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Comparison of the Alternative Asbestos Control Method and the NESHAP Method for Demolition of Asbestos-Containing Buildings

Notice

In 2006 and 2007 the Environmental Protection Agency (EPA) conducted three tests to examine the cost and environmental effectiveness of Alternative Asbestos Control Method (AACM). Two tests were conducted in Fort Chafee, Arkansas and one was conducted in Forth Worth, Texas. The EPA discontinued testing the AACM due to technical deficiencies. The AACM remains unapproved and should not be used.

By

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Foreword

The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

Sally Gutierrez, Director
National Risk Management Research Laboratory
Office of Research and Development

Notices

Erratum: This report has been revised to correct the asbestos level used for occupancy of residential structures surrounding the World Trade Center. The correct value is 0.0009 s/cm^3, not the value of 0.009 s/cm^3 cited in the previous version of this report.

Mention of trade names, products, or services does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.

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EXECUTIVE SUMMARY

The Asbestos NESHAP (National Emission Standard for Hazardous Air Pollutants) requires the removal of all Regulated Asbestos-Containing Material (RACM) prior to the demolition of the buildings that fall under the auspices of the NESHAP. This removal process can be a costly and time-consuming endeavor and contributes to the growing crises of abandoned buildings in this country. The Alternative Asbestos Control Method (AACM) allows certain asbestos-containing materials (ACM) to remain in the building during demolition. In addition to leaving most of the ACM in the building, the AACM process differs from the NESHAP process in that it requires pre-wetting of the interior of the building with amended water (water with a wetting agent added), continuous wetting with amended water during demolition of the building, containment of all runoff, removal of two or more inches of soil after demolition, disposal of all material as regulated asbestos-containing waste, and the use of respirators and protective garments throughout the entire demolition process.

This research effort compared the use of the NESHAP process with the AACM process on two architecturally identical asbestos-containing buildings in a remote location at the Fort Chaffee Redevelopment Authority near Fort Smith, AR. The buildings contained significant quantities of asbestos-containing wall systems and vinyl asbestos floor tile.

EPA does not endorse the AACM at this time as an approved method under the asbestos NESHAP for demolishing buildings containing RACM.

Conclusions

The following conclusions are relevant to the demolitions of the identical structures at Fort Chaffee Redevelopment Authority:

Primary Objectives

- The airborne asbestos concentrations measured by transmission electron microscopy (TEM) during both the NESHAP and the AACM demolition processes were orders of magnitude below any EPA existing health or performance criterion. At an analytical sensitivity of 0.0005 asbestos structures per cubic centimeter of air (s/cm^3), the maximum asbestos air concentration was 0.0005 s/cm^3 (one structure observed) for the NESHAP process and 0.0019 s/cm^3 (four structures observed) for the AACM process.

- The airborne asbestos (TEM) concentrations were near or below the limit of detection. The statistical analyses for the demolition phase of both processes showed that the airborne asbestos (TEM) concentrations from the AACM were equal to the NESHAP (based upon the observed proportion of detects). The statistical analyses comparing both total processes (including the soil removal phase of the AACM) showed that the airborne asbestos (TEM) concentrations from the AACM were not equal to the airborne asbestos (TEM) concentrations from the NESHAP Method ($p=0.0006$, where p represents a strength of evidence that the null hypothesis is true. The smaller the p-value, the stronger the evidence is that the null hypothesis should be rejected. In this study, the null hypothesis was rejected for p values less than 0.05.). The empirical evidence (the proportion of non-detects and the maximum values) from the investigation suggests airborne asbestos (TEM) concentrations from the AACM were greater than the airborne asbestos (TEM) concentrations from the NESHAP Method. Based upon the observed proportion of detects, it was concluded that the difference between the two methods is a function of the Day 2 AACM activities (soil excavation and removal). This was likely due to an operational error where no water was added during the soil removal stage of the process.

- The statistical analyses showed that the post-excavation asbestos TEM concentrations in the soil from the AACM were not equal to the post-demolition asbestos concentrations in the soil from the NESHAP Method (p=0.033). Based on descriptive statistics, it was concluded that the post-excavation asbestos concentrations in the soil from the AACM were less than the post-demolition asbestos concentrations in the soil from the NESHAP Method. Polarized Light Microscopy (PLM) analyses for all soil samples from both processes indicated very low concentrations of asbestos; the NESHAP post-demolition soil had only one of ten samples with detectable asbestos (0.3 percent) whereas the AACM post-excavation soil had no samples with detectable asbestos at an analytical sensitivity of 0.1 percent.

- The cost of the NESHAP demolition process ($108,331) was approximately twice the cost of the AACM demolition process ($57,864) for this site. Costs specific to conducting the research were not included.

Secondary Objectives

- Based upon descriptive statistics, the fiber concentrations in air from the AACM as measured by phase contrast microscopy (PCM) were equal to the fiber concentrations from the NESHAP Method.

- A brief visible emission was observed during the removal of a concrete foundation structure during the NESHAP demolition, but it was not an asbestos-containing material. No visible emissions were observed during the AACM demolition.

- Settled dust asbestos loadings during the AACM demolition were equal to the settled dust loadings during the NESHAP demolition.

- The statistical analyses showed that the total particulate concentrations, as collected and measured by National Institute of Occupational Safety and Health's (NIOSH) Method 0500, from the AACM were not equal to the total particulate concentrations from the NESHAP Method. Based on the observed proportion of detects, the total particulate concentrations from the AACM were higher than the total particulate concentrations from the NESHAP Method. This is attributed the extended sampling period for the AACM process, which included soil removal and disposal. Since wetting was inadvertently not performed during the soil removal, it is possible that this increased the particulate loading.

- Based on the observed proportion of non-detects, the worker breathing zone asbestos concentrations (TEM) from the AACM were less than the worker breathing zone asbestos concentrations (TEM) from the NESHAP method. This was due to the concentrations encountered by workers during the abatement required by the NESHAP. The maximum breathing zone asbestos concentration was 0.093 s/cm^3 for the NESHAP process (abatement phase) whereas no asbestos was detected on any of the AACM worker breathing zone samples (<0.005 s/cm^3).

- One NESHAP worker had an Eight-Hour Time-Weighted Average (TWA) fiber (PCM) concentration which equaled the Occupational Safety and Health Administration (OSHA) PEL (Personal Exposure Limit) of 0.1 f/cm^3. The maximum TWA fiber concentration for the AACM was 0.03 f/cm^3.

- Based on descriptive statistics, the NESHAP post-demolition soil asbestos (TEM) concentrations were greater than the NESHAP pre-demolition soil concentrations; the AACM pre-demolition soil asbestos (TEM) concentrations wee greater than the post-excavation soil concentrations; and the AACM post-demolition soil asbestos (TEM) concentrations were greater than the AACM post-excavation soil concentrations.

- The time required to perform the AACM process (1½ days) was about one-fifth the time required to perform the NESHAP process (ten days) for this site. The abatement phase of the NESHAP process was very labor intensive (nine days) and took nine times longer than the demolition itself (one day) for this site.

- Both the NESHAP and the AACM processes left minimal amounts of small fragments of asbestos-containing material (ACM) debris, primarily vinyl asbestos floor tile, in the soil at the completion of the processes; however, the AACM process (post-excavation) left less ACM debris than the NESHAP process (post-demolition).

Results for other secondary objectives of lesser significance are found in the body of the report.

A simplified comparison of results is presented in Table ES-0-1.

Table ES-0-1. Simplified Comparison of Results for the NESHAP and AACM Demolitions at Fort Chaffee

PARAMETER	REPORT SECTION REFERENCE	MORE EFFECTIVE		EQUAL
		NESHAP	AACM	
Asbestos (TEM) in Air (Demolition Only)	**6.1.2.1**			✓[1]
Asbestos (TEM) in Air- (Demolition and Soil Removal)	**6.1.2.1**	✓[1,2]		
Asbestos (TEM) in Soil	**6.1.4**		✓	
Asbestos (PLM) in Soil	**6.1.4**			✓
Cost	**8**		✓	
Visible Emissions	**4.4.1** **4.4.2**			✓
Fibers (PCM) in Air	**6.1.2.3**			✓
Asbestos in Settled Dust (TEM)	**6.1.2.2**			✓
Asbestos (TEM) in Worker Breathing Zone	**6.1.5**		✓	
Fibers (PCM) in Worker Breathing Zone	**6.1.5**		✓	
Particulate in Air	**6.1.2.4**	✓		
Time	**4.2** **4.4.1-4.4.2**		✓	
Asbestos (PLM) Debris in Soil	**6.1.4.2.3**		✓	

[1] Concentrations were near or below the limit of detection limit for both processes.
[2] Water was inadvertently not added during AACM soil removal phase.

ACKNOWLEDGMENT

This was truly a multi-faceted team effort bridging not only the asbestos expertise within EPA and in the Arkansas Department of Environmental Quality, but also the highest caliber contractual support to accomplish the objectives of this study. Each individual listed made significant contributions to assist in the success of the project. The onsite support received from the individuals in the Fort Chaffee Redevelopment Authority/Fort Smith/Fort Chaffee organizations was exemplary. Their cordiality, hospitality, helpfulness, and willing assistance were essential components for the execution and completion of the research project.

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ABBREVIATIONS AND ACRONYMS

AACM	Alternative Asbestos Control Method
ACM	Asbestos-Containing Material
ADEQ	Arkansas Department of Environmental Quality
AED	Aerodynamic Equivalent Diameter
AHERA	Asbestos Hazard and Emergency Response Act
AQMD	Air Quality Management District
ASTM	American Society for Testing and Materials
C&D	Construction and Demolition
CDF	Cumulative Distribution Function
DL	Detection Limit
DMF	Dimethylformamide
DOE	US Department of Energy
EPA	US Environmental Protection Agency
GPM	Gallons per Minute
GR	Gravimetric Reduction
GRR	Gravimetric Reduction Ratio
HEPA	High Efficiency Particulate Air
ISO	International Standards Organization
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
K-S Test	Komolgorov-Smirnov Test
MCE	Mixed Cellulose Ester Filter
MDL	Method Detection Limit
NEIC	USEPA National Enforcement Investigations Center
NESHAP	National Emission Standard for Hazardous Air Pollutants
NFPA	National Fire Protection Association
NIOSH	US National Institute of Occupational Safety and Health
NRMRL	USEPA National Risk Management Research Laboratory
OAQPS	USEPA Office of Air Quality Planning and Standards
OECA	USEPA Office of Enforcement and Compliance Assurance
OGC	USEPA Office of General Counsel
OIG	USEPA Office of the Inspector General
OPEI	USEPA Office of Policy, Economics, and Innovation
OPPT	USEPA Office of Pollution Prevention and Toxics
ORD	USEPA Office of Research and Development
OSHA	US Occupational Safety and Heath Administration
OSRTI	USEPA Office of Superfund Remediation and Technology Innovation
OSW	USEPA Office of Solid Waste
PCM	Phase Contrast Microscopy
PCME	Phase Contrast Microscope Equivalent
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
PEL	Personal Exposure Limit
PLM	Polarized Light Microscopy
PSI	Pounds per Square Inch

QAPP	Quality Assurance Project Plan
RACM	Regulated Asbestos-Containing Material
RCRA	Resource Conservation and Recovery Act
T&D	Transportation and Disposal
TEM	Transmission Electron Microscopy
TSI	Thermal System Insulation
TWA	Time-Weighted Average
VAC	Volts Alternating Current
VAT	Vinyl Asbestos Tile
WTC	World Trade Center

SECTION 1 INTRODUCTION

The Clean Air Act provides the EPA with the authority to promulgate a —*work practice standard*" if it is not feasible to establish an emission standard. Under Section 112 of the Clean Air Act, asbestos is determined to be a hazardous air pollutant and is regulated under EPA's asbestos National Emission Standard for Hazardous Air Pollutants (NESHAP), 40 CFR Part 61, Subpart M.

The Asbestos NESHAP (*a work practice standard*) requires the removal of all regulated asbestos-containing material (RACM)[1] prior to demolition of the facility. The Asbestos NESHAP specifies emission control procedures [§61.145(c)] and waste disposal requirements [§61.150 and §61.154] that must be followed during demolition of a facility that contains asbestos above the threshold amount.[2] Section §61.150 of the Asbestos NESHAP requires owners to —discharge no visible emissions to the outside air" during the collection, processing, packaging, or transporting of any asbestos-containing waste material generated by the source.

If a facility is being demolished because it is structurally unsound and is in danger of imminent collapse, RACM [§61.145(a)(3)] is not removed prior to demolition, but the RACM must be kept adequately wet during demolition. All of the contaminated debris must be kept adequately wet until disposal and must be disposed of as regulated asbestos-containing material (ACM) [§61.150(a)(3)] .

The EPA performed a controlled demonstration to compare the relative environmental impacts of the Alternative Asbestos Control Method (AACM) to the NESHAP method. This study was intended as a stand-alone evaluation of the environmental and cost-effectiveness of two demolition processes on buildings that are architecturally identical in composition and structure and which contain asbestos, meeting the qualifications of containing greater than 160 ft^2 of RACM. These data may be used to help EPA determine whether it is appropriate to include an alternative method in the current asbestos regulations contained in 40 CFR Part 61 Subpart M.

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1 Under Asbestos NESHAP[§61.141], RACM means (a)friable asbestos material, (b) Category I non-friable ACM that has become friable, (c) Category I non-friable ACM that will be or has been subjected to sanding, grinding, cutting, or abrading, or (d) Category II non-friable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder by the forces expected to act on the material in the course of demolition or renovation operation regulated by this subpart.

2 Asbestos NESHAP [§61.145(a)] requires that if the following amounts of RACM are present in a facility, these materials must be removed prior to demolition: (1) At least 260 linear feet on pipes, or (2) at least 160 square feet on other facility components, or (3) where the amount of RACM on pipes or other components could not be measured before stripping, a total of at least 35 cubic feet from all facility components in a facility being demolished. Also, under 40CFR 61.145 (c)(1), ACM has to be removed if, among other things, it is Category I nonfriable ACM that is in poor condition and is friable or it is Category II nonfriable ACM and there is a probability that the materials will become crumbled, pulverized, or reduced to powder during demolition. (These regulations may be supplanted by more stringent local governmental (state, city, etc.) regulations that govern such activities.)

The AACM, if determined to be environmentally acceptable but less costly than the current regulations, may have the benefit of allowing municipalities to demolish abandoned buildings that otherwise would remain standing until they were in danger of imminent collapse.

Previous studies indicated that there were situations where undesirable releases of asbestos were documented from demolition activities. These studies included both demolitions conducted by the NESHAP process and ones conducted under imminent danger of collapse situations (Wilmoth et al 1993, Wilmoth et al 1994, City of Saint Louis 2004).

Exhibit 1 contains the Alternative Asbestos Control Method that was developed by EPA Region 6 and EPA Office of Research and Development (ORD) with input from the EPA Quality Assurance Project Plan (QAPP) Technical Development Team. The applicability criteria listed in Exhibit 1 were developed to conceptually show the types of buildings where it is believed this method can be effective. Depending on the types of building tested, the types of asbestos materials present in the tested buildings, and the test results, additional restrictions on the applicability may be added/removed.

The AACM requires that certain RACM (such as thermal system insulation and fireproofing) be removed before demolition in accordance with the Asbestos NESHAP; other RACM (such as wallboard joint compound, resilient flooring/mastic, glazing compound) may remain in place.

The AACM differs from the existing Asbestos NESHAP in the use of an amended-water wetting process, type of demolition equipment, and demolition techniques. Once the required RACM is removed, the demolition proceeds using amended water suppression before, during, and after demolition to trap asbestos fibers and minimize the potential release to the air.

The RACM is less likely to release fibers to the air when the wetting process and demolition techniques specified in the AACM are used. Wastewater generated during the demolition is collected and filtered, and all debris is disposed of as regulated asbestos-containing waste. Soil in the affected area is excavated and disposed as regulated asbestos-containing waste.

The purpose of this research project was to compare the environmental and cost-effectiveness of the AACM vs. the current Asbestos NESHAP method through a side-by-side comparison of the demolition of buildings that are architecturally identical in composition and structure.

This research project will assist EPA in comparing existing demolition practices of the Asbestos NESHAP with potentially more cost-effective yet equally protective demolition practices.

ALTERNATIVE ASBESTOS CONTROL METHOD
Developed by EPA Region 6 and EPA Office of Research and Development
January 25, 2008

1.0 Background

In response to Section 112 of the Clean Air Act which requires EPA to develop emission standards for hazardous air pollutants, EPA promulgated the National Emission Standards for Hazardous Air Pollutants (NESHAP). 40 CFR Part 61 Subpart M (Asbestos NESHAP) specifically addresses asbestos, including demolition activities.

Asbestos NESHAP regulations require that all regulated asbestos-containing materials (RACM) above a specified amount be removed from structures prior to demolition. Asbestos-containing materials (ACM) are defined as those materials containing more than one percent asbestos as determined using the method specified in Appendix E, Subpart E, 40 CFR Part 763, Section 1, Polarized Light Microscopy (PLM).

RACM includes friable ACM; Category I non-friable ACM that has become friable, Category I non-friable ACM that will be or has been subjected to sanding, grinding, cutting, or abrading; and Category II non-friable ACM that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder by the forces expected during demolition operations.

Asbestos removal can account for a significant portion of the total demolition costs. In many cities, the cost of asbestos removal prohibits timely demolitions and results in substandard structures which become fire and safety hazards, attract criminal activity, and lower property values.

For structures that are structurally unsound and in imminent danger of collapse, the Asbestos NESHAP requires that the portion of the structure which contains RACM must be kept adequately wet during demolition and during handling and loading of debris for transport to a disposal site. No other engineering controls are required.

This Alternative Asbestos Control Method (AACM) was developed by EPA as an alternative work practice to the Asbestos NESHAP, where certain RACM are removed prior to demolition and other RACM are left in place.

The goal is to provide significant cost savings while achieving an equal or better standard of protection of human health and the environment. This method is much more restrictive than the Asbestos NESHAP requirements for buildings in imminent danger of collapse.

2.0 Applicability

This Alternative Asbestos Control Method applies to any structure subject to the Asbestos NESHAP regulation (i.e., structures that meet the definition of facility under the Asbestos NESHAP), except as noted below.

The size of structures which can be demolished using this method is limited to three stories or less (maximum height of 35 feet). This allows adequate wetting of both the interior and exterior of the structures and is within the working reach of both the wetting and the demolition equipment.

3.0 Building Inspection/Asbestos Assessment

A comprehensive inspection of the interior and exterior of the structure to be demolished shall be conducted in accordance with EPA's Asbestos Hazard Emergency Response Act (AHERA, 40 CFR Part 763). Specific criteria for inspection, sampling, and assessment are in Subpart E (763.85, 763.86, and 763.88, respectively). The inspection shall be performed by an accredited asbestos building inspector.

4.0 Asbestos Removal

Table 1 summarizes the ACM that may be present in buildings and whether or not the ACM must be removed prior to demolition.

All thermal system insulation (TSI) and spray-applied fireproofing shall be removed due to the inability to adequately wet these materials during demolition. Fire curtains may be removed if it is easier to do so than to adequately wet and handle this heavy material.

Vermiculite insulation, if present, shall be removed prior to demolition as an RACM, regardless of the measured asbestos concentration.

All asbestos removal operations shall be performed in accordance with state and federal law by a licensed asbestos abatement contractor.

5.0 Demolition Practices

Several demolition work practice standards shall be employed to ensure that the method is protective of human health and the environment. These standards involve the equipment used, the wetting process, the demolition process, and visible emissions.

Demolition contractors shall provide an Asbestos NESHAP-trained individual to oversee the demolition process.

5.1 Equipment Used

Track hoes and end loaders or equivalent shall be used during demolition to minimize the generation of dust. No bulldozers, explosives, or burning will be permitted.

5.2 Wetting Process

Structures to be demolished will be thoroughly and adequately wetted with amended water (water to which a surfactant has been added) prior to demolition, during demolition, and during debris handling and loading. Surfactants reduce the surface tension of the water, increasing its ability to penetrate the ACM.

For this method, the Asbestos NESHAP definition for –adequately wet” will be used. That is, –sufficiently mix or penetrate with liquid to prevent the release of particulates. If visible emissions are observed coming from the asbestos-containing material (ACM), then that material has not been adequately wetted. However, the absence of visible emission is not sufficient evidence of being adequately wet.” The demolition contractor’s Asbestos NESHAP-trained individual will verify that ACM is adequately wetted.

Amended water shall be applied with a minimum of two hoses. The water shall be delivered as a mist. Direct high-pressure water impact of RACM is prohibited.

The wetting process consists of three stages. In each stage, both interior and exterior wetting of the structure shall be performed. To the extent feasible, cavity areas and interstitial wall spaces shall be wetted during each of the wetting stages.

Table 1. Asbestos Removal Requirements of AACM

Asbestos-Containing Material	Removed Prior to Demolition?
Thermal System Insulation (TSI)	
▪ Tank insulation	Yes
▪ Pipe insulation	Yes
▪ Elbow/fitting/valve insulation	Yes
▪ Boiler insulation	Yes
▪ Duct insulation	Yes
▪ Cement and patching compound	Yes
Surfacing Material	
▪ Asbestos-impregnated plaster, stucco	No
▪ Spray-applied fireproofing	Yes
▪ Spray-applied surface coatings (popcorn ceiling, vermiculite treatments)	No
▪ Spray applied acoustical or decorative surfacing	No
▪ Troweled-on crows foot texture, splatter texture, and joint compound.	No
▪ Spray-applied surface coatings crows foot texture, splatter texture, etc.	No
Miscellaneous Material	
▪ Fire curtains in auditoriums	Optional
▪ Fire doors	Optional
▪ Vibration-dampening cloths	No
▪ Asbestos-cement tiles, sheets, roofing, shingles, and transite	No
▪ Asbestos-impregnated roofing cement and asphalt roofing	No
▪ Shingles	No
▪ Linoleum or other floor tile	No
▪ Roll flooring	No
▪ Ceiling tile	No
▪ Asbestos-impregnated pipe	No
▪ Vermiculite insulation	Yes
▪ Mastic for flooring	No
▪ Window Cauking	No

On the day before the demolition, access openings shall be made into the attic spaces from the exterior. The structure shall be first pre-wet (until adequately wet) from the interior and then from the constructed exterior attic access openings to enhance water retention and maximize wetting effectiveness.

This pre-wetting shall prohibit further access into the structure, because of safety concerns. The structure shall be re-wet (until adequately wet) from the exterior through the windows, doors, and attic access openings on the day of demolition prior to demolition. Finally, wetting (until adequately wet) shall be done during the demolition and during loading of debris into lined disposal containers.

5.3 Demolition Process

The demolition contractor shall minimize breakage of asbestos-containing materials. All demolition shall be completed in a timely manner that will allow the debris generated during that day to be completely removed from the demolition site for disposal.

5.4 Visible Emissions

The Asbestos NESHAP standard of ―no visible emissions" shall be employed. Visible emissions mean any emissions, which are visually detectable without the aid of instruments, coming from RACM or asbestos-containing material. This does not include condensed, uncombined water vapor. The demolition contractor's NESHAP-trained individual shall verify the absence of visible emissions and has the authority to stop work if visible emissions are observed.

During a demolition, it is often not possible to distinguish visible emissions from ACM and those from construction debris; therefore, should a visible emission be observed, the demolition effort shall pause until the deficiencies in the application of the wetting controls eliminate the visible emission.

6.0 Weather Restrictions

Demolition activities shall be delayed/halted in the case of any inclement weather that will impede the demolition contractor's ability to adequately wet the structure (e.g., freezing temperatures).

In addition, if visible dusting is observed in the vicinity of the demolition site, the demolition shall be delayed/halted.

7.0 Monitoring Requirements

Demolition contractors are required to comply with all applicable OSHA (29 CFR 1926) regulations for worker protection during asbestos removal and demolition activities. This includes the use of personal protective equipment (PPE) such as Tyvek suits or equivalent, respirators (as necessary), and gloves (as necessary); and personal monitoring.

Because, like the Asbestos NESHAP, this method is designed to be a work practice standard, monitoring of air (other than that mandated by OSHA statute), soil, and other media is not required.

