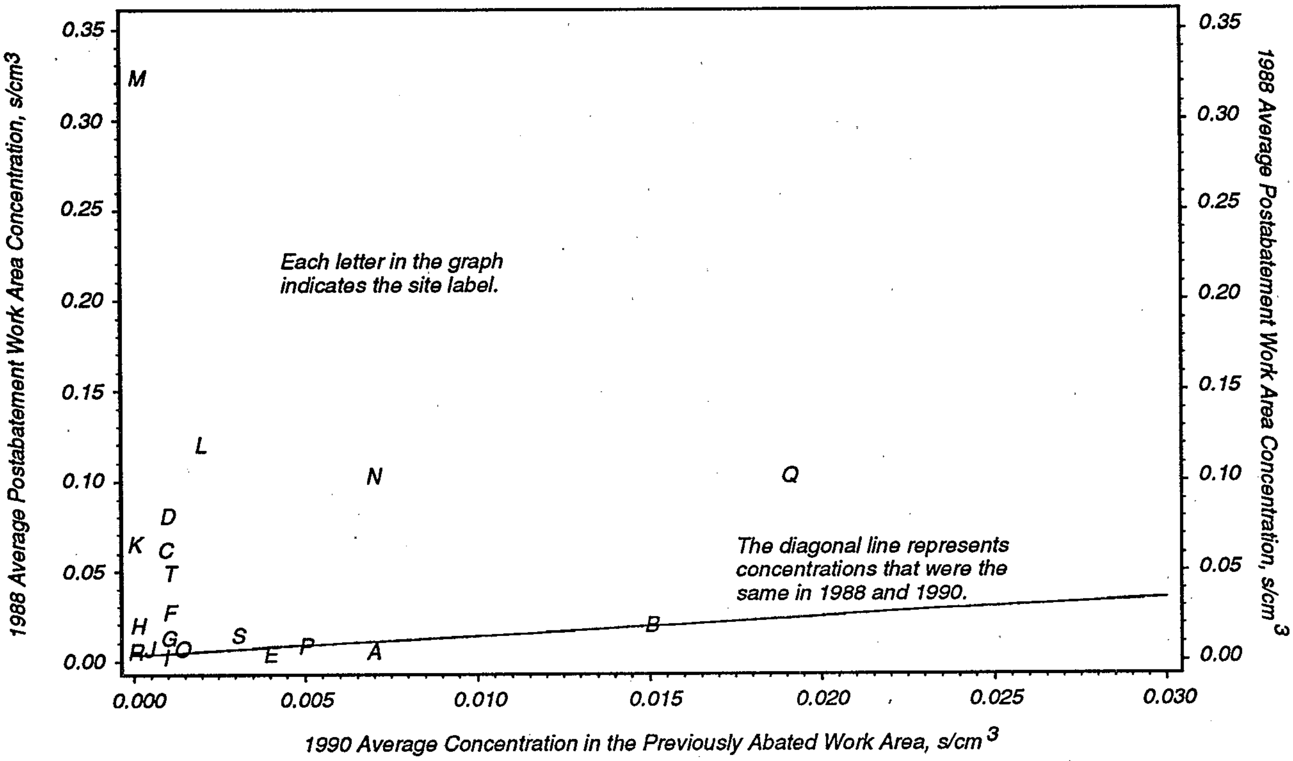

Figure 1. *Comparison of postabatement (1988) work area concentrations with work area concentrations two years after abatement (1990).*

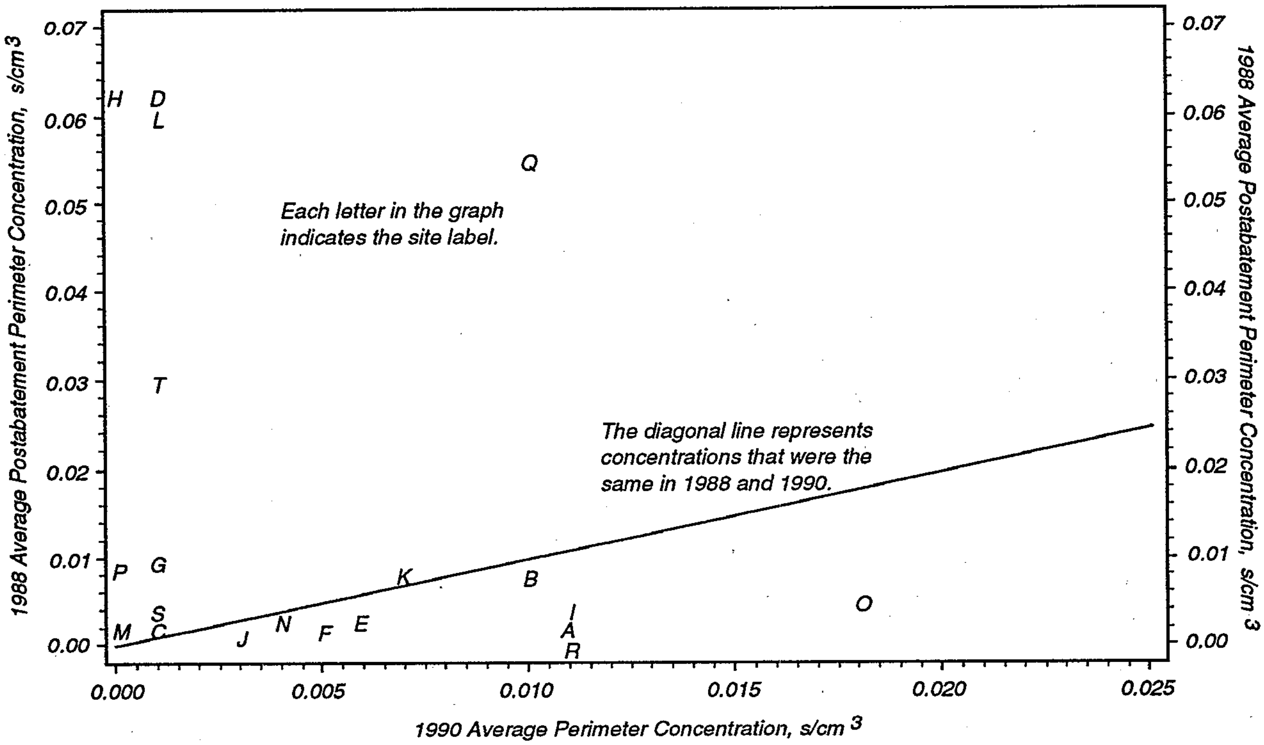

Figure 2. *Comparison of postabatement (1988) perimeter concentrations with perimeter concentration two years after abatement (1990).*

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***T.J. Powers** is the EPA Project Officer (see below).*
The complete report, entitled "Asbestos Concentrations Two Years after Abatement in Seventeen Schools," (Order No. PB92-158 476/AS; Cost: $17.00, subject to change) will be available only from:
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