8.0 Waste Handling

Several wastes are generated during demolition activities, including demolition debris, disposable PPE, and potentially contaminated water and soil, and must be properly disposed. All wastes generated must be removed from the site at the end of the day and transported to an appropriate disposal facility. Transport and disposal shall be in accordance with all federal, state, and local requirements. All waste haulers shall be leak-proof. Double-lining of the haulers with 4-mil or thicker polyethylene film and then sealing the top seams of the film is a suggested mechanism, but the contractor must do what is required to prevent leaks from the transport vehicles. Vehicles shall be decontaminated within the bermed area before leaving the demolition area.

8.1 Demolition Debris

Segregation of portions of a structure that may contain RACM from portions of a structure that clearly do not contain RACM shall be done when practical in an effort to minimize RACM debris. For example, segregation may be used if a large warehouse is being demolished and only a small portion (e.g., office space) contains RACM.

When segregation is not practical, all demolition debris shall be disposed as RACM in a licensed asbestos disposal facility. Debris shall be kept adequately wet during loading into containers. Containers shall be covered during transport.

8.2 PPE

All disposable PPE shall be disposed as RACM. Reusable PPE shall be decontaminated in accordance with OSHA standard practices.

8.3 Potentially Contaminated Water and Impervious Surfaces

No potentially contaminated water runoff is permitted from the site during the demolition period. All impervious surfaces will be thoroughly washed with amended water before site closure.

Construction site best management practices shall be used to prevent water runoff. Drains and sewer connections must be capped or plugged prior to wetting. Berms and/or trenches must be created as necessary to prevent runoff of water from the demolition site. If possible, the bermed/trenched area should extend 25 ft from the building and/or loading area. If not possible, adjacent areas and structures need to be covered with plastic.

The berm/trench must be sufficiently spaced from the building to permit the movement of the demolition equipment and to allow the truck loading to occur within the enclosed space. All plastic shall be disposed as RACM.

If large water volume use or impermeable conditions surrounding the building create excessive water volume and simple containment and percolation is not feasible, the water must be pumped and either disposed as ACM or filtered through a series of filters ultimately removing all fibers equal to or larger than five microns before transporting to a publicly-owned treatment works or discharging to a sanitary sewer. The filters must be disposed as RACM.

8.4 Potentially Contaminated Soil

Following the removal of demolition debris, bare soil within the bermed area shall be excavated to a minimum depth of three inches or until no debris is found. Berms created shall also be removed and disposed as potentially asbestos-contaminated. All removed soil shall be disposed as RACM. Wetting will be continued throughout the soil removal process.

9.0 Site Closure

Following demolition and waste disposal, all waste and debris must be gone from the site and the site must be secured so as not to create a safety hazard

SECTION 2 PROJECT OBJECTIVES

The goal of this research study was to compare the effectiveness of the AACM to the current Asbestos NESHAP demolition practice on buildings that were architecturally identical. Primarily, this means that the environmental releases of asbestos to the air and to the soil as measured by their respective concentrations should not be greater in the case of the AACM than those of the NESHAP Method. In addition, the cost of the AACM must be less than the NESHAP Method for the alternative to be attractive. All of the data collected were evaluated and considered, as appropriate, to make this comparison.

The quality assurance project plan (QAPP), *Evaluation of an Alternative Asbestos Control Method for Building Demolition, March 2006* was developed by ORD in combination with the select EPA QAPP Technical Develpoment Team to serve as the guide for collecting and analyzing the data from this research effort. The QAPP was also formally peer-reviewed and offered for public comment. The QAPP as revised specified the following project objectives:

2.1 Primary Objectives

1. To determine if the **airborne asbestos (TEM) concentrations** from the AACM are statistically equal to or less than the NESHAP Method.

2. To determine if the **post-excavation asbestos concentrations** in the soil from the AACM are statistically equal to or less than the post-demolition NESHAP Method. The AACM requires soil excavation following demolition and the NESHAP Method does not.

3. To determine if the **AACM is more cost-effective** than the NESHAP Method considering all costs, including disposal of all asbestos-contaminated materials and soils, and projected costs for enforcement.

2.2 Secondary Objectives

The following secondary objectives provided additional information to further characterize the interrelationships among several multimedia parameters to enhance the understanding of the process and to further the science. These data were also considered in a holistic sense in assessing the comparability of the two demolition methods:

2.2.1 Air

1. To determine **background asbestos concentrations (TEM)** prior to the NESHAP and AACM demolitions.

2. To determine if the **airborne fiber (analyzed by phase contrast microscopy –PCM) concentrations** from the AACM are statistically equal to or less than the concentrations from the NESHAP Method.

3. To document **visible emissions** during both demolitions.

4. If wind conditions allow, to determine if the **airborne asbestos concentrations downwind are statistically greater than the upwind concentrations** for the NESHAP Method.

5. If wind conditions allow, to determine if the **airborne asbestos concentrations downwind are statistically greater than the upwind concentrations** for the AACM.

2.2.2 Dust

6. To determine if the **asbestos concentrations in the settled dust (TEM)** from the AACM are statistically equal to or less than the concentrations from the NESHAP Method.

7. To determine if the **total particulate concentrations** (as collected and measured by NIOSH Method 0500) from the AACM are statistically equal to or less than the concentrations from the NESHAP Method.

2.2.3 Worker

8. To determine if **worker breathing zone fiber concentrations (PCM)** from the AACM are statistically equal to or less than the concentrations from the NESHAP Method.

9. To determine if **worker breathing zone asbestos concentrations (TEM)** from the AACM are statistically equal to or less than the concentrations from the NESHAP Method.

2.2.4 Activity

10. To document **worker breathing zone asbestos concentrations (TEM)** for individuals that are maintaining the perimeter air monitoring network.

2.2.5 Soil

11. To determine if the **asbestos concentration in the post-excavation soil** from the AACM is statistically equal to or less than the pre-demolition asbestos concentration.

12. To determine if the **asbestos concentration in the post-demolition soil** from the NESHAP Method is statistically equal to or less than the pre-demolition asbestos concentration.

13. To determine if **asbestos concentration in the post-excavation soil is statistically equal to or less than the concentration in the post-demolition soils** from the AACM.

14. To determine if **asbestos concentrations from elutriator tests on the post-excavation soils from the AACM are statistically equal to or less than the concentrations from the post-demolition** NESHAP Method.

15. To determine if **asbestos concentrations from elutriator tests on the post-excavation soils from the AACM are statistically equal to or less than the pre-demolition** concentrations.

16. To determine if **asbestos concentrations from elutriator tests on the post-demolition soils from the NESHAP Method are statistically equal to or less than the pre-demolition** concentrations.

17. To determine if **asbestos concentrations from elutriator tests on the post-excavation soil are significantly equal to or less than the concentrations from tests on the post-demolition soil** from the AACM.

2.2.6 Water

18. To measure the **asbestos concentrations in the water applied** to control emissions from both the AACM and NESHAP Method and to measure the **asbestos concentrations in collected water** for both processes during demolition activities.

2.2.7 Landfill

19. To determine **background airborne asbestos concentrations (TEM) prior to landfilling** of the NESHAP building debris and again prior to landfilling of the AACM building debris.

20. To determine if the **airborne asbestos concentrations at the landfill (TEM) during disposal** of the AACM debris are statistically equal to or less than the concentrations during disposal of the NESHAP Method debris.

21. To determine if **landfill worker breathing zone fiber concentrations (PCM)** from the AACM are statistically equal to or less than the concentrations from the NESHAP Method.

22. To determine if **landfill worker breathing zone asbestos concentrations (TEM**) from the AACM are statistically equal to or less than the concentrations from the NESHAP Method.

2.2.8 Time

23. To document the **time required for all activities** related to demolition by the NESHAP Method, including abatement, and for the AACM.

2.2.9 Modeling

24. To collect **additional asbestos and fiber data** necessary for potential future air dispersion modeling efforts.

25. To compare the **modeled emission factors** from the AACM with those from the NESHAP Method.

SECTION 3 SITE INFORMATION

3.1 Site Selection

EPA conducted a nationwide search for buildings that contained, as a minimum, asbestos-containing wall systems and vinyl asbestos floor tile. Other ACM components such as popcorn ceilings, window glazing, transite, and vermiculite attic insulation were considered a plus in this search. Another major criterion was that the buildings needed to be identical in construction. The most significant criterion, and the most limiting as well, was the EPA requirement that the structures needed to be about 1,000 feet from the nearest occupied residence. The task of locating paired structures was a truly difficult endeavor, and many locations were investigated before the ones used in this research effort were located.

The buildings were located at the Fort Chaffee Redevelopment Authority in Fort Smith, Arkansas (Figure 3-1). The NESHAP (#3602) and AACM (#3607) buildings are shown in Figure 3-2.

The demolition site was in a remote, secure location to ensure no public exposure. There were no private residences within a radial distance of one mile from the study buildings. The nearest residence was approximately two miles from the demolition site. The buildings had a clearance of approximately 1,000 linear feet from the nearest occupied military building on the eastern side, and greater than 1,400 linear feet in all other directions.

The demolition debris was transported to City of Fort Smith's Subtitle ―D" landfill, which is approved to accept asbestos-containing waste materials. The landfill is owned and operated by the City of Fort Smith. It is located at 5900 Commerce Road in Fort Smith, which is approximately seven miles southwest of the demolition site.

3.2 Site Description

These 1940-era buildings were architecturally identical both in composition and structure (Figure 3-3 and Figure 3-4), which was ideal for the testing and comparative evaluation of the AACM versus the Asbestos NESHAP Method. The building footprint is approximately 4,500 square feet (30 feet by 150 feet). The buildings were wood-frame construction with wood clapboard exterior siding and non-ACM asphalt shingle roofs. The interior finish was gypsum wallboard on both the ceiling and walls, and associated painted millwork. Resilient floor tile (nine inch by nine inch) was present in all areas excluding the bathrooms, which was resilient sheet vinyl. The building had a concrete pier and wooden beam foundation system with one large concrete box structure whose function was not known. The buildings utilized window-unit air conditioners with heating formerly supplied by radiant heaters. Forced hot water for the radiant heat was supplied by a central steam plant located elsewhere in the complex.

All asbestos-containing thermal system insulation on the steam pipes associated with these buildings had been previously abated in 1999.

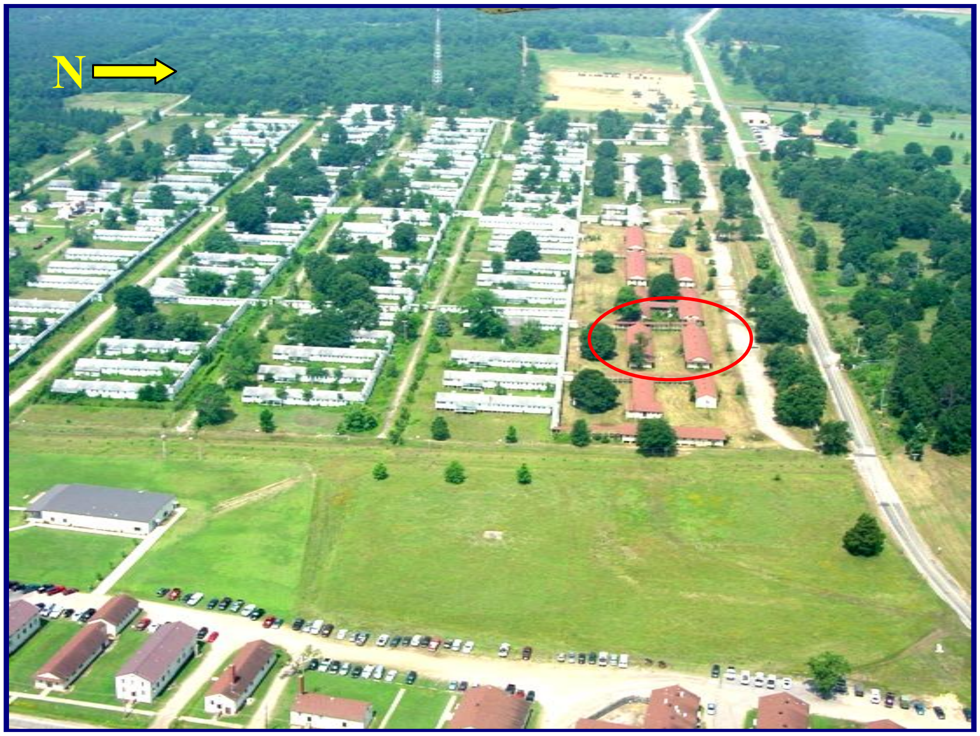

Figure 3-1. Project location at Fort Chaffee. Buildings selected for demolition are #3602 (NESHAP Method) and #3607 (AACM).

Figure 3-2. (Top) Exterior view of Building #3602 (NESHAP Method) and (Bottom) #3607 (AACM). Dimensions: 30-feet by 150-feet.

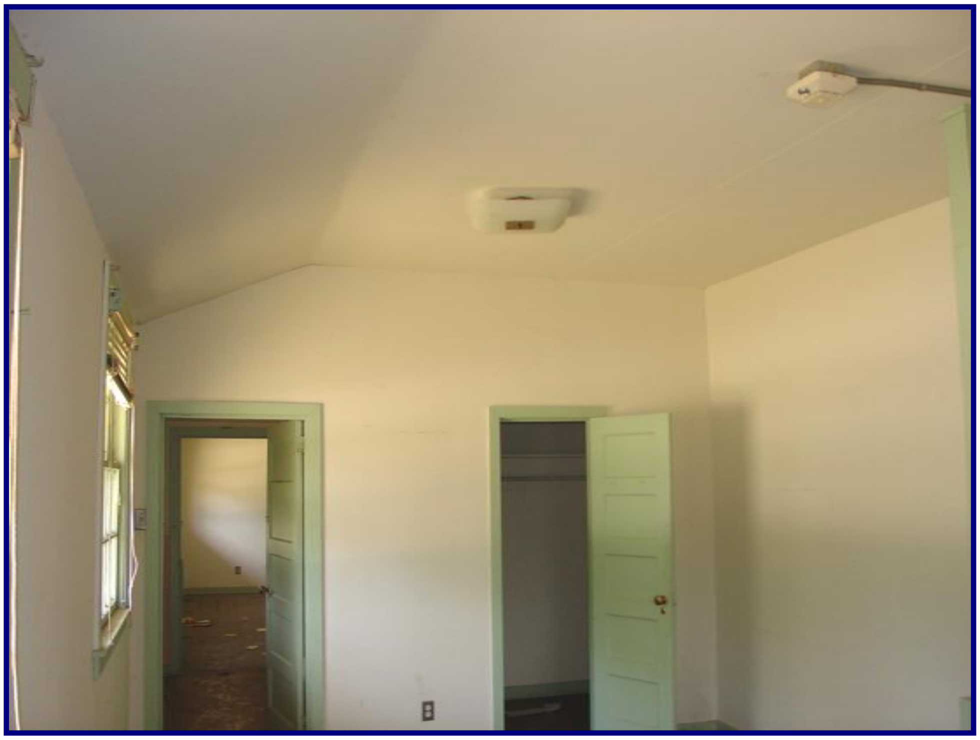

Figure 3-3. Interior view of Building #3602 (NESHAP). Interior finishes are gypsum wallboard (ceiling and walls) and nine-by-nine-inch resilient floor tile.

Figure 3-4. Interior view of Building #3607 (AACM). Interior finishes are gypsum wallboard (ceiling and walls) and nine-by-nine-inch resilient floor tile.

3.3 Pre-Demolition Inspection of Buildings

Several months before the scheduled demolitions, samples of site building materials, soil, source (hydrant) water, and background air were collected and analyzed to determine the suitability of the site for the comparative method evaluation.

3.3.1 Asbestos Inspection of Buildings

A comprehensive pre-demolition inspection was conducted in accordance with the Asbestos Hazard Emergency Response Act (AHERA) (40 CFR §763) to identify the type, quantity, location, and condition of ACM in the buildings [§61.145(a)] (Kominsky 2005; Smith Aug 2005). Under NESHAP 40 CFR 61.145(a), not only RACM must be identified prior to demolition or renovation but also Category I and Category II nonfriable ACM. The inspection was conducted by a State of Arkansas Department of Environmental Quality (ADEQ) licensed Asbestos Abatement Consultant. The inspection data were used to determine the pre-demolition asbestos abatement plan for these buildings (Smith Nov 2006).

The samples were analyzed for asbestos content using polarized light microscopy (PLM) and dispersion staining in accordance with EPA's *Method for the Determination of Asbestos in Bulk Building Materials* (EPA/600/R-93/116, July 1993). Gravimetric reductions (GR) followed by TEM analyses (as specified in EPA/600/R-93/116, July 1993) were performed on wallboard joint compound, resilient floor tile, and window glazing compound samples. For materials composed of distinct layers or two or more distinct building materials (e.g., shingle and roofing felt), each layer or distinct building material was treated as a discrete sample. The layers or materials were separated and analyzed individually. The laboratory reported a single value for each material or discrete layer. In addition, the laboratory reported a composite value for wallboard joint compound samples. Composite values were calculated using estimates of the quantity of each layer in the sample as determined by measuring to a distance as wide as the seam (Figure 3-5, *d2*). That is, the sample used to estimate the quantity of each layer is represented by *d2* in Figure 3-5.

Figure 3-5. Section of ½-inch gypsum wallboard showing a multi-layered joint interval. Wallboard was obtained from Building #3607 (AACM)

Table 3-1 summarizes the results of the building material samples collected from the NESHAP Method (#3602) and AACM (#3607) buildings. Table 3-2 lists the ACM present in the NESHAP Method (#3602) and AACM (#3607) buildings and their corresponding quantities and locations. These buildings contain ACM that are commonly present in structures that could conceivably fall under the AACM. Window glazing was not asbestos-containing by PLM in Building 3602 but TEM revealed that it was asbestos-containing. The glazing had apparently been replaced by non-ACM glazing in Building 3607. According to NESHAP rules, the glazing compound would not have been required to have been removed since it was less than one percent asbestos by PLM.

Table 3-1. Asbestos Content of Building Materials

Homogeneous Material		Number of Samples	Mineral	Asbestos Content, %	
				PLM	GR/TEM
NESHAP Method Building (#3602)					
Wallboard	Joint Compound	4	Chrysotile	1-5	10-19
	Joint Interval Composite			NA	4-7
	Non-Joint Skim Coat	4	-	ND[a]	NA
Flooring	9- by 9-inch Tile	4	Chrysotile	10-20	14-24
	Sheet	4	Chrysotile	15-25	NA[c]
	Mastic	4	-	ND	NA
Roofing	Shingle	4	-	ND	NA
	Felt	4	-	ND	NA
Glazing Compound		4	Chrysotile	TR[b]	8-9
Attic Insulation		4	-	ND	NA
AACM Method Building (#3607)					
Wallboard	Joint Compound	4	Chrysotile	1-5	4-10
	Joint Interval Composite			NA	1-4
	Non-Joint Skim Coat	4	Chrysotile	ND	<0.3-2
Flooring	9- by 9-inch Tile	4	Chrysotile	10-20	17-20
	Sheet	4	Chrysotile	15-25	NA
	Mastic	4	-	ND	NA
Roofing	Shingle	4	-	ND	NA
	Felt	4	-	ND	NA
Glazing Compound		38	-	ND	<0.1
Attic Insulation		4	-	ND	NA

[a]ND = None Detected, < 1% visual estimate.
[b]TR = Trace, <1% visual estimate.
[c]NA = Not analyzed.

Table 3-2. ACM Present in the NESHAP Method and AACM Buildings.

Sample Group	HA[a]	Material Description	Sample Location	Friable/ Non-Friable	Quantity	Condition
NESHAP Method Building (#3602)						
3602-RFC-02	2	Red Multi-Colored Linoleum	Bathrooms	Non-Friable	252 ft^2	Good
3602-FT-03	3	Brown Floor Tile	Throughout	Non-Friable	3,992 ft^2	Good
3602-WG-05	5	Window Glazing	Windows	Friable	814 lf	Damaged
3602-JC-06	6	Gypsum Wallboard	Throughout	Non-Friable	20,700 ft^2	Good
AACM Building (#3607)						
3607-RFC-02	2	Red Multi-Colored Linoleum	Bathrooms	Non-Friable	252 ft^2	Good
3607-FT-03	3	Brown Floor Tile	Throughout	Non-Friable	3,992 ft^2	Good
3607-JC-06	6	Gypsum Wallboard	Throughout	Non-Friable	20,700 ft^2	Good

[a]HA = Homogeneous area

3.3.2 Lead Paint Inspection of Buildings

The NESHAP Method (#3602) and AACM (#3607) buildings were surveyed for inorganic lead to characterize the potential for occupational exposure during demolition and landfilling of the resultant construction debris.[3] The samples were prepared for analysis in accordance with EPA SW-846 Method 3050A and analyzed by inductively coupled plasma atomic emission spectroscopy (ICP-AES) in accordance with EPA SW-846 Method 6010B (Smith, 2006).

Table 3-3 presents the concentrations of lead measured in paint chip samples obtained from Buildings #3602 and #3607. Because the paint contained >600 ppm lead, personal breathing zone monitoring was conducted during asbestos abatement of Building #3602 and during demolition and landfilling of both buildings in accordance with OSHA Lead Standard 29 CFR §1926.62. Representative composite bulk samples of the lead-containing building materials were analyzed to determine the leachable lead content (EPA SW-846 Method 1311, *Toxicity Characteristic Leaching Procedure*), as required by the local landfill operator. All samples showed a leachable lead content of <5 mg/L RCRA criterion.

[3] The OSHA Lead Standard (29 CFR §1926.62) does not define lead paint based on the amount of lead present. That is, the standard does not specify a minimum amount or concentration of lead that triggers a determination that lead is present and the potential for occupational exposure exists. It is theoretically not possible to exceed the OSHA permissible exposure limit of 50 $\mu g/m^3$, eight-hour time-weighted average (TWA) if the lead content is $\leq$600 ppm (equivalent to 0.06%). Accordingly, exposure monitoring must be conducted when the lead content of the material is $\geq$ 600 ppm to determine if a worker is being exposed to lead at or above the action level of 30 $\mu g/m^3$ eight-hour TWA.

Table 3-3. Lead in Paint Chip Samples from Interior and Exterior Building Components.

Building Component	Number of Samples	Concentration of Lead, ppm		
		Mean	Minimum	Maximum
NESHAP Method (#3602) Building				
Millwork	4	11,400	4,400	24,000
Gypsum wallboard	4	1,310	500	2,000
Exterior clapboard siding	4	81,500	34,000	120,000
AACM (#3607) Building				
Millwork	4	12,000	8,000	15,000
Gypsum wallboard	4	1,220	1,000	4,000
Exterior clapboard siding	3	55,300	46,000	73,000

3.3.3 Concentrations of Asbestos in Soil

A total of nine individual soil samples were collected for asbestos. Three samples were collected from beneath each of the two buildings, and three samples were collected from the perimeter of the two buildings at approximately 15 feet from the face of the buildings. The purpose of these samples was to provide a preliminary assessment of the background soil asbestos concentrations.

The soil samples were collected using a clean scooping tool to acquire approximately the top ½-inch of soil from a six-inch by six-inch area. The samples were analyzed for asbestos content using PLM and dispersion staining in accordance with EPA's *Method for the Determination of Asbestos in Bulk Building Materials* (EPA/600/R-93/116, July 1993). The soil samples were also analyzed for asbestos using gravimetric reduction and subsequent TEM analysis described in the above method. The asbestos concentrations present in the soil are summarized in Table 3-4.

Beneath the buildings, asbestos concentrations near the analytical sensitivity were observed in some samples. This was attributed to the prior removal of thermal system insulation (pipe wrap) noted in section 3.2.

Table 3-4. Asbestos in Soil (PLM) and Gravimetric Reduction (GR/TEM).

Location	Number of Samples	Asbestos Found[a]	Asbestos Content, %	
			PLM	GR/TEM
NESHAP Method (#3602) Building				
Beneath Building	3	Chrysotile	TR[b]	BAS[c]
AACM (#3607) Building				
Beneath Building	3	Chrysotile, Amosite, Anthophyllite	TR	BAS-0.005
Perimeter of Buildings				
Perimeter	3	ND[d]	ND	BAS

[a]If detected, no more than one fiber was observed in any sample.
[b]TR = Trace, <1% by visual estimate.
[c]BAS = Below analytical sensitivity, 0.001 (mass %).
[d]ND = None Detected, <1% visual estimation.

3.3.4 Concentrations of Asbestos in Source Water

Three one-liter samples of the source water were obtained from the flush hydrant at the demolition site in January 2006, approximately four months prior to the study. Prior to collecting the samples, the hydrant was operated until the water stream was relatively clear. The samples were analyzed for asbestos by EPA Method 100.2 (TEM). All sample concentrations were below the analytical method measurement sensitivity concentrations, which ranged from 0.04-1.91 million asbestos structures per liter.

3.3.5 Background Air Sampling

Preliminary background asbestos air sampling was conducted at the demolition site and at the landfill in January 2006, approximately four months prior to the study. Five-fixed station area samples were collected around the NESHAP and AACM buildings. Six fixed-station area samples were collected at the Fort Smith Landfill in the area selected to receive the demolition debris from both buildings. The samples were analyzed for asbestos using the International Standards Organization (ISO) Method 10312:1995. All sample concentrations were below the analytical method measurement sensitivity concentrations of 0.0005 structures/cm^3.

This background sampling was done for pre-assessment purposes. Prior to the actual demolitions, additional background sampling was performed as described later in this document.

SECTION 4 STUDY DESIGN AND IMPLEMENTATION

4.1 Sampling Strategy

The overall summary of the field samples collected during the study is presented in Table 4-1 through Table 4-3. These tables summarize the numbers and type of samples collected for each media for both the NESHAP and AACM demolitions and disposal operations. Sections 4.1.3 through 4.1.5 present the details of the sampling strategies for the demolition site and the landfill.

Table 4-1. Summary of Field samples (excluding quality control samples) Collected for Asbestos Analysis by TEM.

Description of Sample		NESHAP Building				AACM Building			
		Air[a]	Soil[b]	Water	Settled Dust	Air	Soil	Water	Settled Dust
Background Sampling Prior to Building Demolition									
Demolition site at Ring 1		6	-	-	-	6		-	-
Fort Smith landfill at Ring 1		6[c]	-	-	-	-	-	-	-
Asbestos Abatement of NESHAP Building									
Worker	Asbestos abatement	6	-	-	-	-	-	-	-
	Loadout of drummed ACM	3	-	-	-	-	-	-	-
	Equipment operator landfill drummed ACM	4	-	-	-	-	-	-	-
HEPA unit discharge air		4	-	-	-	-	-	-	-
Demolition of Buildings									
Rings 1 and 2		54	-	-	-	107	-	-	-
		-	-	-	36	-	-		36
Worker	Hose and equipment operators, and truck drivers	8	-	-	-	8	-	-	-
	Walkers outside of containment berm	3	-	-	-	3	-	-	-
Soil	Bulk	-	20	-	-	-	30	-	-
	Elutriation	-	6	-	-	-	9	-	-
Water	Source hydrant	-	-	2	-	-	-	3	-
	Amended	-	-	-	-	-	-	2	-
	Pooled surface	-	-	-	-	-	-	7	-
Landfill of Demolition Debris									
Ring 1		9	-	-	-	18	-	-	-
Landfill equipment operator		3	-	-	-	4	-	-	-
Total samples		106	26	2	36	146	39	12	36

[a] Samples (excluding soil elutriation and HEPA unit discharge) were also analyzed for total fibers.
[b] Samples were analyzed by both PLM and TEM.
[c] Applicable also to AACM.

Table 4-2. Summary of Personal Breathing Zone Samples Collected for Lead.

Description of Sample	Number of Air Samples	
	NESHAP Building	AACM Building
During abatement	13	NA[a]
During building demolition	8	8
During landfill of building debris	3	2

[a]Not applicable.

Table 4-3. Summary of Ring 1 Air Samples Collected for Total Particulate.

Description of Sample	Number of Air Samples	
	NESHAP Building	AACM Building
During building demolition	18	18

4.1.1 Meteorological Monitoring

Meteorological conditions were determined and continuously monitored during sampling at both the demolition site and the landfill using MetOne Automet Meteorological Monitoring Systems (Automet 466A). The meteorological parameters that were measured included wind direction and speed, air temperature, relative humidity, and barometric pressure. The monitoring station at the landfill site failed at the beginning of the study, but meteorological data from the Fort Smith Airport site, located about 1000-ft from the landfill, was used.

4.1.2 Weather Restrictions

The demolition was not conducted during rain or snow conditions. For this study, if sustained wind speeds of 15 mph (60-minute average) or gusts above 20 mph were encountered, demolition and monitoring would pause until the wind speed was less than these conditions. The maximum limits were established to attempt to prevent the higher winds speeds from excessively modifying the micrometeorology. Operations would resume upon the winds returning to stable conditions (15-minutes minimum allowable within the confines of the test), or would be delayed until satisfactory conditions exist. Wind conditions at the site were continuously monitored by the onsite weather station. During the study, none of the weather restriction situations were encountered.

4.1.3 Demolition Site Sampling

4.1.3.1 Background Air Monitoring

Air monitoring was conducted prior to demolitions of the NESHAP and the AACM buildings to collect data necessary for potential comparison of air concentrations of asbestos and total fibers during demolition. The target air volume for an eight hour sample at a flow rate of four liter/min was 1,920 liters.

The air monitoring network for the background data consisted of one ring of six fixed-station samplers around the building. The samplers were placed at 60-degree intervals measured along a radius from the center of the building. The samplers were placed within 15 feet of the building and at a height of five feet above ground. The background monitoring was prior to the respective demolition.

4.1.3.2 Perimeter Air Asbestos, Total Fibers, Settled Dust, and Particulate Sampling During Demolition

Since the demolition study was initially scheduled to be performed during the March-April time frame, an analysis was conducted of 3,660 hours of meteorological data (wind direction and wind speed) collected between 07:00 to 18:00 hours from March 1 through April 30 during the years of 1999, 2000, and 2002 through 2004 at the Fort Smith Municipal Airport (Station #13964). The results of this analysis showed that the wind direction varied between up to six 20-degree sectors during a given day. It was concluded that the primary air sampling design should be based on a concentric ring approach rather than on an upwind to downwind approach. This study design is consistent with the primary objective of this project: i.e., to compare the effectiveness of the AACM to the Asbestos NESHAP Method.

The distance of the rings from the face of the building was determined using two EPA dispersion models: SCREEN3 and ISCST3. SCREEN3 (a Gaussian plume dispersion model) is a screening tool that uses a worst-case meteorology to produce a conservative one-hour average air concentration estimate. A refined modeling analysis was then conducted using the ISCST3 (a steady-state Gaussian model) to predict location (i.e., lateral distance and height above ground level) where the maximum concentration of airborne asbestos was likely to occur.

Modeling conducted using the EPA dispersion models SCREEN3 and ISCST3 indicated that the maximum airborne asbestos concentrations during demolition and loading of debris would most likely occur approximately 15 feet from the building at a height of five feet above the ground. Therefore, the samplers were placed approximately 15 feet from the face of each building or as close as possible to the demolition or debris loading areas. *Note:* On the north side of the building, the samplers in the first ring (Ring 1) were positioned approximately 25 feet from the face of the building to accommodate the space needed for loading the construction debris disposal trucks. This provided about ten feet between the truck side and the building.

Eighteen samplers (for each asbestos/total fibers, particulate, and settled dust) were evenly spaced at 20-degree intervals around each building in Ring 1 at the five-ft height. An additional 18 samplers (asbestos/total fibers) were positioned at a height of 15 feet in the primary ring (Ring 1) on the same sampling poles, directly above the five-ft-high samplers. The perimeter air samplers were placed immediately outside of the containment berm. The samplers were in numerical order corresponding to the manner in which the samplers were placed around the buildings. That is, the first sample in each group of 18 corresponded to the location on the front right (northwest) corner of the building and then were numbered in a clockwise fashion around the structures. The trucks were loaded along the front of the building as the demolitions progressed (samplers one through seven in each grouping).

Samplers were also located to collect additional data necessary for potential future air dispersion modeling efforts. A second ring (Ring 2) of 18 evenly-spaced samplers (asbestos/total fibers and settled dust) was located about 50 ft away from the building. The Ring 2 samplers were placed at the five-ft height above ground.

If any asbestos-containing dust was released during the demolition of the buildings and associated debris-loading activities, it could settle on nearby surfaces. As previously mentioned, settled dust collectors were placed at the five-ft heights at the same locations as the air samples in Rings 1 and 2.

In order to provide a measure of total particulate in the air from the two demolitions, samples were collected at the same locations as the perimeter air asbestos samples in Ring 1.

The perimeter air sampling network consisting of the two concentric rings is shown for the NESHAP and AACM buildings in Figure 4-1 and Figure 4-2, respectively.

All primary air samples were collected at an airflow rate of four liter/min for approximately eight to ten hours to achieve a target air volume of 1,920 to 2,400 liters. Additionally, lower volume samples were collected at a flow rate of two liter/min for approximately eight to ten hours to achieve an air volume of 960 to 1,200 liters, to serve as backup samples if the primary ones were overloaded. The primary samples were not overloaded; therefore these low flow samples were not analyzed and were archived.

All air samplers were activated shortly before demolition activities began, and were continued until demolition activities ceased for that day.

For the AACM, the demolition was completed on the first day (Day 1). Air sampling for asbestos/total fibers was halted and the filters were capped and removed for analysis. Concrete structures and some small residual debris remained. On the second day, removal of the concrete structures and remaining debris and the subsequent soil sampling was delayed until the afternoon because of rain. Prior to the initiation of Day 2 activities, to assure no filter overloading, new filters were positioned for asbestos/total fiber sampling. Due to the rain, concrete/debris removal, and the subsequent soil sampling which required a significant amount of time, soil excavation was delayed until the third day. The asbestos/total fiber filters were capped overnight and during periods of inactivity on Days 2 and 3. These samples, which reflect AACM activities over the second and third day, are referred to as Day 2 samples throughout this report. The settled dust samplers and particulate filters were positioned for the entire duration of the AACM study and capped overnight and during periods of inactivity.

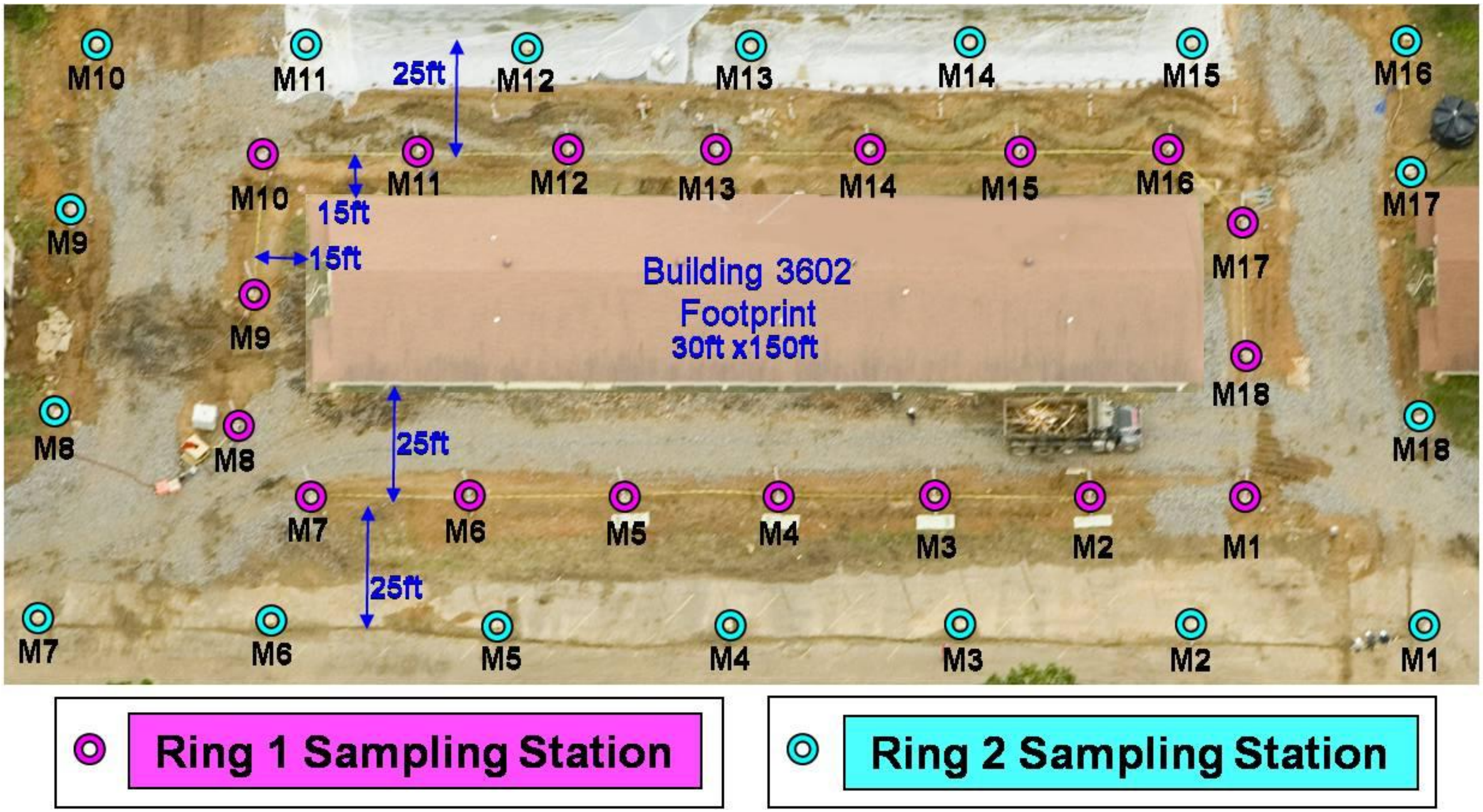

Figure 4-1. Location of Ring 1 and 2 samplers around the NESHAP Method building.

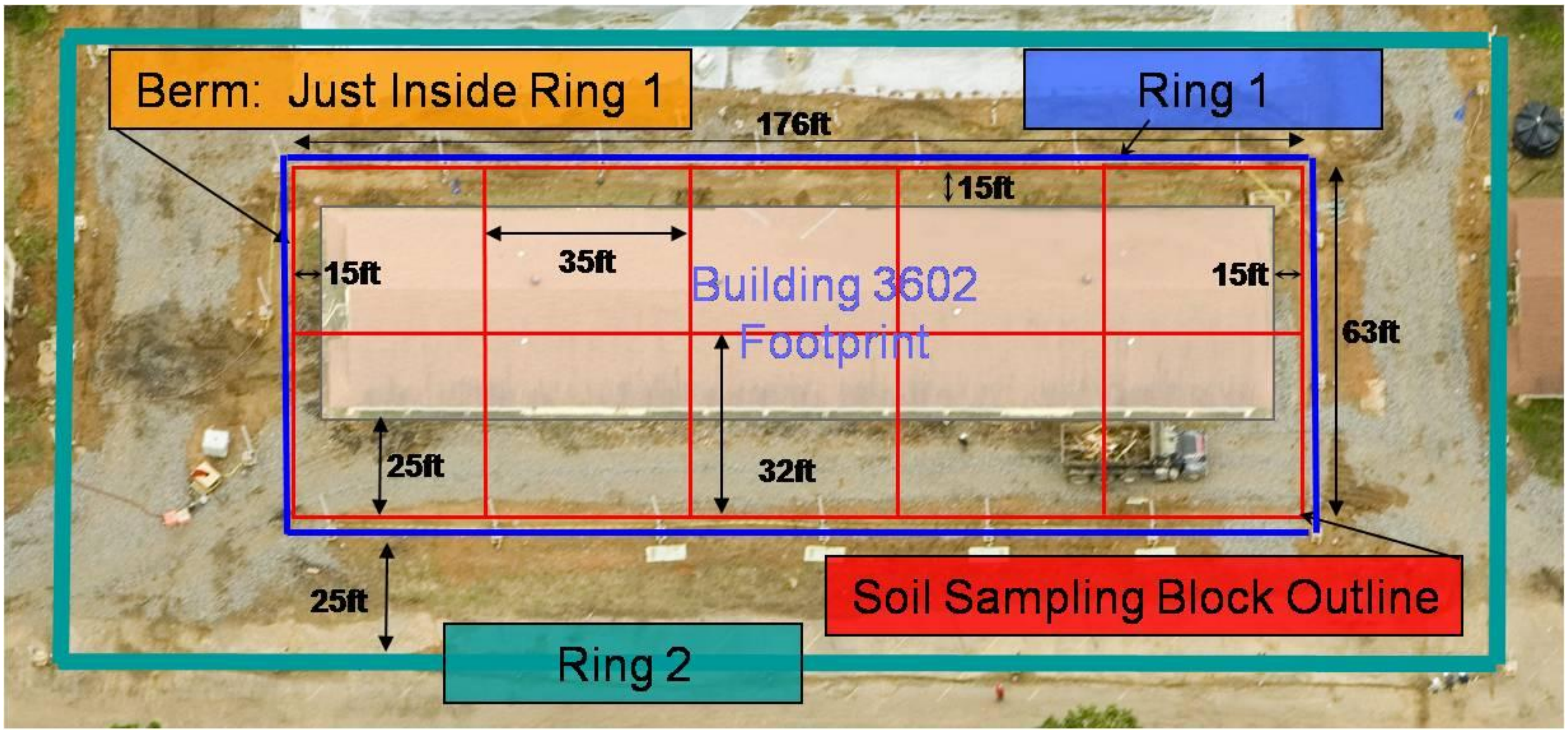

Figure 4-2. Location of soil sampling grid around the NESHAP building.

4.1.3.3 Work Area Sampling

4.1.3.3.1 Discharge Air Sampling During Asbestos Abatement of NESHAP Building

Previous studies conducted by EPA of air filtration units equipped with High Efficiency Particulate Air (HEPA) filtration to maintain a negative static air pressure at asbestos abatement sites showed that a large percentage of the units discharged asbestos fibers (Kominsky et al 1989; and Wilmoth et al 1993).

In-duct isokinetic samples of the discharge air from each HEPA-filtration unit used during the abatement of the NESHAP Method building were collected according to the procedures outlined in Wilmoth, et al, 1993 and analyzed for asbestos by direct transfer preparation. Four air filtration units were required to maintain the static negative air pressure within the building. Because the discharge air was being processed through new HEPA filters that were specifically installed for this study, it was expected that the particulate loading on the filter would be minimal, and this was the case. Accordingly, each sample was collected over three consecutive eight- to ten-hour work shifts.

4.1.3.3.2 Personal Breathing Zone Sampling During Abatement

Personal breathing zone sampling for asbestos, total fibers, and lead was conducted during the abatement and during the load-out of the bagged and drummed ACM to determine the extent of asbestos fiber release during these activities. This sampling approach provides a reasonable characterization of the asbestos concentrations in air closest to the source of any potential release. Six personal breathing zone samples were collected from workers during the abatement process. The selection of the workers was random, but there was no formalized selection process. In addition, three personal breathing zone samples were obtained during the load-out process. A sampler was placed on the worker responsible for transferring the bagged and/or drummed ACM into the disposal container.

4.1.3.3.3 Personal Breathing Zone Sampling During Demolition

Personal breathing zone samples were collected and analyzed for asbestos, lead, and total fibers from all workers directly involved with the demolition of the buildings and the handling of the resultant construction debris. In addition, fixed station area samples were collected in the cab of the excavator as a backup to the personal breathing zone samples. For each of the two building demolitions, samples were collected during the demolition sampling periods to calculate the time-weighted average (TWA) concentration for comparison to the OSHA Permissible Exposure Limit for Asbestos (29 CFR §1926.1101) and lead (29 CFR §1926.62). The samplers ran the entire time the individual was performing the specific assigned task. For example, the samplers for the truck drivers operated from the time they came on site until they left the site (or the landfill) for the day. The samplers operated during transit between the demolition site and the landfill.

4.1.3.3.4 Personal Breathing Zone Activity Sampling

It was felt that “*walker samples*” would provide additional insight to complement the data from the perimeter samplers surrounding the demolition. These walker samplers were placed in the breathing zone of individuals who maintained the sampling stations both in Ring 1 and in Ring 2.

4.1.3.4 Soil Sampling

There were five soil sampling events. Baseline soil samples were collected prior to abatement of the NESHAP Method building and prior to demolition of the AACM building. Following demolition, all demolition debris was removed from each building site and soil samples were then collected. In the case of the AACM, approximately the top two to three inches of soil were then excavated and removed from the site and an additional set of soil samples collected. The comparison of asbestos soil concentrations between the two methods was based on the post-demolition samples for the NESHAP Method vs. the post-excavation samples for the AACM.

For each of the soil sampling events described above, the area within the containment berm was evenly divided into a ten-block grid system. Each block was approximately 32 ft by 35 ft. Three random grab samples were collected from each block and composited to form an “interleaved” composite to represent the entire footprint of the bermed area. This process was repeated ten times to provide ten “interleaved” composite samples. Each of the ten interleaved samples was therefore a composite of 30 grab samples, three from random locations in each of the ten blocks of the grid. The entire sampling process produced ten final interleaved composites from 300 grab samples. The sampling grid for the NESHAP Method building and AACM building is shown in Figure 4-2.

For each sampling event, ten composite samples were submitted to the laboratory and analyzed by PLM and TEM. For each sampling event, three of the ten composites were also submitted for analysis using the elutriation method. The elutriator samples were collected to provide additional information on the potential asbestos soil contamination by providing a measure of the asbestos concentration in respirable dust in the soils.

4.1.4 Water for Wetting Structure and Demolition Debris

4.1.4.1 Source Water

Measurements were taken of the asbestos concentrations of the source water from a flushed fire hydrant applied to control the particulate emissions during demolition and debris loading of the NESHAP Method and AACM buildings. A source water sample was collected at both the commencement and completion of the demolition activities.

4.1.4.2 Amended Water

Samples of the wetting agent used to prepare the amended water used in the AACM demolition were collected and analyzed for asbestos.

4.1.4.3 Surface Water from Demolition

As described in Section 1, Exhibit 1, earthen containment berms were constructed to trap water runoff during demolition and debris loading of the NESHAP and AACM buildings. Representative samples of surface water were intended to be collected during the demolition activity for both the NESHAP and AACM buildings. Drainage channels were constructed to direct water runoff for collection in plastic fabricated basins located within the containment berm. These channels were small in size, constructed of impervious material, and were only intended to ensure some collection of runoff, not to divert flow. This was intended to have minimal impact on soil permeation. The sampling of the collected runoff water was spaced over the duration of the demolition activity. Sample collection volumes were noted as a function of time and as a function of the progression of the demolition. No water runoff occurred during demolition of the NESHAP building.

4.1.5 Landfill

4.1.5.1 Background Air Sampling at Landfill

Air sampling was conducted prior to disposal of any materials from the NESHAP and AACM buildings to collect data necessary for potential comparison of air concentrations of asbestos and total fibers during disposal. The sampling was conducted prior to disposal of the respective waste materials. The target air volume for an eight-hour sample at a flow rate of four liter/min was 1,920 liters.

The air monitoring network for the background data consisted of one ring of six fixed-station perimeter samplers. The samplers were placed at 60-degree intervals measured along a radius from the center of the debris landfilling area. The samplers were placed as close to the disposal area as feasible (the goal was 15 feet from the activity) and at a height of five feet above ground.

4.1.5.2 Air Sampling During Landfilling of NESHAP Drummed ACM

During landfilling of the drummed ACM from abatement of the NESHAP building, the air was sampled to determine whether this activity released airborne asbestos fibers. The activity took approximately 30 minutes per load of drummed ACM. The bulldozer operator was fitted with a personal sampling pump which operated only during the period when the drummed ACM was being dumped and covered. In addition, fixed-station area samples were positioned in the cab and on the exterior of the cab of the bulldozer as backups for the personal breathing zone samples for asbestos analysis. The duration of the sampling integrated the ACM dumping activities over the nine days of abatement. The samples were collected at a flow rate of one liter/min for an estimated air volume of 810 liters.

4.1.5.3 Work Area Sampling during Landfilling of Demolition Debris

Personal breathing zone samples were collected from the bulldozer operator involved with the landfilling of the demolition debris. Personal samples for asbestos and total fibers were collected to calculate the time-weighted average concentration for comparison to the OSHA Permissible Exposure Limit (PEL) for Asbestos. In addition, a fixed-station area sample was positioned in the cab of the same bulldozer as a backup for total asbestos analysis. Personal samples for lead were also collected on the bulldozer operator each day of the landfilling activity for comparison to the PEL for lead (29 CFR §1926.62).

4.1.5.4 Perimeter Air Asbestos and Total Fiber Sampling During Landfilling of Demolition Debris

Air samples were collected for asbestos and total fibers during landfilling of the demolition debris from the NESHAP and AACM buildings.

The perimeter air sampling network consisted of one ring of samplers. The goal was to place the samplers at 40-degree intervals measured along a radius from the center of the asbestos landfilling activity as site conditions permitted, i.e., site topography and other ongoing landfilling activities. The samplers were placed at a height of five feet above ground and approximately 15 feet from the activity, or as close to that as possible. All samples had a target air volume of 1,920 to 2,400 liters.

4.2 Abatement of the NESHAP Building

The first phase of the NESHAP demolition was the abatement. Prior to demolition of the NESHAP Method building (#3602), all of the gypsum wallboard and glazing compound (windows and doors) were removed in accordance with the technical specifications for asbestos abatement prepared by an ADEQ-licensed asbestos project designer, Environmental Enterprise Group, Inc (EEG) (Smith, November 2005). The RACM was meticulously removed under full containment, loaded into barrels, and sealed for transport to the landfill by an ADEQ-licensed asbestos abatement contractor (Gerken Environmental Enterprises Inc.) in accordance with the Arkansas Pollution Control and Ecology Commission Regulation 21 (A.C.A. §20-27-1001 and §8-4-11 et seq). The vinyl asbestos tile and asbestos-containing linoleum were left in place.

This effort began on April 10 and continued for nine working days, with the completion and final acceptance on April 18, 2006. During this time, workers were monitored for asbestos (TEM) as well as total fibers (PCM) and lead for OSHA compliance. At the completion of the removal, the interior of the building was locked down with latex paint as an encapsulant and then final acceptance samples were collected in accordance with ADEQ requirements (PCM).

Throughout the period of the abatement, air discharges from the HEPA-filtration units were monitored for asbestos using isokinetic sampling and analysis by TEM. Although not normal industry practice, a new high-efficiency particulate air (HEPA) filter was used in each HEPA-filtration unit during the abatement of the NESHAP building.
The abatement process took nine days (4/10 to 4/18), the crew size ranged from seven to ten with a mean of nine workers, and the process required an abatement team commitment of 823 man-hours or 103 man-days. Visual inpection and clearance testing by PCM was completed at the end of the abatement process, The site passed both tests but those data are not presented in this document because they were not governed by the EPA QAPP.

The EPA and contractor staff inspected the abated area following acceptance and commented that this was a rigorous application of the NESHAP process. Figure 4-3 through Figure 4-7 illustrate the condition of the building during and after abatement and Figure 4-8 shows disposal at the landfill.

Figure 4-3. Wetting and removal of drywall during abatement of NESHAP building.

Figure 4-4. Loading abated material into barrels.

Figure 4-5. Loading asbestos-containing material into roll-off container.


Figure 4-6. Abated area after application of encapsulant.

Figure 4-7. Abated area after final clearance.

Figure 4-8. Covering abatement debris at the landfill.

4.3 Site Preparation

4.3.1 Surface Water Control

For this study, separate earthen containment berms were constructed surrounding the NESHAP building and the AACM building. The location of these coincided with the location of the inner ring of samplers: i.e., about 15 ft from the buildings on three sides and 25 ft from the buildings on the front (north) side (to permit haul truck access). Water within the containment berm was captured, filtered through a 50-µm pre- and 5-µm final filters, stored in a 2,400 gallon tank, and then transported and discharged to the Fort Smith Wastewater treatment Plant. Figures 4-9 through 4-11 illustrate the surface water control system. No surface water formed pools of a size sufficient to sample during the demolition of the NESHAP building. Figure 4-10 illustrates the pooling which occurred during the AACM building demolition.

Figure 4-9. Pooled surface water collection sump.

Figure 4-10. Water accumulation near the berm during the AACM demolition.

Figure 4-11. Water filtration system and holding tank.

4.3.2 Sampling Network

The sampling stations were located on 3-in schedule 40 polyvinyl chloride (PVC) poles inserted into a 4-in PVC schedule 40 PVC standpipe imbedded in concrete. A pulley/rope system was used to position the 15-ft sample cassette at the desired elevation. The five-ft high sampling cassettes were attached to the standpipe using eyebolts. The settled dust samplers were affixed to the standpipe with cable ties.

The asbestos sampling cassettes were connected to the 1/10 hp, 110 VAC pumps using Tygon® tubing. Electrical service to each sampling station was provided by underground conduit. Nine sampling stations were connected to each 20-amp circuit. No two adjacent stations were on the same circuit to prevent wholesale loss of samples. In addition, constant flow, battery-powered vacuum pumps were used to collect total particulate. All pumps were placed on a wooden table affixed to the standpipe. Figure 4-12 through Figure 4-15 show the sampling stations in Ring 1 and Ring 2.

Figure 4-12. Sampling stations at Ring 1 and Ring 2.

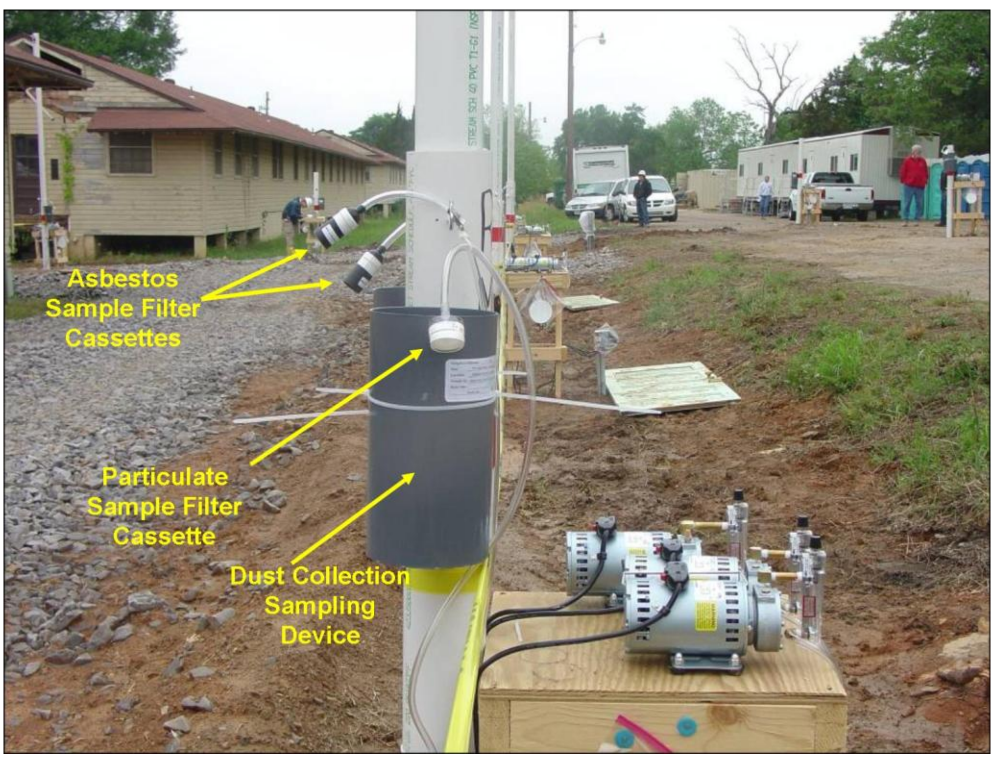

Figure 4-13. The five-ft high sampling array on the inner ring (Ring One).

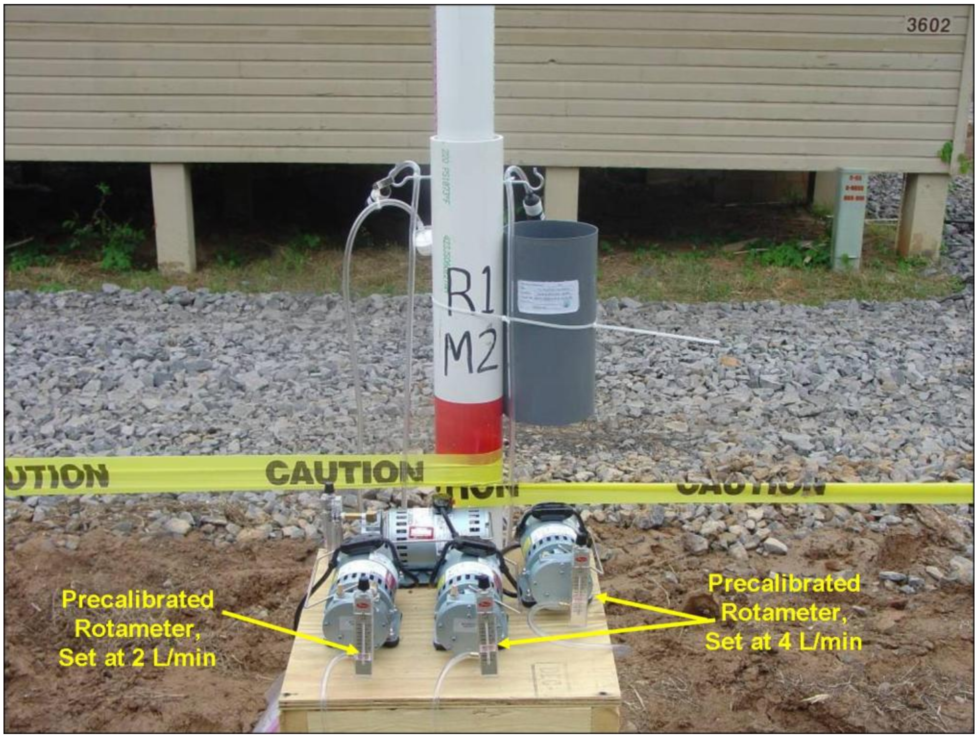

Figure 4-14. Red band denotes NESHAP building; a green band seen in other photos denotes AACM building. R1 denotes Ring 1 and M1 monitoring Location 1. Two pumps support filters at five-ft height and one at 15-ft height. Samplers were numbered in clockwise order, with sample #1 located at front (north) right (west) side of building. The same nomenclature applied to Ring 2, but with samplers only at five-ft height.

Figure 4-15. Pre-calibrated rotameters with sight gauges set at two and four liter/min.

4.3.3 Cross-contamination control

To prevent potential cross-contamination of the AACM building as well as the soil within its containment berm during demolition of the NESHAP building, the AACM building and associated bermed area were covered with six-mil polyethylene sheeting as illustrated in Figure 4-16.

Figure 4-16. Preparation of site prior to demolition of NESHAP Method building (left).

4.4 Planned demolition and disposal of buildings

The NESHAP Method building (#3602) was demolished in accordance with the procedures specified in 40 CFR Part 61, Subpart M, and in the ―*Guide to Normal Demolition Practices Under Asbestos NESHAP*" (EPA-340/1-92-013, September 1992). The AACM building (#3607) was demolished using the demolition practices specified in the ―*Alternative Asbestos Control Method*" contained in SECTION 1, Exhibit 1. The NESHAP Method building was demolished first (including removal of the foundation and all associated debris) and then the AACM building was demolished.

To reduce the number of variables involved in the comparison and to evaluate the NESHAP Method under optimum and ideal conditions, certain practices were specifically required for the NESHAP process that are not normal industry practice:

- Demolition equipment was identical to that used for the AACM building. It is not likely that the demolition equipment used on the NESHAP would have been used if not prescribed in this test. The demolition contractor stated that it would have been more typical to use a bulldozer to knock the structure down, run over it repeatedly to compact it, and then using an end loader to fill the unlined trucks.

- Demolition debris disposal vehicles were washed before leaving the NESHAP building demolition site. *This too is not normal industry practice.*

In addition, the bulldozer at the landfill was washed prior to the disposal of the debris from both demolitions to prevent cross-contamination.

4.4.1 NESHAP demolition and disposal

The demolition began on April 26, 2006 and was completed the same day, rather than the two days that had originally been envisioned. No significant problems were encountered during this demolition.

A Caterpillar 330BL track-hoe was used for demolition and for debris loading. A single water spray (about 30-gpm maximum) was used to control fugitive dust emissions. A single visible emission was observed, but it was during the removal of a concrete foundation and did not constitute an emission from ACM. No water pooled within the bermed area and therefore it was not possible to obtain samples of the water resulting from wetting the building. The debris was disposed as construction and demolition debris (C&D) in unlined trucks. Some soil was removed during the NESHAP demolition and debris cleanup as an inevitable result of the operation of the track-hoe.

Figure 4-17 through Figure 4-20 illustrate the demolition process. Based on a negative exposure assessment using objective data obtained by OSHA, neither respiratory protection nor protective garments were required during the demolition of the NESHAP building.

Soil sampling was conducted following the demolition, site cleanup, and grading. Soil sampling proved to be an onerous task, requiring about four hours to collect the required composite samples.

Figure 4-17. Starting demolition of the NESHAP building.

Figure 4-18. Loading NESHAP debris into trucks.

Figure 4-19. Finishing NESHAP demolition.


Figure 4-20. Aerial view showing NESHAP building nearly demolished.

4.4.2 AACM demolition and disposal

Prior to demolition of the AACM building (#3607), no asbestos-containing materials were removed; however in 1999 as previously noted, there was removal of thermal system insulation (pipe wrap) beneath both buildings.

4.4.2.1 Amended Water System

Amended water is water to which a surfactant (wetting agent) has been added to improve the penetrating capability of water. The surfactant reduces the surface tension of the water which allows it to penetrate a material where water might normally run off, to reach interior spaces of materials. For this study, the chosen surfactant was a Kidde Fire Fighting NF-3000 Class ―A" Foam Concentrate, as shown on Figure 4-21. Foaming ingredients give water the ability to adhere to vertical surfaces, which allows the water longer contact with the surface. The material safety data sheet (#NFC970) for NF-3000 is contained in the appendix.. This wetting agent is similar to Kidde Fire Fighting product Knockdown® that is used by firefighters to aid in extinguishing a fire.

The NF-3000 wetting agent was added to achieve target application strength of one percent concentration. For this study, a one-percent concentration was used to ensure adequate proportioning and provide confidence that sufficient wetting agent was always present in the application of amended water. According to the manufacturer, the surfactant is effective at significantly lower concentrations. Optimizing the application concentration was not a research goal of this project.

Figure 4-21. Wetting agent supply tank for the AACM demolition.

The system layout consisted of a flush hydrant equipped with a water meter, gasoline-powered portable-water pump, nitrile rubber weave construction fire hose, ball shutoff nozzle, and in-line foam eductor system. To ensure accurate proportioning (one-percent solution) of the NF-3000 wetting agent, the target operating pressure at the gauge on the inlet to the eductor was 200 psi (range 175 to 225 psi). To assure adequate proportioning, the nozzles were operated in a full-open position. The system was designed and supplied by Kidde Fire Fighting of National Foam Inc. The pump system employed in this study was used for the purpose of the research effort only, and it is not anticipated to be required in any real-world application of the AACM process. It is expected that simple and low-cost in-line eductors operating at typical hydrant pressures would suffice.

The wetting agent application system used during the pre-wetting of the building consisted of a single 90-gpm high-foaming nozzle and matching eductor. This system provided the best foam quality, but had less application range. That is, the maximum reach of the foam from the 90-gpm nozzle was approximately 30 feet, which would not be adequate during demolition of the building.

The wetting agent application system used during demolition employed two matched 30-gpm non-aspirating variable-pattern nozzles and matching in-line eductor (30 gpm at 200 psi design pressure).

Wetting agent proportioning was verified by performing periodic conductivity measurements of the application flow throughout the duration of the AACM demolition process. According to the National Fire Protection Association (NFPA) Standard for Low-, Medium, and High-Expansion Foam (NFPA 11, 2005 Edition), there are two acceptable methods for measuring the wetting agent concentrate in water: (1) Refractive Index Method and (2) Conductivity Method. Both methods are based on generating a baseline calibration curve comparing percent concentrations (of pre-measured foam solutions) to the instrument reading. The method selected for the NF-3000 solution concentration determination for this study was the conductivity method.

As stated previously, the target application strength of the NF-3000 wetting agent was approximately one percent. Therefore, following the procedures contained in the NFPA 11 Standard using the Conductivity Method, three standard solutions were prepared using the hydrant water and the foam concentrate from the application system. The percent concentrations for the three standards were 0.5, 1, and 1.5 based on a target concentration of one percent. The conductivity of each foam solution standard was then measured and a plot created of the foam concentration versus conductivity. Figure 4-22 shows the plot serving as the baseline calibration curve for the test series.

Throughout the duration of the AACM demolition activities, the concentration of the wetting agent was monitored by taking conductivity measurements at a minimum of every four hours as recommended by Kidde Fire Fighting. Sample collection took place after water flowed for enough time to assure a good sample. The real-time sample conductivity measurements were compared with the baseline calibration curve (conductivity versus concentration) shown in Figure 4-22. A summary of the conductivity monitoring is presented in Table 4-4. With the exception of two instances, the resulting concentrations based on conductivity measurements of the application flow show that foam concentrations ranged from 0.81 to 1.26 percent as compared to a target concentration of one percent. This was well within the calibration range of 0.5 to 1.5 percent.

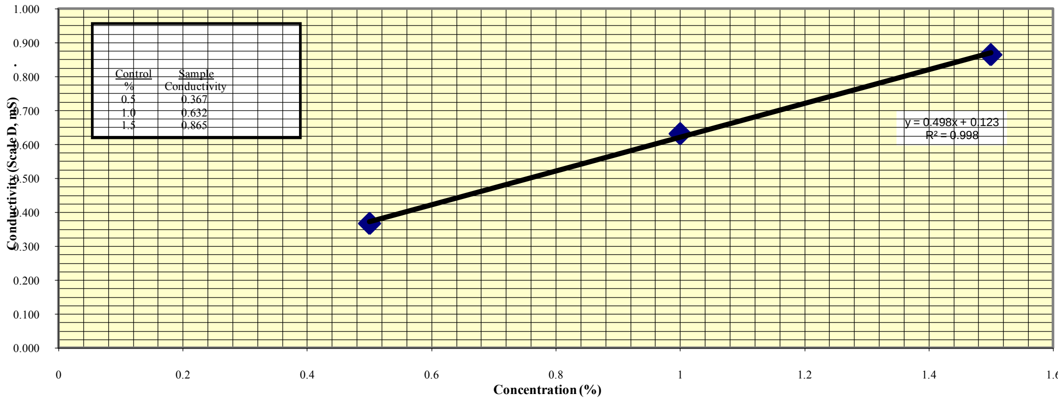

Figure 4-22. Calibration Curve for the NF-3000 Wetting Agent.

Table 4-4. Summary of NF-3000 Quality Monitoring During AACM Demolition Activities.

Date	Time of Measurement (hours)	Number of Nozzles/ Flow Rate, gpm	Conductivity, mS	NF-3000 Concentration (%) [a]	Conductivity, mS	NF-3000 Conc [a] (%)
			Line 1		Line 2	
5/1/06	0743 (L1,L2)	Two/30	0.751	1.26	0.749	1.26
5/1/06	0821 (L1,L2)	Two/30	0.114	-- [b]	0.114	-- [b]
5/1/06	0838	One/90	0.728	1.21	N/A	
5/1/06	1042 (L1,L2) [c,d]	Two/30	0.630	1.02	0.135	0.02
5/1/06	1104 (L1,L2) [e]	Two/30	0.696	1.15	0.648	1.05
5/1/06	1529 (L1) 1523 (L2)	Two/30	0.528	0.81	0.689	1.14
5/1/06	1740 (L1) 1742 (L2)	Two/30	0.741	1.24	0.684	1.13
5/2/06	1448	One/90	0.555	0.87	N/A	

[a] Concentration was calculated based on the calibration curve (conductivity versus concentration) generated for the NF-3000 wetting agent and measured conductivity readings throughout the AACM demolition activities.
[b] Measurements taken at 0821 hours on 5/1/06 indicated problems with the 30-gpm (1.5-inch line) eductors causing non-foam proportioning. The two 30-gpm lines were replaced with the alternate 90-gpm foam nozzle and in-line eductor while investigating the problem.
[c] 30-gpm (1.5-inch line) eductors back in use, replacing the alternate 90-gpm foam nozzle and in-line eductor.
[d] Measurements taken at 1042 hours on 5/1/06 indicated that the Line 1 (30-gpm) eductor was working properly (as evidenced by the resulting conductivity and concentration readings); however measurements from the Line 2 eductor showed non-foam proportioning. Samples from both lines were retaken at 1104 hours.
[e] Measurements retaken at 1104 hours on 5/1/06 indicated that both 30-gpm eductors were operating properly (as evidenced by the resulting conductivity and concentration readings). It was speculated that the non-foam proportioning occurring with Line 2 at 1042 hours was due to the nozzle not being fully opened during operation.

4.4.2.2 AACM Pre-Wetting

The AACM building (#3607) was pre-wetted on April 30, 2006, the evening before the demolition. The interior of the building was wetted first using the 90-gpm foaming nozzle (Figure 4-23 through Figure 4-27). This part of the pre-wetting process required 17 minutes. Respiratory protection was worn by the worker because of the mild acute irritancy of the amended water. After the interior was wetted, the amended water was applied to the attic, alternately through the gable vents at both ends of the building. The attic wetting took about 22 minutes per gable or 45 minutes total for the attic. The amended water was quite effective in soaking through the drywall joints, particularly in the ceiling. By the next morning (about 12 hours later), several sections of drywall ceiling had collapsed into the rooms.

On the day of the demolition (May 1, 2006), the attic was rewetted through the gables with the amended water (taking about seven minute per gable or 15 minutes total) and the interior of the structure was re-wetted by knocking out the windows and spraying the rooms from the exterior (requiring an extra ten minutes). The 90-gpm foaming nozzle was used for this rewetting. Figure 4-28 illustrates this process. The amended water was dripping from several areas beneath the building and from beneath the doors.

In total, the pre-wetting process required roughly an hour (62 minutes) on the day before the demolition and a half-hour (25 minutes) on the day of the demolition.

4.4.2.3 AACM Demolition Phase

The demolition of the AACM building was conducted on May 1, 2006. Amended water was used continuously during the demolition and truck-loading operations. Two 30-gpm nozzles were used to apply the amended water during demolition of the building and debris loading activities. A standard garden hose (approximately four gpm of hydrant water) was used to wash the trucks before they left the containment (bermed) area.

The trucks hauling the AACM debris to the landfill were lined with two layers of six-mil polyethylene. This lining process took about five minutes per truck.

After loading of the debris, the two layers of plastic were folded together over the top of the truck bed and sealed with tape into a burrito-wrap configuration. This closing and sealing process required an average of approximately seven minutes per truck.

Some brief but easily surmountable complications were encountered during this AACM demolition. First, the application rate of the wetting agent during the first 15 to 30 minutes of the demolition was indeterminable because a leak developed in the wetting agent eductor for the 30-gpm nozzles, breaking the suction on the eductor. The 90-gpm nozzle was substituted for the two 30-gpm nozzles for about a 30-min period of demolition, until the cause of the leak could be remedied (tightened the nozzles as they were drawing air rather than wetting agent) and the two

Figure 4-23. Pre-wetting with Amended Water.

Figure 4-24. Pre-wetting the hallway with Amended Water.

Figure 4-25. Pre-wetting the attic with Amended Water.

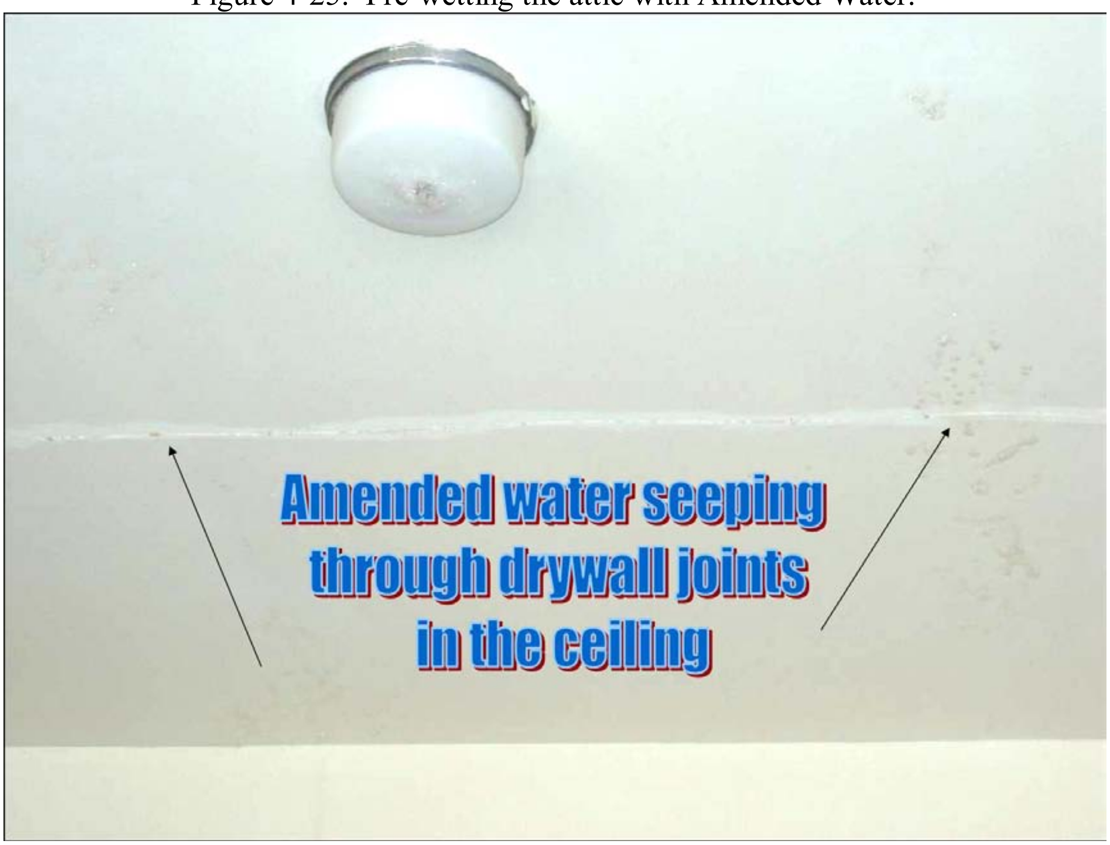

Figure 4-26. Amended Water seeping through ceiling drywall joints.

Figure 4-27. Amended Water seeping through wall openings.


Figure 4-28. Wetting through openings on the day of the AACM demolition.

30-gpm nozzles and matched eductor were returned to service. Secondly, about a one-hour delay was encountered while resolving paper manifest issues with the trucks hauling the debris to the landfill. During this delay, the pump overheated because no water was flowing and ruptured a plastic pressure line. This was repaired on site in about 15 minutes. Demolition was halted during these periods.

There were several periods where the demolition was halted awaiting trucks to return from the landfill as several previous days of rain at the landfill caused the first truck in line to get stuck.

The AACM building was demolished by approximately 6:00 pm of the first day (May 1) and the concrete piers were removed, washed, and stockpiled at the site, leaving a single concrete box/pier and a small amount of residual debris to be removed the following day.

On the following day (May 2), it rained in the morning so all work was halted. In the afternoon, the remaining stockpiled concrete, the concrete box/pier, and the small debris were removed from the site and taken to the landfill. The post-demolition soil sampling was completed, which required about four hours. The amended water was extremely effective in wetting the soil and keeping it wet, making soil sampling quite difficult.

Also, some pooled water had saturated the berm and seeped below it in a couple of spots and created a wetted area about four feet outside the berm on the downhill side (rear) of the site. This water was sampled.

The morning rain, which re-wetted the area, made soil sampling increasingly difficult. This extended the time required for post-demolition soil sampling and delayed the final soil excavation until the following day (May 3). The soil excavation took approximately two hours and then the post-excavation soil sampling was conducted, taking almost five additional hours to complete.

No visible emissions were observed during the entire AACM demolition/soil removal process.

If soil sampling and the aforementioned complications had not delayed the project, the demolition and soil removal for the AACM building would have been completed in a single day, taking a couple of hours longer than the demolition of the NESHAP building.

Under normal circumstances, the extra time to implement the AACM would include:

- lining the trucks (five minutes/truck),
- sealing the burrito wrap (seven minutes/truck), and
- excavating/removing the soil (approximately two hours).

Figure 4-29 through Figure 4-37 document the AACM demolition process.

Figure 4-29. Double-lining the trucks for hauling of the AACM debris (View 1).

Figure 4-30. Double-lining the trucks for hauling of the AACM debris (View 2).

Figure 4-31. Starting the AACM demolition.

Figure 4-32. Progressing with the AACM demolition.

Figure 4-33. Loading the AACM demolition debris.

Figure 4-34. Sealing the ―burrito wrap” before leaving the AACM site.

Figure 4-35. Washing the trucks with water before leaving the site.


Figure 4-36. Nearing the completion of the AACM demolition.


Figure 4-37. An aerial view nearing completion of the AACM demolition.

SECTION 5 SAMPLING AND ANALYTICAL METHODOLOGY

5.1 Sampling Method Requirements

5.1.1 Perimeter Air Sampling for Asbestos/Total Fibers

The samples for both asbestos and total fibers analysis were collected on the same open-face, 25-mm-diameter 0.45-µm pore size mixed cellulose ester (MCE) filters with a 5-µm pore size MCE diffusing filter and cellulose support pad contained in a three-piece cassette with a 50-mm conductive cowl. This design of cassette has a longer cowl than the design specified in ISO 10312:1995, but it has been in general use for some years for ambient and indoor air sampling. Disposable filter cassettes with shorter conductive cowls, loaded with the appropriate combination of filter media of known and consistent origin, do not appear to be generally available.

The filter cassettes were positioned on a sampling pole that accommodated cassette placement at five feet and 15 feet above ground. The filter face was positioned at approximately a 45-degree angle toward the ground. At the end of the sampling period, the filters were turned upright before being disconnected from the vacuum pump, capped, and then stored in this position.

The filter assembly was attached with flexible Tygon® tubing (or an equivalent material) to an electric-powered (110-volt alternating current) 1/10-hp vacuum pump operating at an airflow rate of approximately four liter/min. An air volume of 1,920 to 2,400 liters was targeted for all samples. Each pump was equipped with a flow-control regulator and individually-calibrated rotameter to measure and maintain the initial flow rate of four liter/min to within +/- 10% throughout the sampling period. The target flow rate for each pump was demarcated on the rotameter, checked approximately every two hours throughout the sampling period, and adjusted if required. Lower volume samples (960-1,200 liters) from the same locations were also collected and archived.

5.1.2 Personal Breathing Zone and Work Area Sampling for Asbestos/Total Fibers and Lead

Asbestos/Total Fibers—Personal breathing zone and work area samples were collected on open-face, 25-mm-diameter 0.8-µm pore size MCE filters with a cellulose support pad contained in a 3-piece cassette with a 50-mm conductive cowl. The filter assembly was attached to a constant-flow, battery-powered vacuum pump operating at a flow rate of either one or two liters per minute. An air volume of approximately 480 to 960 liters was targeted for these samples.

Lead—Personal breathing zone and work area samples were collected on closed-face, 37-mm-diameter 0.8-µm pore size MCE filters with a cellulose support pad contained in a three-piece cassette. The filter assembly was attached to a constant-flow, battery-powered vacuum pump operating at a flow rate of two liter/min. An air volume of 960 to 1,200 liters was targeted for these samples.

5.1.3 Total Particulate Sampling

Fixed-station area air samples were collected on closed-face, tared 37-mm diameter 5-µm pore size polyvinyl chloride (PVC) filters with a cellulose support pad contained in a three-piece cassette. The filter assembly was attached to a constant-flow, battery-powered vacuum pump operating at a flow rate of two liters per minute. An air volume of 960 to 1,200 liters was targeted for all samples.

5.1.4 Meteorological Monitoring

Two portable meteorological stations manufactured by Met One Instruments, Inc., and equipped with AutoMet Sensors (or equivalent instruments) were used to record five-minute average wind speed and wind direction data, as well as temperature, barometric pressure, and relative humidity. A meteorological station was installed at both the Fort Chaffee demolition site and the City of Fort Smith Landfill. The data files were downloaded and archived using an on-site personal computer. Periodic (at least hourly) direct readout of the data was recorded on a Meteorological Measurement Log. The wind speed and wind direction sensors of the meteorological station located at the landfill malfunctioned during the study. Fortunately, the Fort Smith Airport Weather Station was about 1000 ft away and the meteorological data were obtained from this station and were used for the disposal portion of the study.

5.1.5 Asbestos Soil Sampling

For each of the soil sampling events described previously, the area within the containment berm was evenly divided into a ten-block grid system. Each block was approximately 35 ft by 32 ft. Three random grab samples were collected from each block and composited to form an “interleaved” composite to represent the entire footprint of the bermed area. This process was repeated ten times to provide ten “interleaved” composite samples. Each of the ten interleaved samples was therefore a composite of 30 grab samples; the entire sampling process produced ten final interleaved composites from 300 grab samples. Each grab sample was collected from an area measuring six-inches by six-inches with approximately a ½-inch depth. The area was delineated using a metal template, which helped ensure that each component of the ten-part composite sample was of similar mass. Rocks and organic material (e.g., roots) larger than ⅜-inch were excluded.

The grab samples were collected using a clean metal scooping tool (e.g., a garden trowel) and placed in a clean one-gallon metal container with lid (Figure 5-1). The 30 grab samples were composited in a two-gal plastic container for shipment to the laboratory. Between collections of each sample, the template and trowel were cleaned with detergent water.


Figure 5-1. Soil sampling after the NESHAP demolition.

5.1.6 Settled Dust Sampling

Settled dust samples for asbestos analysis were passively collected using ASTM Method D 1739-98 *"Method for Collection and Measurement of Dustfall (Settleable Particulate Matter)."* The collection container was an open-topped cylinder approximately six inches in diameter with a height of 12 inches. The container was fastened to the same sampling pole as the air samples at a height of five feet above the ground. The sampling time for the ASTM protocol was extended one hour beyond the end of demolition activity. Upon completion of sampling, the dust collection container was capped and sealed for shipment to the laboratory.

5.1.7 Water Sampling—Flush Hydrant, Amended Water, and Pooled Surface Water

The sample container was an unused, one-liter pre-cleaned, screw-capped amber glass bottle. Prior to sample collection, the water from the water source was allowed to run for a sufficient period to ensure that the sample collected was representative of the source water.

Approximately 800 milliliters of water for each sample were collected. An air space was left in the bottle to allow efficient re-dispersal of settled material before analysis. A second bottle was

Figure 5-2. Sampling pooled water.

collected and stored for analysis if confirmation of the results obtained from the analysis of the first bottle was required.

The samples were transported to the laboratory and filtered by the laboratory within 48 hours of sample collection. No preservatives or acids were added. At all times after collection, the samples were stored in the dark at about 5° C (41° F) in order to minimize bacterial and algal growth. The samples were not allowed to freeze because the effects on asbestos fiber dispersions are not known. On the same day of collection, the samples were shipped in a cooler at about 5° C (41° F) to the lab for analysis via one-day courier service. Figure 5-2 shows the collection of pooled water.

5.2 Analytical Methods

5.2.1 Air Samples (TEM)

Perimeter Samples—The 0.45-µm pore size MCE air sampling filters were prepared and analyzed using ISO Method 10312:1995, *Ambient Air - Determination of Asbestos Fibres - Direct-Transfer Transmission Electron Microscopy Method.*" Note: After TEM analysis, a sector from the same filter was then analyzed using PCM.

Personal Samples— The 0.8-µm pore size MCE air sampling filters were prepared and analyzed using ISO Method 10312:1995, *Ambient Air - Determination of Asbestos Fibres - Direct-Transfer Transmission Electron Microscopy Method.*" Note: After TEM analysis, a sector from the same filter was then analyzed using PCM.

5.2.1.1 TEM Specimen Preparation

TEM specimens were prepared from the air filters using the dimethylformamide (DMF) collapsing procedure of ISO 10312:1995, as specified for cellulose ester filters. DMF was used as the solvent for dissolution of the filter in the Jaffe washer. For each filter, a minimum of three TEM specimen grids were prepared from a one-quarter sector of the filter using 200 mesh-indexed copper grids. The remaining part of the filter was archived in the original cassette in clean and secure storage.

5.2.1.2 Measurement Strategy

1. The minimum aspect ratio for the analyses was 3:1, as permitted by ISO 10312:1995. As required in the ISO method, any identified compact clusters and compact matrices were counted as total asbestos structures, even if the 3:1 aspect ratio was not met.

2. Table 5-1 presents the size ranges of structures that were evaluated, and target analytical sensitivities for each TEM method. The laboratories adjusted individual numbers of grid openings counted based upon the counting rules, the amount of material prepared for each sample, and the air volume, as applicable.

3. The structure counting data was distributed approximately equally among a minimum of three specimen grids prepared from different parts of the filter sector.

4. The TEM specimen examinations were performed at approximately 20,000x magnification.

5. PCM-equivalent asbestos structures, as defined by ISO 10312:1995, were also determined.

6. The type of structure was specified. In addition to classifying structures as one of the six NESHAP-regulated asbestos types, any other amphibole mineral particles meeting the aspect ratio of ≥3:1 and lengths ≥0.5 µm) were required to be recorded, if present (e.g., winchite, richterite). **However, none of these non-regulated amphiboles were observed.** Reference to or implication of use of either of the terms cleavage fragments and/or discriminatory counting did not apply.

Table 5-1. Number of TEM grid openings to achieve target analytical sensitivity.

Method	**Structure Size Range**	**Target Analytical Sensitivity**	**Approximate Magnification for Examination**	**Approximate Grid Area Examined, mm²**	**Approximate Number of 0.01-mm² Grid Openings Required**
ISO 10312:1995 Perimeter Air Direct Preparation	All Structures (minimum length of 0.5 µm; aspect ratio ≥3:1)	0.0005 s/cc	20,000x	0.32 based on air Volume of 2,400 L	32
ISO 10312:1995 Worker Air Direct Preparation	All Fibers (minimum length of 0.5 µm; aspect ratio ≥3:1)	0.005 f/cc	10,000x	0.16 based on air Volume of 480 L	16
EPA/600/R-93/116, 1993 Soil	All Structures (minimum length of 0.5 µm; aspect ratio ≥3:1)	0.1%	20,000x	0.1	10
ASTM D 5755-03 – Settled Dust	All Structures (minimum length of 0.5 µm; aspect ratio ≥3:1)	250 s/cm²	20,000x	0.1 based on filter area of 923 mm² and 100 ml of 500 ml filtered	10
EPA 100.2 Water, Flush Hydrant, and Pooled Surface Water	All Structures (minimum length of 0.5 µm; aspect ratio ≥3:1)	0.05 million s/L Hydrant 2 million s/L Surface	20,000x	0.37 based on filter area of 923 mm² and 50 ml filtered; 0.46 based on filter area of 923 mm² and 1 ml filtered	37 46

5.2.1.3 Determination of Stopping Point

The analytical sensitivity and detection limit of microscopic methods (such as TEM and PCM) are a function of the volume of air drawn through the filter and the number of grid openings or fields counted. In principle, any required analytical sensitivity or detection limit can be achieved by increasing the number of grid openings or fields examined. Likewise, statistical uncertainty around the number of fibers observed can be reduced by counting more and more fibers. Stopping rules are needed to identify when microscopic examination should end, both at the low end (zero or very few fibers observed) and at the high end (many fibers observed). Table 5-2 identifies the stopping rules used for this study.

Table 5-2. Stopping rules for asbestos counting.

Method	Stopping Rules
TEM (ISO 10312:1995) Perimeter air	Count a minimum of 10 grid openings. If ≥10 structures are identified, counting is stopped. If < 10 structures are identified, count until 10 structures are identified or the required number of grid openings to achieve an analytical sensitivity of 0.0005 asbestos structures/cm^3.
TEM (ISO 10312:1995) Worker air	Count a minimum of 10 grid openings. If ≥10 structures are identified, counting is stopped. If < 10 structures are identified, count until 10 structures are identified or the required number of grid openings to achieve an analytical sensitivity of 0.005 asbestos structures/cm^3.
PCM (NIOSH 7400) Perimeter air	100 fields are viewed or 100 fibers are counted (but not less than 10 fields must be counted).
EPA/600/R-93/116, 1993 Soil	TEM--Terminate fiber count at a minimum of 100 fibers or 10 grid openings (whichever occurs first), providing that an analytical sensitivity of 0.1% has been achieved. If not, continue until this analytical sensitivity has been achieved. Always complete the structure count for the last grid opening evaluated. PLM—Sample is point counted until 0.1% sensitivity has been achieved.
ASTM D 5755-03 Settled Dust	Terminate fiber count at a minimum of 100 fibers or 10 grid openings (whichever occurs first), providing that an analytical sensitivity of 250 s/cm^2 has been achieved. If not, continue until this analytical sensitivity has been achieved. Always complete the structure count for the last grid opening evaluated.
EPA 100.2 Water	Terminate fiber count at a minimum of 100 fibers or 10 grid openings (whichever occurs first), providing that an analytical sensitivity of 0.05 million s/L or 2 million s/L depending on water source has been achieved. If not, continue until this analytical sensitivity has been achieved. Always complete the structure count for the last grid opening evaluated.

5.2.2 Air Samples (PCM)

Perimeter Samples—The 0.45-µm pore size MCE air sampling filters were prepared and analyzed for total fibers using NIOSH Method 7400 –*Asbestos Fibers by PCM*" (A Counting Rules). Fibers greater than five µm in length and with an aspect ratio greater than 3:1 were counted.

Personal Samples—0.8-µm pore size MCE air sampling filters were prepared and analyzed for total fibers using NIOSH Method 7400 –*Asbestos Fibers by PCM*" (A Counting Rules). Fibers greater than 5 µm in length and with an aspect ratio greater than 3:1 were counted.

The applicable stopping rules in Section 5.2.1.3 were used.

5.2.3 Air Samples (Lead)

The 0.8-µm pore size MCE air sampling filters were prepared and analyzed for inorganic lead using NIOSH Method 7300 –Elements by ICP *(Nitric/Perchloric Acid Ashing)."*

5.2.4 Soil Samples

5.2.4.1 Soil Preparation

The composite soil samples were shipped to the laboratory where the samples were dried, homogenized, and evenly split for total asbestos analysis (PLM and TEM) and for soil elutriation tests.

The laboratory processed the samples as follows:

- All sample preparation was conducted under a negative air ventilation hood with a HEPA filter. Samples were weighed to the nearest 0.1g prior to and after the every step of the preparation process.

- Using ASTM 2540G, moisture content was first determined. Then, using flat dishes, the sample was spread out as much as possible to maximize surface area. The wet soil was manually reduced to pieces < ¾ inch in size. Samples were dried in a convection oven at 60ºC for a period of 24-48 hours, or until a constant weight was obtained. A constant weight was determined when less than 4% of the previous weight or 0.5mg was lost.

- If necessary, large chunks of the dried soil were reduced to < ¾ inch in size. If rocks or organics were observed, these were removed and if present the mass and asbestos type and percentage were documented. If pieces of building materials were observed, these were removed and analyzed by PLM, and if present the mass and asbestos type and percentage were documented.

- The remaining sample was transferred to its original clean air-tight heat dried container until it was transferred to a riffle splitting facility in the Port Orchard EPA laboratory.

- Using the riffle splitter, the sample was distributed into two receiving pans. One pan was immediately returned to its original container (¾ of original). This portion was archived and stored if reanalysis was necessary. The second pan was further split to create a portion to be used for elutriation (~one liter in size) and a portion to be used for PLM/TEM (~one liter in size). Each portion was weighed and its dry weight recorded on the prep sheet. These portions were coned and quartered to generate optimal sample sizes for elutriation (~40-60 grams) and PLM/TEM (~20 grams). These sample portions were transferred to clean airtight bottles.

5.2.4.2 Soil Analysis (TEM and PLM)

Soil samples were prepared and analyzed for asbestos using EPA's ―*Method for the Determination of Asbestos in Bulk Building Materials*" (EPA/600/R-93/116, July 1993). The following approach was used to prepare the samples for analysis:

- As described in Section 5.2.4.1, after the samples were dried and homogenized, large rocks/organics and building debris were removed and weighed. Confirmation of asbestos type and concentration was done by PLM analysis. Representative portions of the remaining soil were then prepared for analysis for both PLM and TEM.

- The soil sample was ground and homogenized, using a standard plate grinder, to a particle size of approximately 250 micrometers. The soil sample was concentrated using gravimetric reduction by ashing and hydrolysis. A portion of the ground sample was weighed and ashed in a muffle furnace for one hour at 250˚C and for four hours at 480˚C. After weighing the ashed sample, it was then hydrolyzed in concentrated hydrochloric acid, ground lightly for one minute using a mortar and pestle, filtered onto tared MCE filters, and weighed. The gravimetric reduction ratio (GRR) was calculated.

A representative portion of the residue was point-counted using PLM by placing it on a slide, and counting until 0.1-weight percent sensitivity was achieved (1000 points).

Another representative portion of residue was prepared for TEM analysis. The residue was suspended in water, acidified to approximately pH 3 with acetic acid, hand shaken for 30 seconds, sonicated for three minutes, hand shaken for another 30 seconds, and allowed to settle for two minutes. A range of aliquots was pipetted onto MCE filters to ensure optimal loading. The filters were prepared for asbestos analysis using a direct transfer preparation. The required grid openings were analyzed evenly over a minimum of two grids. Results in structures/gram (s/g) were reported.

The measurement strategy and stopping rules provided in Section 5.2.1.2 and 5.2.1.3 were used, as applicable to soils.

5.2.4.3 Elutriation

Soil samples were prepared as described in EPA 540-2-90-005, *Modified Elutriator Method for the Determination of Asbestos in Soils and Bulk Materials* (Revision 1). The elutriated air samples were analyzed by TEM using ISO Method 10312:1995.

The method involves placing an approximately 60 g (weighed) sample in a tumbler (one-inch square cross section), passing constant humidity air over the sample while tumbling (to pick up entrainable dust), separating out the respirable fraction[4] of dust in a vertical elutriator, and depositing the resulting dust on a pre-weighed polycarbonate filter, which is re-weighed (to determine the quantity of dust deposited) and prepared (using a direct transfer procedure) for analysis by TEM (ISO 10312:1995) for the determination of asbestos. Results are reported as the number of asbestos structures per gram of respirable dust (s/gPM_{10}).

5.2.5 Settled Dust Samples (TEM)

The analytical sample preparation and analysis for asbestos followed ASTM Standard D5755-03 –*Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading*", modified as described in the following discussion. The sample collection container was rinsed with approximately 100 ml of 50/50 mixture of particle-free water and reagent alcohol using a plastic wash bottle. The suspension was poured through a 1.0 by 1.0 mm opening screen into a pre-cleaned 500 or 1000 ml specimen bottle. All visible traces of the sample contained in the collection device were rinsed through the screen into the specimen bottle. The washing procedure was repeated three times. The volume of the suspension in the specimen bottle was brought to 500 ml with particle free water. An aliquot of this suspension was filtered onto a MCE filter. These filters were prepared and analyzed using ISO 10312:1995.

The measurement strategy and stopping rules provided in Section 5.2.1.2 and 5.2.1.3 were used, as applicable to settled dust.

5.2.6 Water Samples

The asbestos content of the water samples was determined using EPA Method 100.2 –*Analytical Method Determination of Asbestos in Water.*" The method was modified to count all structures greater than or equal to 0.5 µm in length and with an aspect ratio of greater than or equal to 3:1.

The measurement strategy and stopping rules provided in Section 5.2.1.2 and 5.2.1.3 were used, as applicable to water

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4 The respirable fraction is composed of respirable dust. Respirable dust is defined as the set of structures exhibiting an aerodynamic equivalent diameter (AED) less than or equal to 10 µm, which is captured by devices designed to extract what is termed the –PM_{10}" fraction of particulate matter. The AED of a particle is the diameter of a sphere of unit density that exhibits the same settling velocity in air as that of the actual particle.

SECTION 6 RESULTS

The results obtained for samples collected during the demolition (Section 6.1) and landfill activities (Section 6.2) are provided in this section, including process monitoring. Detailed statistical discussions are provided in Section 7. Only the results from the closest ring of samplers (Ring 1) were used for the statistical comparisons because modeling indicated that the samplers closet to the demolition had the highest probability of detecting releases. The cost analysis is provided in Section 8.

The vast majority of airborne asbestos data yielded non-detects at very low limits of detection. It was initially anticipated that a value of one-half the analytical sensitivity would be substituted for those values that were less than the analytical sensitivity. Further comparisons would then be made substituting additional variants below the analytical sensitivity to evaluate the effect of the substituted value. Overall, close to 90 percent of the air samples for asbestos during the demolitions were non-detect at 0.0005 s/cm^3 analytical sensitivity. All but one were at or below the limit of detection of 0.0015 s/cm^3 (2.99 times the analytical sensitivity); the one concentration above the limit of detection was 0.0019 s/cm^3.

In asbestos analyses, one either sees and counts asbestos structures in a specified number of grid openings or sees none (zero). In the case of non-detects, zero asbestos structures were seen in the grid openings observed. The use of one-half the analytical sensitivity would reflect that one-half of a structure was seen, when in fact, none was seen. In an 18-sample set (as in Ring 1 for example), the addition of one-half structure per sample for 16 non-detects would artificially add the observance of eight asbestos structures (again when none were observed); therefore, for the purpose of descriptive statistics, zero was used for non-detects. For inferential statistical analyses, the zeros don't adversely affect non-parametric tests which were used in this evaluation. Also, tests of significance using the ―censored data" approach were considered but not employed because of the extreme proportion of non-detects (Helsel 2006).

The ISO 10312:1195 protocol suggests reporting conventions for asbestos measurements that include the 95-percentile upper and lower confidence levels for any observed asbestos structure count. Table F.1 in the ISO 10312 suggests the following reporting convention for the structure counts observed in the air samples in this study as shown in Table 6-1.

Since the lower confidence limits are less than one for structures counts from zero to three, ISO recommends the use of reporting less than the corresponding one-sided 95-percent confidence limits rather than the calculated concentration. In this study, the ISO reporting convention was not strictly adopted as it was believed that reporting the individual observed concentrations was a more comprehensive approach. With the caveats of ISO reporting methodology, any conclusions that are based upon counts less than four, as almost all the ones in this study were, should be used with some caution as there is probably no real difference between these numbers.

Table 6-1. ISO 10312:1995 Reporting Convention for Structure Counts Between Zero and Four

Structure Count	95-% Confidence Lower Limit	95-% Confidence Upper Limit
0	0	3.689
1	0.025	5.572
2	0.242	7.225
3	0.619	8.767
4	1.090	10.242

To summarize:

- For descriptive statistics, a value of zero was substituted for non-detects.
- In cases where there were less than five-percent non-detect data and substituting one-half the analytical sensitivity would not affect the conclusions of the inferential test, the parametric methods proposed in the QAPP were employed. In those cases, one-half the analytical sensitivity was used.
- In cases where there were between five- and 90-percent non-detect data, nonparametric methods based on ranks and adjusted for ties were employed.
- In cases where there were greater than 90-percent non-detect data for either method, no statistical analyses were conducted.

6.1 Demolitions

6.1.1 Meteorology

Late April-early May weather in Arkansas, like elsewhere, is unpredictable. Rain loomed throughout the study and the AACM demolition was delayed for several days for the uncertainty of rain. However, no rain occurred during sampling or demolition of either building. Rain was encountered one morning following the AACM demolition but prior to the removal of the concrete structures and small residual debris from the site, which delayed the effort one half day. The rainfall history during the demolition of the buildings is graphically presented in Figure 6-1.

It is clear that both demolitions had significant rain events of approximately one inch of rainfall preceding the demolition. The disadvantage that the AACM building had was that it was down-gradient from the NESHAP building. Therefore, the rain on April 25, plus the wetting during the NESHAP demolition on April 26, plus the rain on April 28 and 29, saturated the soil for the AACM building demolition on May 1.

The wind rose for the NESHAP demolition is shown in Figure 6-2 and the wind roses for the AACM demolition are presented in Figure 6-3 for the demolition and in Figure 6-4 for the soil removal as those activities took place on separate days. For each wind rose, the wind is blowing *from* the indicated direction. For example, in Figure 6-2, the dominant wind direction is from the southwest at one to four mph. In general, the winds were mild for all events, generally blowing from the south/southwest at less than seven mph. The descriptive statistics for wind speed are presented in Table 6-2.

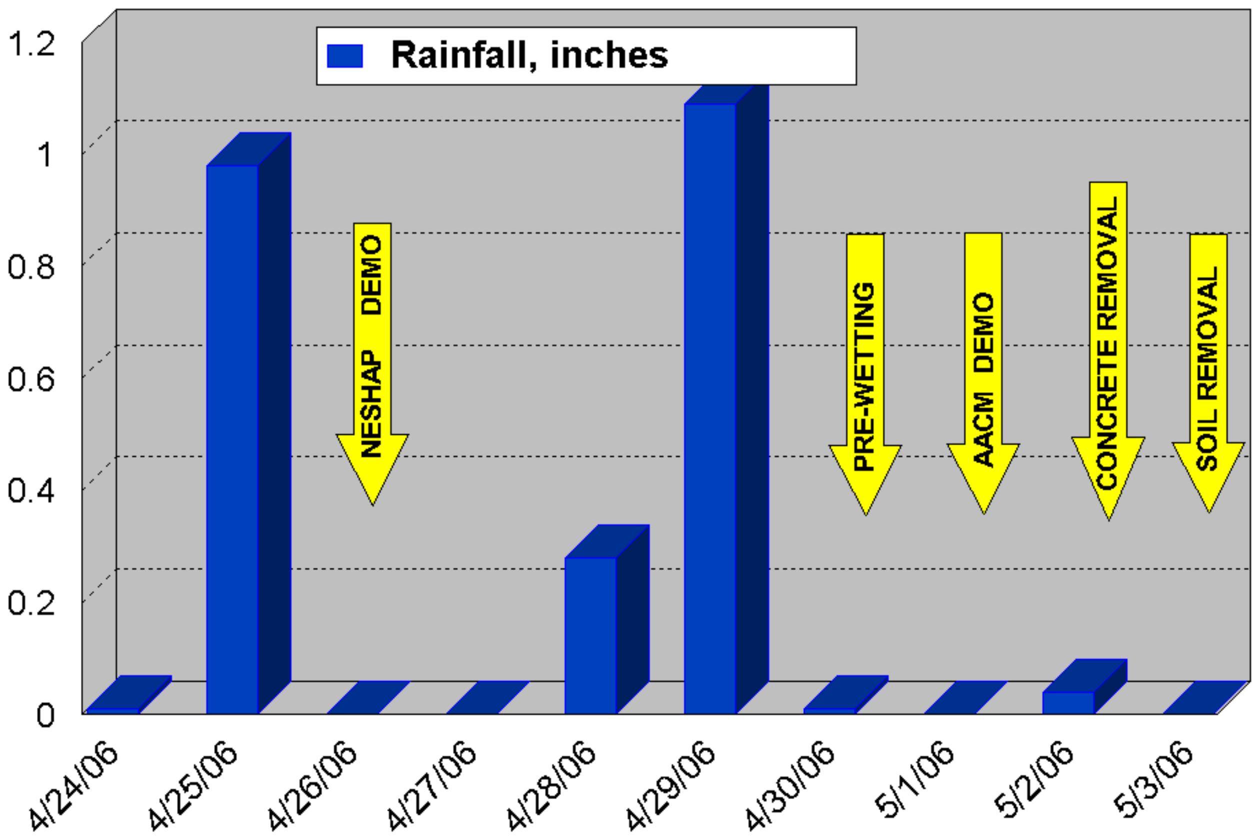

Figure 6-1. Rainfall history at the Fort Chaffee project site during the study.

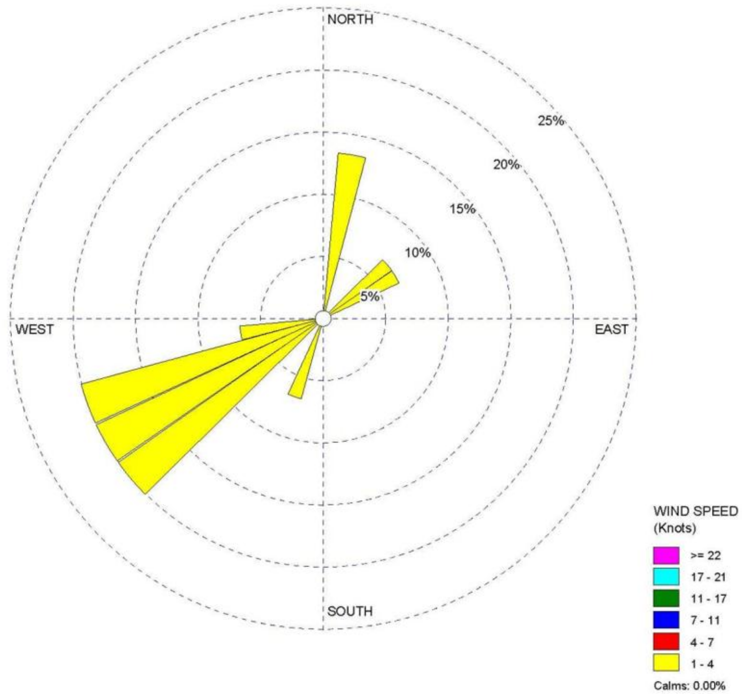

Figure 6-2. Wind rose during the hours of the NESHAP building demolition.

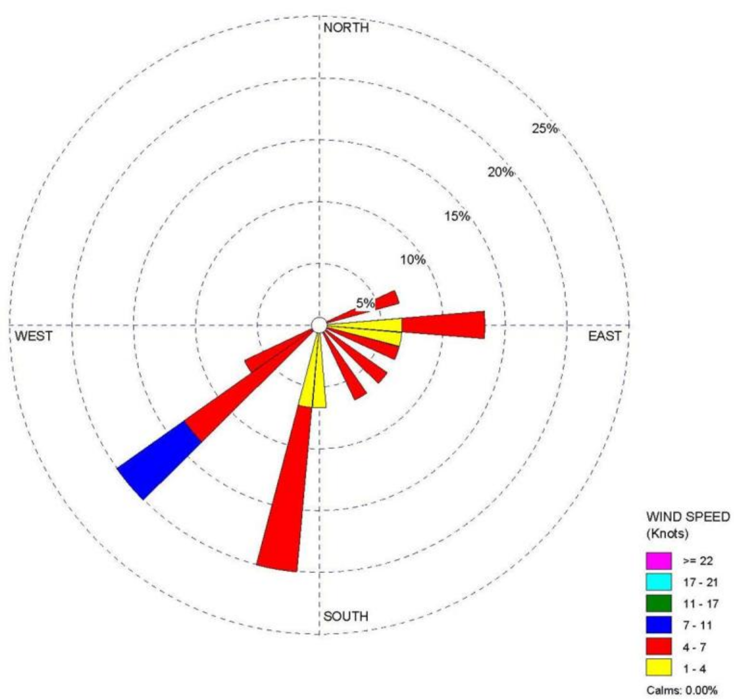

Figure 6-3. Wind rose during the hours of the AACM building demolition.

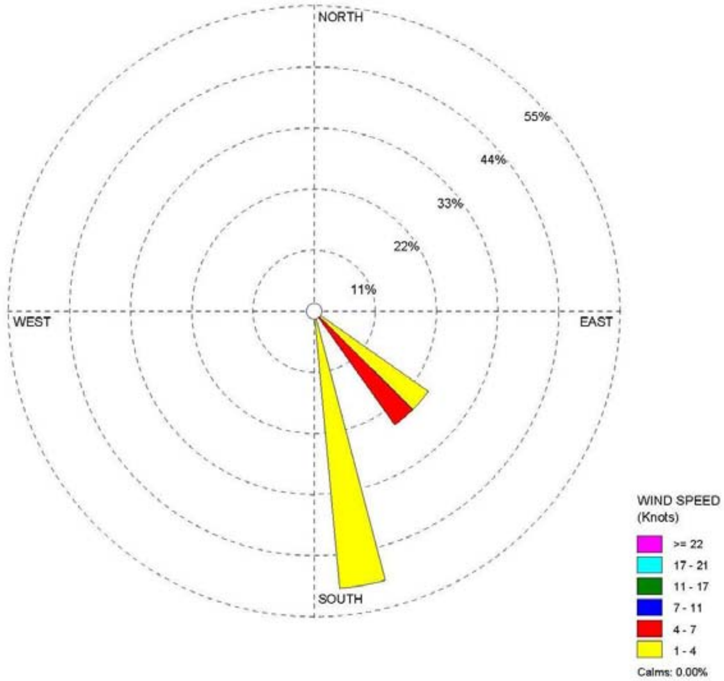

Figure 6-4. Wind rose during the hours of the AACM building soil removal.

Table 6-2. Descriptive Statistics for Wind Speed

Mean Wind Speed, mph	Min Wind Speed, mph	Max Wind Speed, mph
NESHAP Building – Day 1		
3.1	2.3	3.8
AACM Building – Day 1		
4.7	2.7	7.1
AACM Building – Day 2		
3.6	1.3	3.8
AACM Building – Total for Both Days		
4.2	1.3	7.1

6.1.2 Perimeter Air

6.1.2.1 Asbestos in Air Samples

6.1.2.1.1 Background Air

All of the background samples showed that the asbestos concentration was below the analytical sensitivity (<0.00049 s/cm^3). The individual sampling results are contained in Table A-4 of

Appendix A. These levels are consistent with the pre-study assessment samples done several months earlier and shown in the same table.

The Health Effects Research Institute-Asbestos Research (1991) reported “average concentrations on the order of 0.00001 f/mL for outdoor rural air (except near asbestos-containing rock outcroppings) and average concentrations up to about 10-fold higher in the outdoor air of urban environments” for asbestos fibers longer than five microns (essentially PCME structures). In naturally-occurring asbestos areas such as California, the ambient levels can range from eight to 80 PCME fibers per cubic meter (0.008 s/cm^3) at Sonora to 50 to 500 PCM(E) fibers per cubic meter (0.005 to 0.080 s/cm^3) at South Gate (California Air Resources Board, 1986). EPA reported urban ambient concentrations ranging from non-detect to 0.008 s/cm^3 for PCME-type asbestos structures (Chesson 1985).

6.1.2.1.2 Demolition Air

Table 6-3 presents the descriptive statistics for the airborne asbestos concentrations measured during demolition of the NESHAP building, and demolition and soil removal from the AACM building. The individual sample results for the NESHAP building are contained in Table A-2 of Appendix A. The individual sample results for the AACM building are contained in Table A-3 of Appendix A. The individual asbestos concentrations are illustrated in Figure 6-5. One sample was inadvertently not removed and replaced at the end of Day 1 but operated for the duration of all sampling activities. Since no asbestos was detected for this sample, it was assumed that the results for this location for Day 1 and Day 2 were also non-detect.

In each grouping of samples presented in Figure 6-5, the samples are in numerical order in the manner in which the samplers were placed around the buildings (Figure 4-1). That is, the first sample in each group of 18 corresponds to the location on the front right (northwest) corner of the building and then were numbered in a clockwise fashion around the structures. The trucks were loaded along the front of the building as the demolitions progressed (samples one through seven in each grouping). Visually, there does not appear to be any correlation between sample location and the small concentrations of asbestos observed in the air samplers. The wind was generally blowing from the front left to the rear right (from the south-southwest) of the buildings.

For the AACM, the demolition was completed on the first day (Day 1). Air sampling for asbestos/total fibers was halted and the filters were capped and removed for analysis. Concrete structures and some small residual debris remained. On the second day, removal of the concrete structures and remaining debris and the subsequent soil sampling was delayed until the afternoon because of rain. Prior to the initiation of Day 2 activities, to assure no filter overloading, new filters were positioned for asbestos/total fiber sampling. Due to the rain, concrete/debris removal, and the subsequent soil sampling which required a significant amount of time, soil excavation was delayed until the third day. The asbestos/total fiber filters were capped overnight and during periods of inactivity on Days 2 and 3. These samples, which reflect AACM activities over the second and third day, are referred to as Day 2 samples. The settled dust samplers and particulate filters were positioned for the entire duration of the AACM study and capped overnight and during periods of inactivity.

Table 6-3. Airborne asbestos (TEM) during demolition of NESHAP and AACM buildings.

Sample Location (Position and Height)		Total Asbestos n/N[a]	Total Asbestos: Asbestos Structures Counted, Total per ring and max per filter	Total Asbestos: Mean[b] (s/cm^3)	Total Asbestos: Min (s/cm^3)	Total Asbestos: Max (s/cm^3)	PCME Asbestos n/N[a]	PCME Asbestos: Asbestos Structures Counted, Total per ring and max per filter	PCME Asbestos: Mean[b] (s/cm^3)	PCME Asbestos: Min (s/cm^3)	PCME Asbestos: Max (s/cm^3)
NESHAP Building – Day 1											
Ring 1	5-ft	1/18	1 total 1 max	0.00003	0	0.00049	1/18	1 total 1 max	0.00003	0	0.00049
	15-ft	3/18	3 total 1 max	0.00008	0	0.00049	2/18	2 total 1 max	0.00005	0	0.00049
Ring 2	5-ft	1/18	3 total 3 max	0.00008	0	0.0015	1/18	1 total 1 max	0.00005	0	0.00098
AACM Building – Day 1											
Ring 1	5-ft	2/18	3 total 2 max	0.00008	0	0.00096	0/18	0 total 0 max	0	0	0
	15-ft	1/18	1 total 1 max	0.00003	0	0.00049	0/18	0 total 0 max	0	0	0
Ring 2	5-ft	1/18	1 total 1 max	0.00003	0	0.00049	0/18	0 total 0 max	0	0	0
AACM Building – Day 2											
Ring 1	5-ft	6/18	6 total 1 max	0.00016	0	0.00049	2/18	2 total 1 max	0.00005	0	0.00049
	15-ft	5/18	8 total 4 max	0.00021	0	0.0019	2/18	2 total 1 max	0.00005	0	0.00049
Ring 2	5-ft	2/18	2 total 1 max	0.00005	0	0.00049	1/18	1 total 1 max	0.00003	0	0.00048

[a] Denotes number of samples at or above analytical sensitivity/total number of samples. The analytical sensitivity ranged from 0.00048 to 0.00049 s/cm^3. The ISO limit of detection for asbestos is equal to three times the analytical sensitivity (<0.0015 s/cm^3) for TEM.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

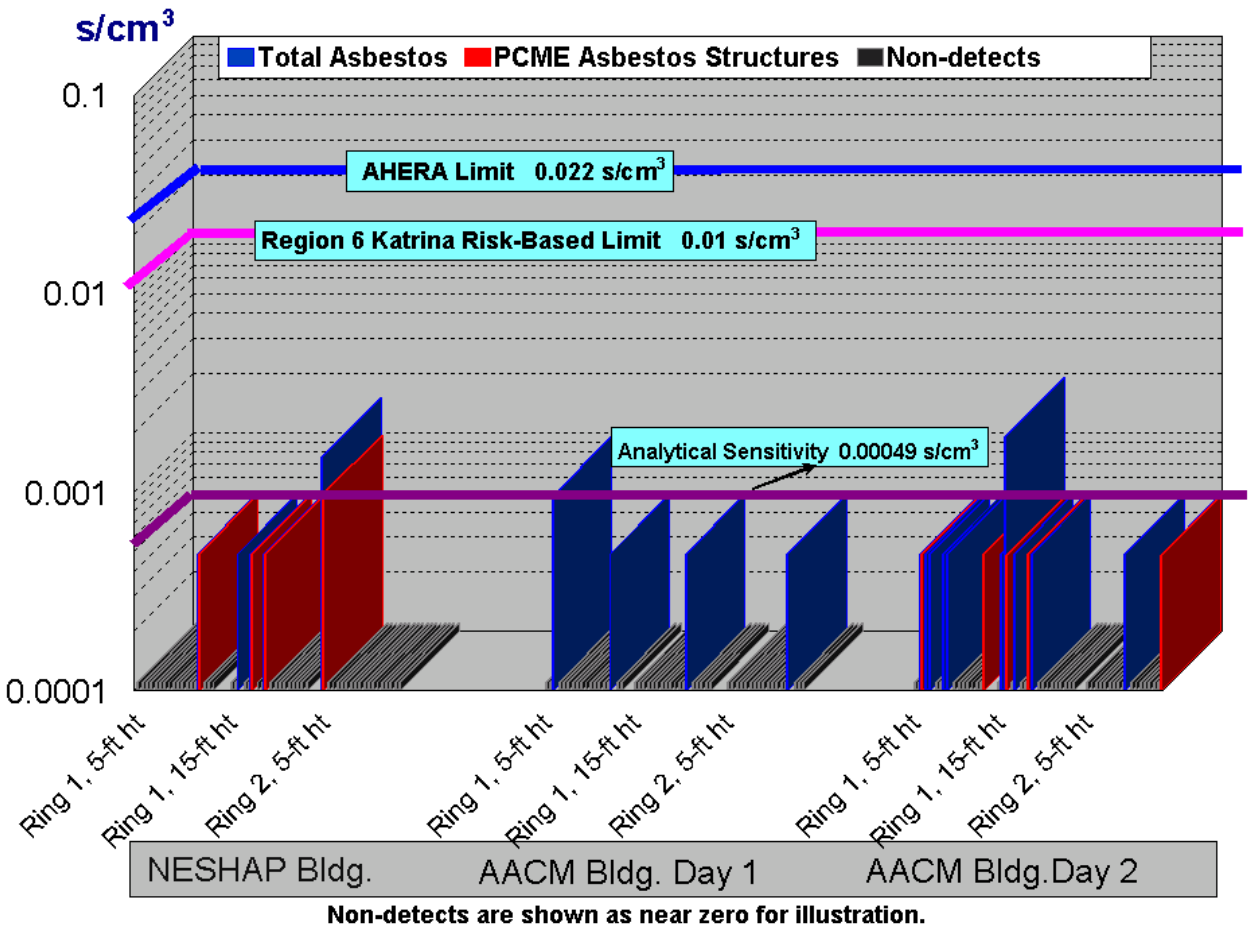

Figure 6-5. Airborne asbestos (TEM) during demolition of buildings.

During actual demolition of both the NESHAP and AACM buildings (Day 1 for the AACM), approximately ten percent (5/54 samples) and eight percent (4/54 samples) of the samples showed asbestos concentrations above the analytical sensitivity (Table 6-3), respectively. The largest total asbestos concentrations observed during demolition of both buildings was measured in Ring 1 of the AACM building (0.0019 s/cm^3), with 0.0015 s/cm^3 measured in Ring 2 of the NESHAP building. Four of the 54 samples from the NESHAP building showed measurable PCME asbestos concentrations (0.00049 to 0.00098 s/cm^3). The largest total asbestos concentration (0.00096 s/cm^3) observed during demolition of the AACM building (Day 1) was measured in Ring 1 (Table 6-3). None of the 54 samples from AACM Day 1 showed measurable concentrations of PCME-structures.

The AACM building soil removal process (Day 2) resulted in measurable total asbestos concentrations in 13 of 54 samples (Table 6-3 and Figure 6-5). Five of the 54 samples showed concentrations at the analytical sensitivity (0.00048 to 0.00049 s/cm^3) of PCME-structures. It is noted that no application of the wetting agent occurred during soil removal because the ground was saturated due to rainfall as well as from application of the wetting agent during building demolition. In retrospect, this was a judgmental error. It is probable that the edges of the containment berms and the berms themselves dried out somewhat during soil sampling and they may have been the source of the few asbestos fibers observed during analysis of the air samples collected during the soil removal phase.

As stated previously, the airborne asbestos concentrations observed were *near or below the limit of detection.* The highest total asbestos concentrations (0.0015 s/cm^3 observed during demolition of the NESHAP building and 0.0019 observed during demolition of the AACM), are significantly less than AHERA (40 CFR §763) clearance criterion (0.022 s/cm^3) and the level (0.01 s/cm^3) established by EPA for Hurricane Katrina recovery (EPA 2005). The highest concentration of PCME-structures was 0.00098 s/cm^3. The highest concentration observed (0.0019 s/cm^3) was about three times lower than the average ambient air concentrations (0.0057 s/cm^3) reported by the California Air Resources Board for Eldorado County between 1998 and 2001 (State of California 2003).

The statistical analyses (Section 7.1) showed that the airborne asbestos (TEM) concentrations from the AACM are not equal to the airborne asbestos (TEM) concentrations from the NESHAP Method. The empirical evidence (the proportion of non-detects and the maximum values) from the investigation suggests airborne asbestos (TEM) concentrations from the AACM are greater than the airborne asbestos (TEM) concentrations from the NESHAP Method. Based upon the observed proportion of detects, it was concluded that the difference between the two methods is a function of the Day 2 AACM activities (soil excavation and removal).

6.1.2.2 Asbestos in Settled Dust

Table 6-4 presents the descriptive statistics for the settled dust samples collected in Rings 1 and 2 at the five-ft height during demolition of the NESHAP and AACM Method buildings. The individual sample results are contained in Table A-7 of Appendix A and are illustrated in Figure 6-6. The results are reported as number of asbestos structures per unit area of surface (s/cm^2). A calculated deposition rate in asbestos structures per unit area per time (s/cm^2/hour) is also presented.

Although the following information is not directly applicable to this project, it is provided as a point of reference for settled dust data interpretation. The draft report from the Contaminants of Potential Concern Committee of the World Trade Center Indoor Air Task Force Working Group

Table 6-4. Asbestos (TEM) in settled dust during demolition of NESHAP and AACM buildings.

Sample Description	Total Asbestos Loading, s/cm^2				Asbestos Deposition Rate, s/cm^2/hour		
	n/N[a]	Mean[b]	Minimum	Maximum	Mean[b]	Minimum	Maximum
NESHAP Building							
Ring 1	14/18	6,649	0	46,771	741	0	5,146
Ring 2	10/18	435	0	2,315	48	0	245
AACM Building							
Ring 1	17/18	5,079	0	21,625	238	0	1,012
Ring 2	14/18	925	0	4,686	44	0	221

[a] Denotes number of samples at or above analytical sensitivity/total number of samples. The analytical sensitivity ranged from 146-243 s/cm^2.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

discussed dust analyses and the significance of the results. This report (USEPA 2005) suggests the following action levels to initiate cleanup for residential structures:

- 5,000 s/cm^2 for living spaces and
- 50,000 s/cm^2 for inaccessible spaces.

The report goes on to reference that the cleanup action level at Libby Montana Superfund Site is 5,000 s/cm^2 in generally accessible areas.

As shown in Figure 6-6, the settled dust results were highly variable. The laboratory identified evidence of dried particulate in several of the dust containers; the higher concentrations observed typically were associated with dust containers that had evidence of dried particulate. This most likely can be attributed to the closeness of the sampling stations to the demolition activities and the associated splashing of water used during the demolition (and particularly the loading of wet debris into the adjacent trucks). There was much more evidence of splashing in Ring 1 of both the NESHAP and AACM processes than in Ring 2 as judged by the color of the filters that were produced from the respective dust samplers in preparing the samples for analysis. Also, there was far more coloration on the samples located next to the side of the building where the trucks were loaded. The Ring 1 AACM samples were more highly colored than the NESHAP dust samples, which is consistent with the extra water (and wetting agent) used during the AACM demolition.

There was considerably more asbestos measured in the settled dust than in the co-located air samples for both the NESHAP and the AACM processes. Also for both processes, the asbestos loadings in the settled dust samples in Ring 1 were higher than those measured in Ring 2. Presumably, the asbestos was attached to dust or water particles which settled rapidly. Since the filter cassettes for the air samples faced slightly downward, the air samplers didn't capture that fraction of the asbestos associated with the heavier particles.

Since there was about an order of magnitude reduction (Table 6-4) in the dust asbestos loadings between Ring 1 (which was 15 ft from the building and/or loading) and Ring 2 (which was an additional 25-ft away from Ring 1), it is clear from the settled dust perspective that the containment berms should have been further away from the building than they were. If possible, the berm should be located a minimum of 25 ft from the building.

The statistical analyses (Section 7.5) showed that there is insufficient information to conclude that the asbestos loadings in the settled dust (TEM) from the AACM are not equal to the asbestos loadings in the settled dust (TEM) from the NESHAP Method. Based on descriptive statistics, plots of the empirical cumulative distribution functions (CDFs), and the Komolgorov Smirnov (K-S) test, one would conclude the AACM asbestos loadings in settled dust are equal to the NESHAP asbestos loadings in settled dust.

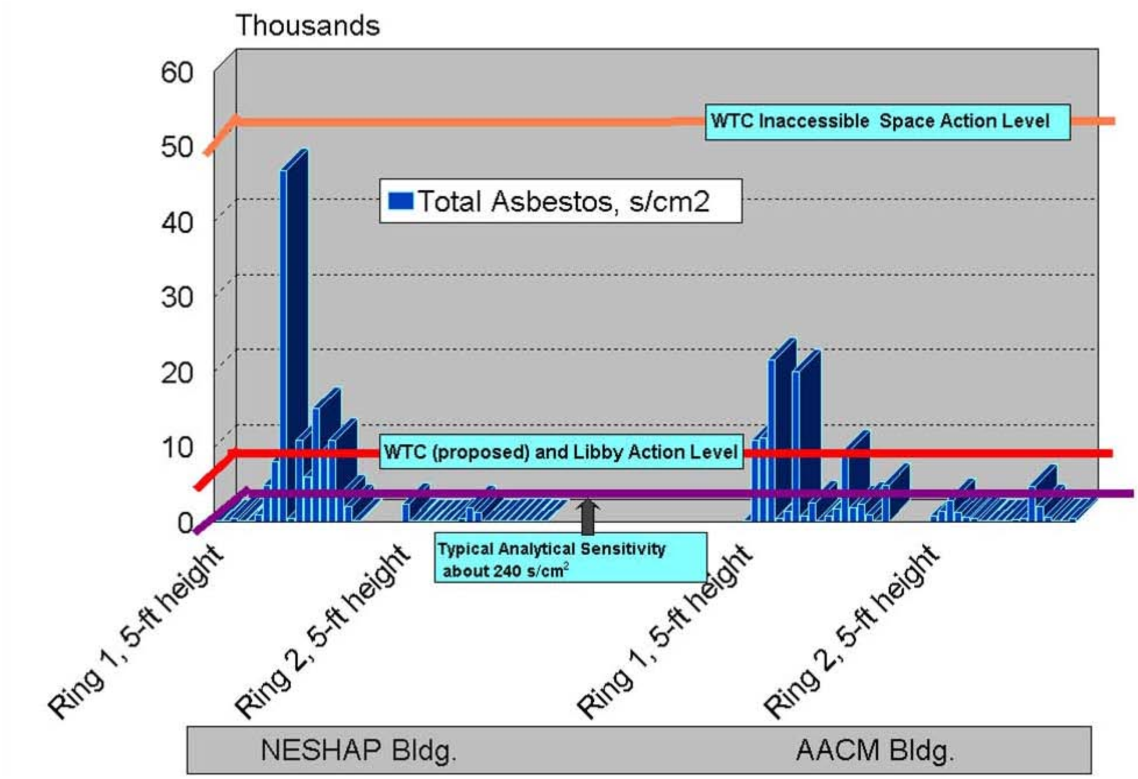

Figure 6-6. Asbestos (TEM) loading in settled dust resulting from the demolitions.

6.1.2.2.1 Total Fibers in Air Samples

6.1.2.2.1.1 Background Air

Table 6-5 presents the descriptive statistics for the background total fiber concentrations. The individual sample results are contained in Table A-4 of Appendix A.

Table 6-5. Background total fibers (PCM) prior to demolition of NESHAP and AACM buildings.

Total Fibers, f/cm^3			
n/N[a]	**Mean[b]**	**Minimum**	**Maximum**
NESHAP Building			
3/6	0.001	0	0.002
AACM Building			
6/6	0.003	0.002	0.005

[a] Denotes number of samples at or above analytical sensitivity/total number of samples. The analytical sensitivity was 0.001 f/cm^3.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

The background concentration of total fibers ranged from <0.001 to 0.002 f/cm^3 (mean = 0.001f/cm^3) around the NESHAP building. The concentration of total fibers ranged from 0.002 to 0.005 f/cm^3 (mean = 0.003 f/cm^3) around the AACM building.

6.1.2.2.2 Demolition Air

Table 6-6 presents the descriptive statistics for the airborne concentrations of total fibers measured by PCM during demolition of the NESHAP building, and demolition and soil removal from the AACM building. The individual fiber concentrations are shown in Table 6-6 and Table A-3 of Appendix A. One sample was inadvertently not removed and replaced at the end of Day 1 but operated for the duration of all sampling activities.

The PCM data (Table 6-6), when compared to the TEM data (Table 6-3), illustrate that PCM analysis is a poor indicator of asbestos concentrations. Only four of the 54 NESHAP samples and five of the 107 AACM samples collected during the demolitions showed measurable concentrations of PCME-asbestos structures. Of the 161 PCM samples, 153 had detectable fibers. Eighty-seven percent (47/54 samples) collected around the NESHAP building and 100% (107/107) of the samples from the AACM building showed measurable concentrations of total fibers. Obviously, the PCM fibers (Table 6-6) were almost entirely not asbestos.

Of 29 individual fibers identified as asbestos by TEM, nine (or about one-third) were PCME-size and might have been counted by PCM (Table A-2 and Table A-3).

The statistical analyses (Section 7.3) showed that there is insufficient information to conclude that the airborne fiber (PCM) concentrations from the AACM are not equal to the airborne fiber (PCM) concentrations from the NESHAP Method. Based on descriptive statistics one would conclude the fiber (PCM) concentrations for the two methods are equivalent.

Table 6-6. Airborne total fibers (PCM) during demolition of NESHAP and AACM buildings.

Sample Location		n/N[a]	Total Fibers, f/cm^3		
			Mean[b]	**Minimum**	**Maximum**
NESHAP Building – Day 1					
Ring 1	5-ft	15/18	0.002	0	0.006
	15-ft	17/18	0.003	0	0.006
Ring 2	5-ft	15/18	0.002	0	0.004
AACM Building – Day 1					
Ring 1	5-ft	17/17	0.003	0.001	0.004
	15-ft	18/18	0.003	0.001	0.005
Ring 2	5-ft	18/18	0.003	0.001	0.004
AACM Building – Day 2					
Ring 1	5-ft	17/17	0.003	0.001	0.006
	15-ft	18/18	0.004	0.002	0.016
Ring 2	5-ft	18/18	0.003	0.001	0.004

[a] Denotes number of samples at or above analytical sensitivity/total number of samples. The analytical sensitivity was 0.001 f/cm^3.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

6.1.2.3 Total Particulate in Air Samples

Table 6-7 presents the descriptive statistics for the airborne concentrations of total particulate measured during demolition of the NESHAP building, and demolition and soil removal from the AACM building. Individual results are in Table A-8 of Appendix A.

The AACM results reflect the cumulative concentration for both the demolition and the soil removal aspects, as overloading the filters was not a concern for particulate; i.e., the same filters were used throughout the AACM process and opened only during the active times for both the demolition and soil removal operations. The particulate concentrations, though uniformly low values, were larger during the AACM than for the NESHAP demolition. This is attributed to both the extended sampling period for the AACM process, which included soil removal and disposal. Since wetting was inadvertently not performed during the soil removal, it is possible that this increased the particulate loading.

Although the OSHA PEL (29 CFR §1910, Table Z-1) for particulates not otherwise regulated (PNOR) of 15 mg/m^3 is not directly applicable, it provides a relative comparison to illustrate the very low concentrations of total particulate observed in both demolitions. The values observed are at least 100 times lower than the PEL.

The statistical analyses (Section 7.6) showed that the total particulate concentrations (as collected and measured by NIOSH Method 5000) from the AACM are not equal to the total particulate concentrations from the NESHAP Method. Based on the observed proportion of detects, it was concluded that the total particulate concentrations from the AACM are higher than the total asbestos concentrations from the NESHAP Method.

Table 6-7. Airborne total particulate during demolition of NESHAP and AACM buildings.

Sample Location		n/N[a]	Total Particulate, mg/m^3		
			Mean[b]	Minimum	Maximum
NESHAP Building – Day 1					
Ring 1	5-ft	7/18	0.032	0	0.11
AACM Building – Day 1 & 2					
Ring 1	5-ft	17/18	0.084	0	0.15

[a] Denotes number of samples at or above analytical sensitivity/total number of samples. The analytical sensitivity ranged from 0.02-0.06 mg/m^3.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

6.1.3 Water

Table 6-8 shows the volume of water used during the demolition of the NESHAP and AACM buildings. The water addition, rainfall history, and activity timing are illustrated in Figure 6-7. Overall, the AACM received more than ten times the water quantity applied to the NESHAP.

During the NESHAP building demolition, no pooled surface water was present at the collection sumps. Hence, no samples of pooled surface water were obtained. With the intervening rainfall plus the water from the NESHAP demolition, the soil appeared saturated when the AACM demolition was conducted. This pre-saturation, plus the quantity of water that was applied during the AACM demolition, as well as the effectiveness of the wetting-agent to improve wetting of the soil, provided a cumulative effect that allowed two small areas on the down-gradient side of the berm in the rear of the AACM building to seep beyond the berm. In the two particular down-gradient spots, a small amount of water accumulated outside the berm and samples were obtained. There was no visible flow; simply two small wet areas that developed. While it was not possible to measure the volume of water that escaped through the berm, it was estimated to be less than one percent, since it was a seep and no flow was observed. It was however clear that the source was the water from within the berm. Overall, 4100 gallons (about 20 percent of the 23833 gallons of amended water that were applied) were collected, filtered, trucked, and disposed at the Fort Smith Sewage Treatment Plant. Roughly 80 percent of the amended water that was applied either percolated into the soil or was taken to the landfill as part of the debris.

Table 6-8. Summary of source (hydrant) water usage during the NESHAP and AACM building demolition.

Day	Hydrant Meter Reading		Hydrant Meter Reading (ft^3)		Source Water Usage		
	Start Time	Stop Time	Start	Stop	ft^3	gallons	Cumulative, Gallons
NESHAP BUILDING							
Day 1 (04/26/06)	0800	1157	211,272	211,530	258	1,930	1930
	1157	1436	211,530	211,659	129	965	2895
AACM Building							
Pre-wetting (4/30/06)	1521	1641	211688	21251	564	4214	4214
Day 1 (05/01/06	0709	1840	212,252	214,666	2,414	18,059	22273
Day 2 (05/02/06)	1300	1604	214,666	214,875	209	1,560	23833
Day 3 (05/03/06)	Water not used.						23833

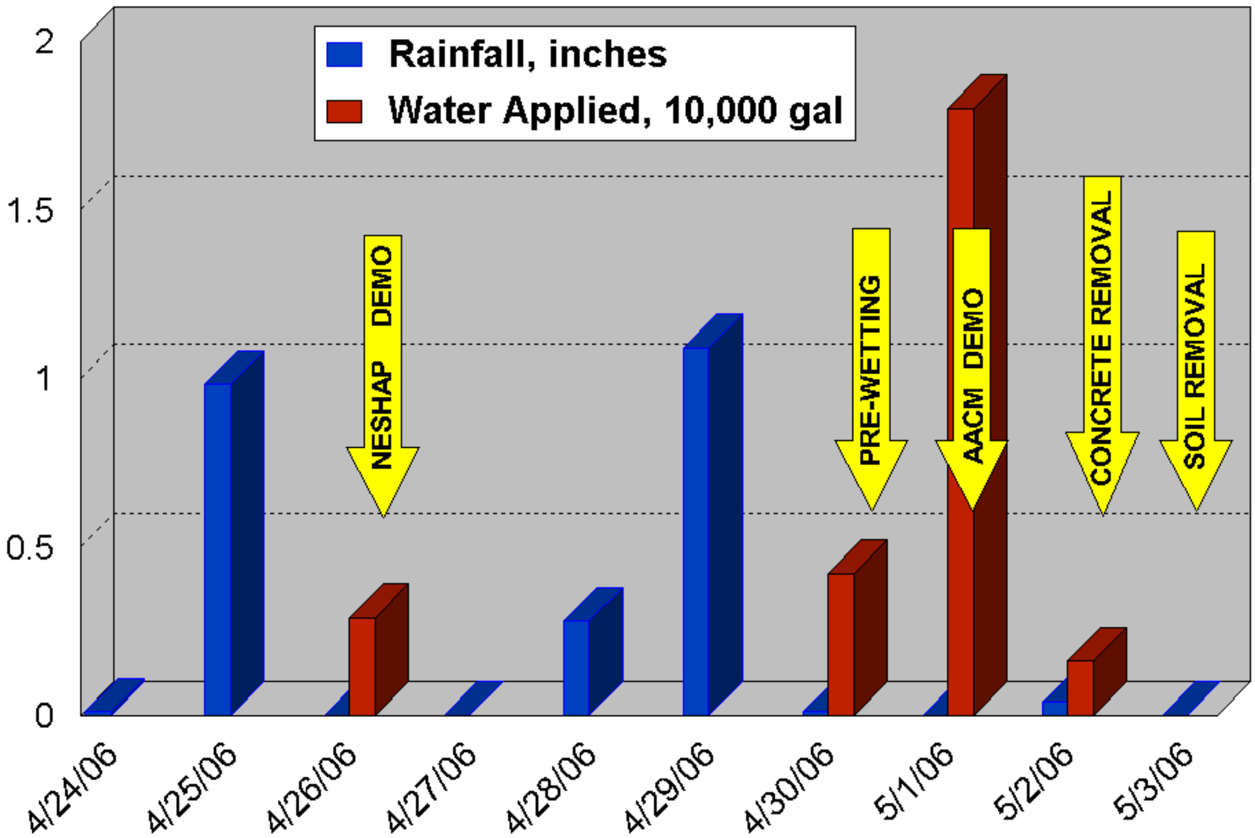

Figure 6-7. Rainfall, Water Application, and Activity History During Demolition Study Period

Table 6-9 presents the asbestos analysis of the source water with and without the wetting agent, as well as pooled surface water resulting from the demolitions. The analytical results indicate that pooled surface water collected from inside and outside the berm contained asbestos. Figure 6-8 illustrates the total asbestos content of water sampled during the AACM demolition. Figure 6-9 illustrates the asbestos structures longer than 10 microns that were present in the pooled water from the AACM building demolition.

The only current EPA regulations on asbestos in water are the drinking water standards. The *U.S. EPA National Primary Drinking Water Standards (40CFR 141.51, 2002)* mandates a limit for the concentration of asbestos fibers (longer than ten microns) at seven million fibers per liter; i.e., the Maximum Contaminant Level (MCL) for asbestos in drinking water. Although the Federal Drinking Water Standard is clearly not applicable in this situation, this discussion is provided to establish a relative frame of reference for the asbestos concentrations observed in the water phase. The maximum asbestos concentration in the pooled surface water was about five times greater than the EPA standard. This is not unexpected since the AACM anticipates transfer of some asbestos to the water, but the water is captured and filtered before ultimate disposal. Where soil exists around the structure, the water permeates into the soil transferring the asbestos into the soil matrix; therefore the AACM requires the removal of some soil from the site at the completion of the demolition. Neither water capture or soil removal are required with the existing NESHAP process.

Table 6-9. Asbestos (TEM) in water from the NESHAP and AACM building demolitions.

Sample Description	Number of Asbestos Structures Counted	Asbestos Concentration (million s/L)	Asbestos Structures >10 µm (million s/L)
NESHAP Building [a]			
Day 1 Source Hydrant Pre-Demo	0	<0.36	<0.36
Day 1 Source Hydrant Post-Demo	0	<0.05	<0.05
AACM Building			
Day 1 Source Hydrant Pre-Demo	0	<0.36	<0.36
Day 1 Source Hydrant Post-Demo	0	<0.76	<0.76
Day 2 Source Hydrant Post-Demo	0	<0.04	<0.04
Day 1 Surface Water from demo (morning)	106	2,770	<26
Day 1 Surface Water from demo (afternoon)	108	3,290	30.4
Day 2 Surface Water from demo (afternoon)	84	745	35.5
Day 1 Surface water outside of berm (location 1)	105	1,600	30.4
Day 1 Surface water outside of berm (location 2)	100	2,280	<23
Day 2 Surface water outside of berm	12	103	<8.6
1% wetting agent in distilled water	0	<0.0004	<0.0004
1% wetting agent in distilled water	0	<0.0003	<0.0003
EPA Drinking Water Standard			**7**

[a] No surface water was present.

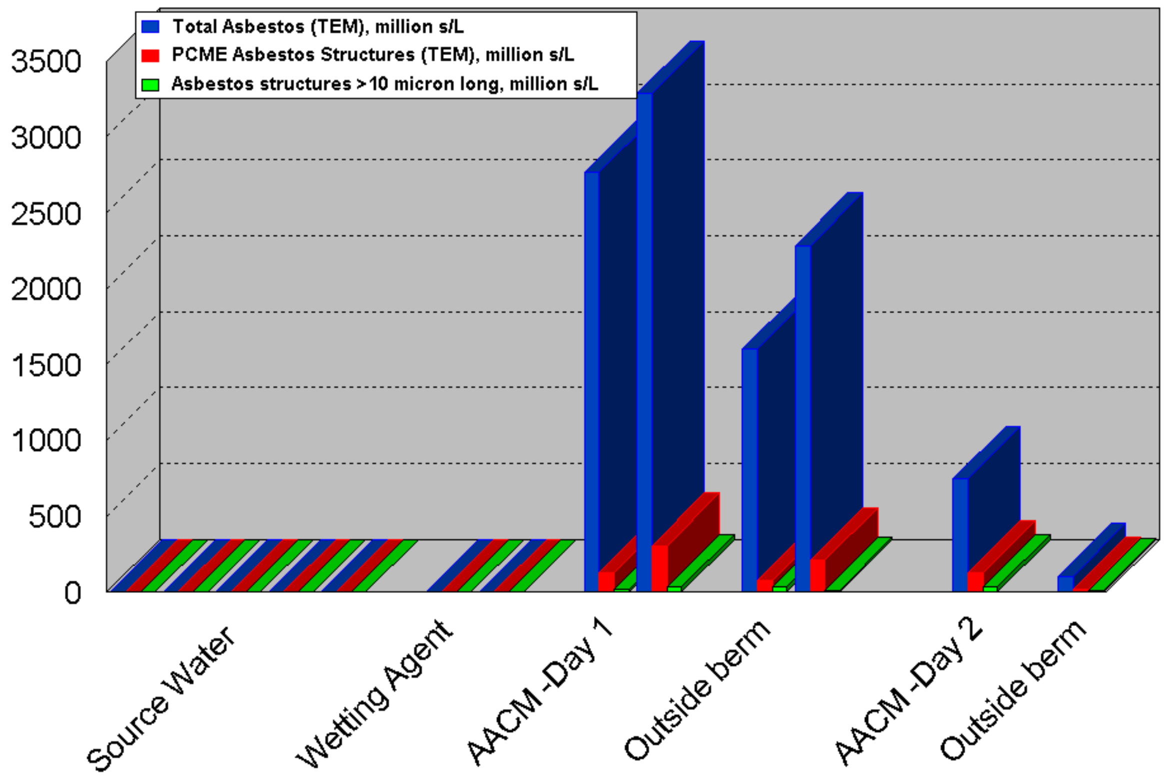

Figure 6-8. Asbestos in water samples.

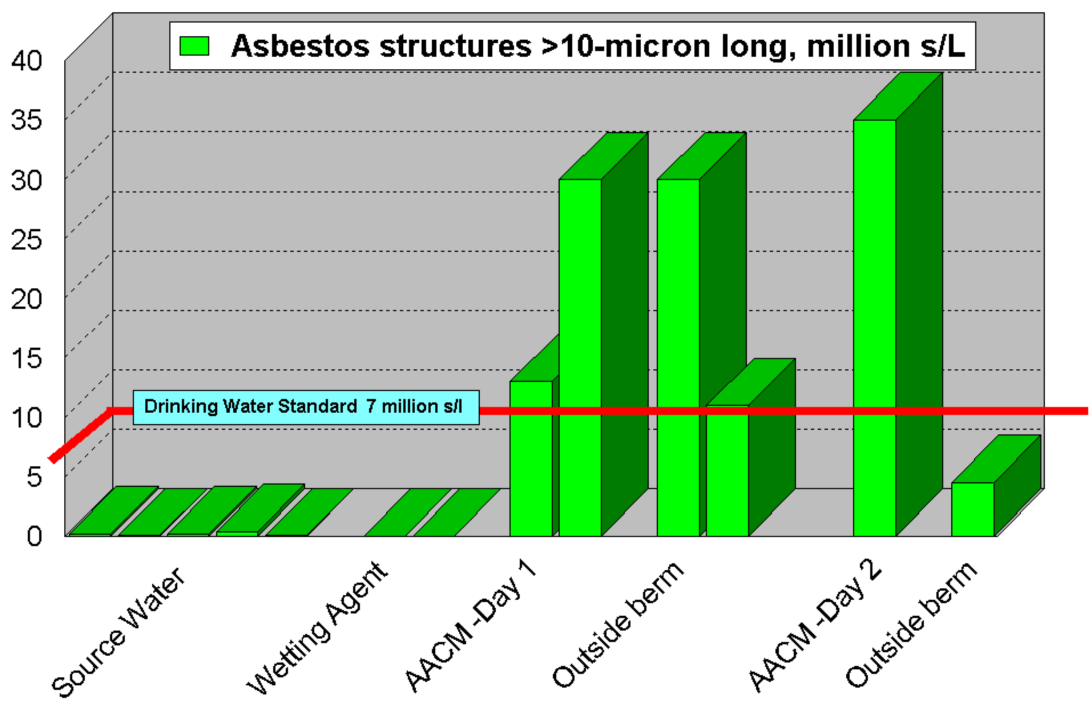

Figure 6-9. Asbestos structures longer than ten microns in water samples.

6.1.4 Soil

Ten replicate composite samples were collected during each sampling event. These samples really represent individual measurements of the overall asbestos concentration within each bermed area.

6.1.4.1 Moisture

Each of the composite samples was dried in the laboratory and homogenized. Any visible rocks/organic material and building debris were removed and weighed. The remaining soil was split into two fractions - one fraction for elutriation and the other fraction for analyses by PLM and TEM. The individual sampling results are contained in Table A-12 of Appendix A.

The descriptive statistics for soil moisture results during both demolitions are presented in Table 6-10. The soil moisture concentrations illustrate an increase in water content of the soil as a result of the wetting agent used during the AACM demolition and the rainfall encountered following the AACM building demolition but prior to soil sampling, soil removal, and final soil sampling. Note that all soil analyses were performed on the dried samples.

Table 6-10. Soil Moisture Content.

Phase	% Moisture Content		
	Mean	Minimum	Maximum
NESHAP Building			
Pre-Demo	19.5	13.3	23.8
Post-Demo	11.5	9.9	13.1
AACM Building			
Pre-Demo	15.2	11.4	18.7
Post-Demo	21.4	19.9	23.5
Post-Excavation	20.2	12.1	24.8

6.1.4.2 Total Asbestos

The soil fraction was analyzed for asbestos by PLM point counting and TEM. The rocks/organics were analyzed by PLM using visual estimation. The building debris fraction was also analyzed by PLM using visual estimation.

6.1.4.2.1 Soil Fraction

Table 6-11 presents the descriptive statistics for the asbestos analyses (PLM and TEM) for the soil fraction. The individual sample results are contained in Table A-12 of Appendix A.

The PLM results for the soil fraction from all samples of the demolitions were largely non-detect at an analytical sensitivity of 0.1 percent, as shown in Table 6-11 and illustrated in Figure 6-10. Only one NESHAP post-demolition sample showed a detectable concentration of asbestos by PLM. None of the post-excavation AACM samples showed detectable asbestos by PLM. Although the NESHAP definition of an asbestos-containing material (one percent) is not directly applicable to soil, all of the concentrations were well below this concentration.

The individual TEM asbestos concentrations are illustrated in Figure 6-11 and the mean TEM concentrations are illustrated in Figure 6-12. With increased sensitivity by this method, the variability is apparent. The higher asbestos concentrations observed in the pre-demolition data from both buildings are attributed to the removal of pipe wrapping from beneath the buildings, which was performed many years earlier. This variability represents the sum of variabilities from both the sampling process (including heterogeneity of the site) and the analytical process. It is very difficult to generate a representative, consistent filter loading for TEM analysis, as a very small portion of the sample must be used to prevent overloading.

Table 6-11. Asbestos (PLM and TEM) results in soil fraction.

% of Sample by wt.	PLM – Point Count Asbestos (%)				TEM Asbestos (10^6 Structures/gm)			
Mean	n/N [a]	Mean [b]	Minimum	Maximum	n/N [a]	Mean [b]	Minimum	Maximum
NESHAP Building – Pre-Demolition								
99.1	0/10	0	0	0	6/10	33	0	165
NESHAP Building – Post-Demolition								
95.8	1/10	0.03	0	0.34	8/10	181	0	1600
AACM Building – Pre-Demolition								
97.9	2/10	0.05	0	0.33	6/10	1160	0	11500
AACM Building – Post-Demolition								
92.9	1/10	0.03	0	0.33	7/10	51	0	211
AACM Building – Post-Excavation								
94.6	0/10	0	0	0	3/10	17	0	151

[a] Denotes number of samples at or above analytical sensitivity/total number of samples.
The analytical sensitivity for PLM point count was 0.1 percent. The analytical sensitivity for TEM ranged from 3.94×10^6 to 2.15×10^7 structures/gm.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

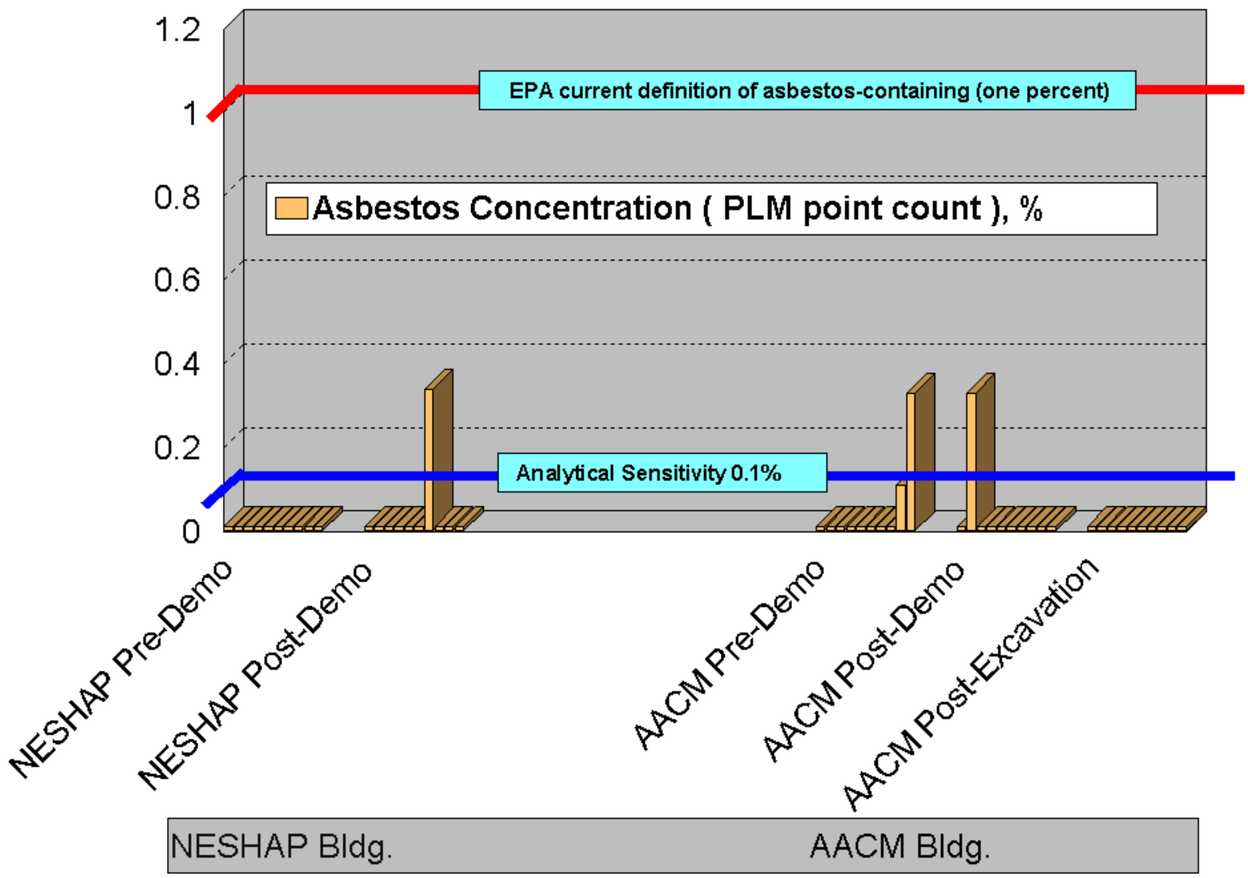

Figure 6-10. Soil asbestos concentrations by PLM for both building demolitions.

The statistical analyses (Section 7.2) showed that the post-excavation asbestos concentrations in the soil from the AACM are not equal to the post-demolition asbestos concentrations in the soil from the NESHAP Method. Based on descriptive statistics, one would conclude the post-excavation asbestos concentrations in the soil from the AACM are less than the post-demolition asbestos concentrations in the soil from the NESHAP Method.

The descriptive statistics (Section 7.2) show that: *the AACM pre-demolition soil concentrations are greater than the post-excavation soil concentrations in the upper tails of the distributions*; *the NESHAP pre-demolition soil concentrations are less than the post-demolition soil concentrations in the upper tails of the distributions;* and *the AACM post-demolition soil concentrations are greater than the AACM post-excavation soil concentration in the upper tails of the distributions.*

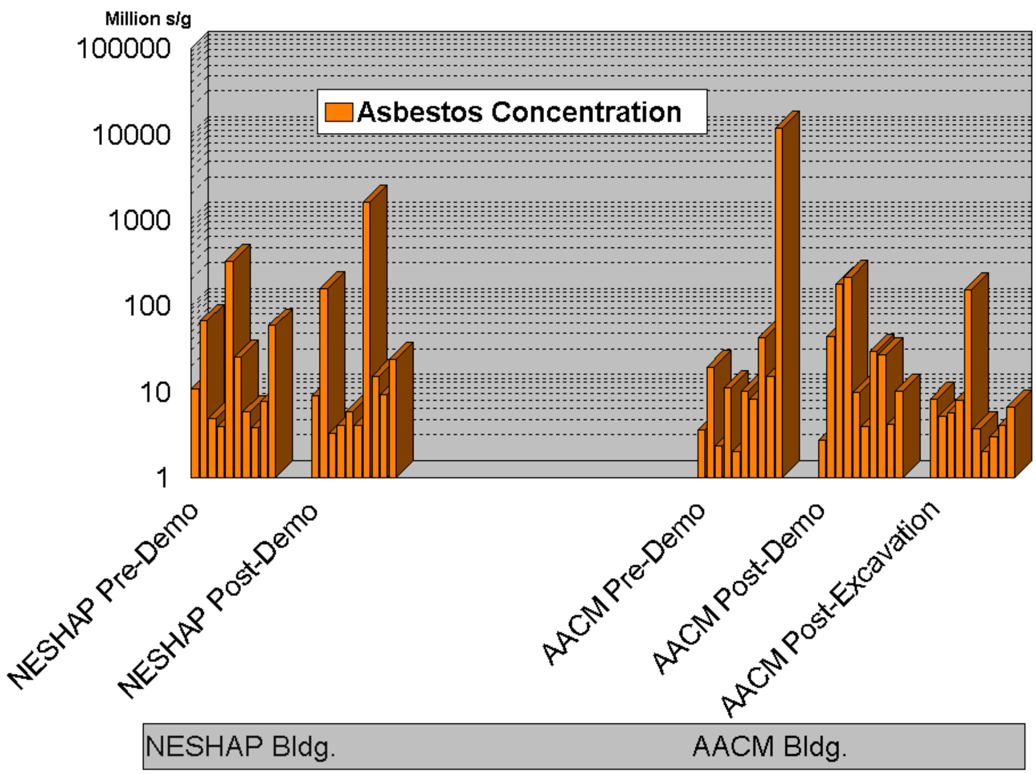

Figure 6-11. Soil asbestos concentrations by TEM for both demolitions.

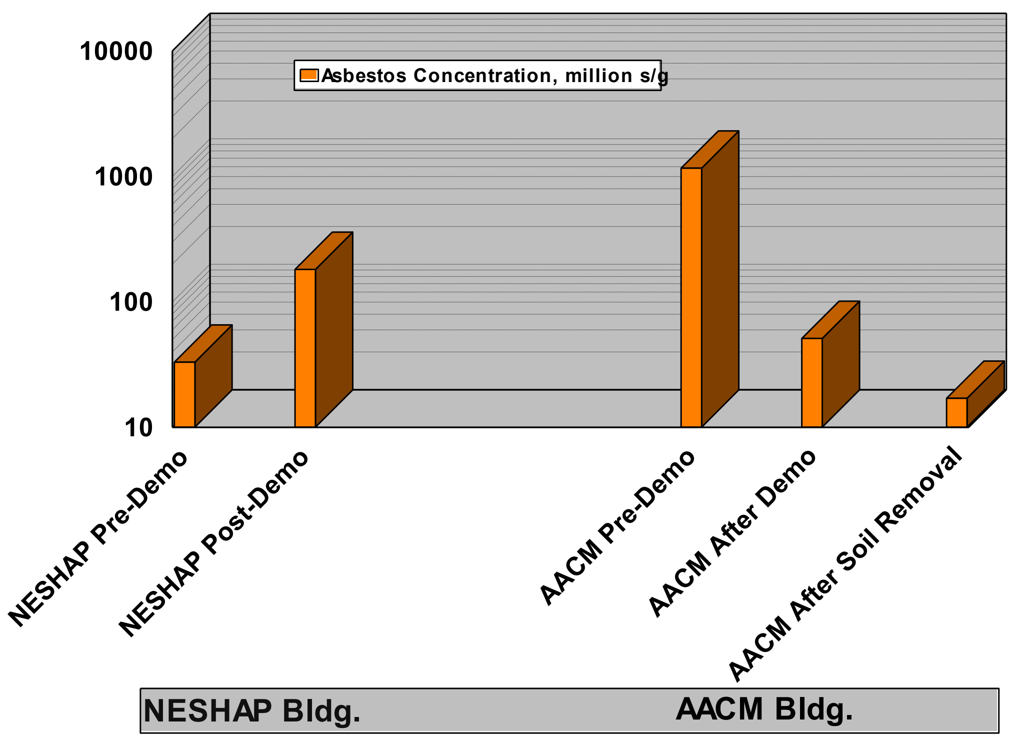

Figure 6-12. Mean soil asbestos concentrations (TEM).

6.1.4.2.2 Rocks/Organics Fraction

Asbestos was not present above the detection limit (one percent) in any of the rocks/organics fractions.

6.1.4.2.3 Building Debris Fraction

Table 6-12 presents the descriptive statistics for the asbestos results (PLM) for the building debris fraction. The individual results are presented in Table A-12 of Appendix A.

There were interesting observations about the building debris that remained at the end of each demolition process and the amount of asbestos therein. At the conclusion of the demolitions, all ten post-demolition samples for the NESHAP building contained building debris that was asbestos-containing; seven of the ten post-excavation AACM samples contained building debris

Table 6-12. Asbestos Content in the Building Debris Fraction of the Soil

Weight % of debris in soil	**PLM Asbestos in building debris by visual estimation,%**			
Mean	**n/N[a]**	**Mean [b]**	**Minimum**	**Maximum**
NESHAP Building – Pre-Demolition				
0.012	2/10	1.2	0	8.3
NESHAP Building – Post-Demolition				
0.28	10/10	2.5	0.16	5.0
AACM Building – Pre-Demolition				
0.04	1/10	0.06	0	0.62
AACM Building – Post-Demolition				
0.87	9/10	0.87	0	2.46
AACM Building – Post-Excavation				
0.68	7/10	0.21	0	0.6

[a] Denotes number of samples at or above analytical sensitivity/total number of samples. The analytical sensitivity for PLM was 0.1 percent.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

that was asbestos-containing. The majority of this asbestos-containing building debris was identified as brown vinyl asbestos floor tile (VAT).

Since the soil samples were weighed after drying at the lab and the suspect ACM, including VAT fragments, were removed and weighed, the percentage of ACM and further of VAT fragments can be expressed on strictly a weight basis. These VAT fragment data are presented in Table 6-13.

Table 6-13. Weight of Vinyl Asbestos Tile (VAT) fragments in the soil samples.

Weight % of VAT fragments in soil samples			
n/N[a]	**Mean [b]**	**Minimum**	**Maximum**
NESHAP Building – Pre-Demolition			
1/10	0.003	0	0.03
NESHAP Building – Post-Demolition			
10/10	0.07	0.01	0.15
AACM Building – Pre-Demolition			
0/10	0	0	0
AACM Building – Post-Demolition			
9/10	0.08	0	0.26
AACM Building – Post-Excavation			
7/10	0.01	0	0.03

[a] Denotes number of samples at or above analytical sensitivity/total number of samples. The analytical sensitivity for the balance was 0.01 g.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

The final mean soil concentration was 0.07 percent by weight asbestos-containing building debris for the NESHAP process and the final mean soil concentration was 0.01 percent ACM by weight for the AACM process. Of those small quantities of asbestos-containing building debris, 90 percent of the NESHAP quantity was VAT fragments and the remaining ten percent was other asbestos-containing materials. For the AACM process, all the ACM building debris in the post-excavation soil was composed of VAT fragments.

Figure 6-13 illustrates the trends of the VAT fragments and of the total ACM present in the building debris as a percentage of the original dry weight of the soil sample. These data clearly illustrate the decrease in VAT fragments in the soil as a result of the AACM as compared to the NESHAP method.

The statistical analyses (Section 7.12) showed that the post-excavation percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the AACM is not equal to the post-demolition percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the NESHAP Method. Additional analyses using box plots lead one to conclude the post-excavation percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the AACM is less than the post-demolition percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the NESHAP Method.

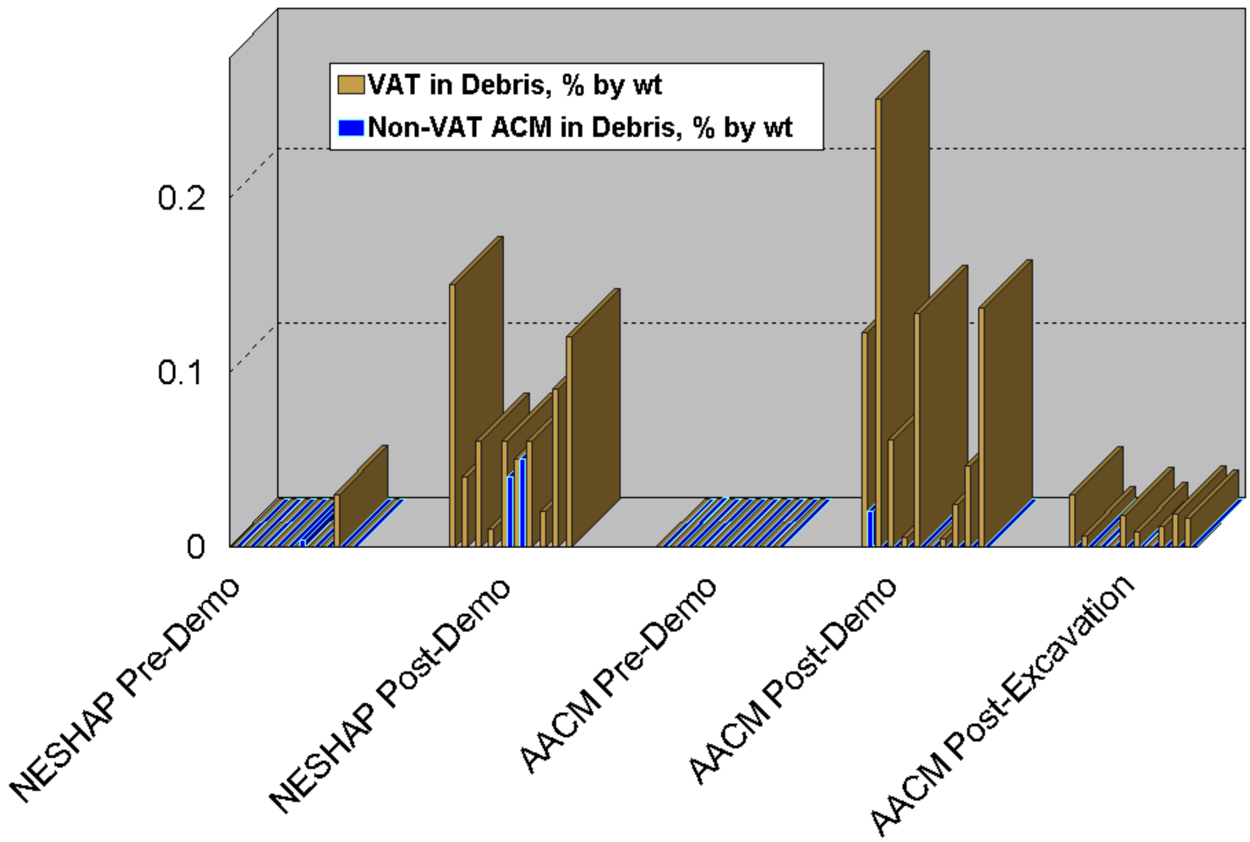

Figure 6-13. Weight fraction of soils that were VAT and ACM building debris.

6.1.4.3 Soil Elutriation

Thirty percent of the soil samples were analyzed using the Modified Elutriator Method. Table 6-14 presents the descriptive statistics for the soil elutriation air samples generated from soil collected before and after demolition of the NESHAP and AACM Method buildings. The individual results are contained in Table A-11 of Appendix A and illustrated in Figure 6-14.

The statistical analyses (Section 7.10) showed that there was insufficient data to evaluate that the post-excavation asbestos concentrations from elutriator test on soil from the AACM are equal to the post-demolition asbestos concentrations from elutriator test on soil from the NESHAP Method; that the post-excavation asbestos concentrations from elutriator test on soil from the AACM are equal to the pre-demolition asbestos concentrations from elutriator test on soil from the AACM; that the post-demolition asbestos concentrations from elutriator test on soil from the NESHAP Method are equal to the pre-demolition asbestos concentrations from elutriator test on soil from the NESHAP Method; or that the post-excavation asbestos concentrations from elutriator test on soil from the AACM are equal to the post-demolition asbestos concentrations from elutriator test on soil from the AACM.

It appears that the soil elutriation total asbestos concentrations are lower following demolition for both the NESHAP and the AACM methods.

Table 6-14. Elutriation air samples (TEM) from soil collected before and after demolition

Sample Description	Total Asbestos Concentration, 10^6 s/gPM$_{10}$				PCME Asbestos Concentration, 10^6 s/gPM$_{10}$			
	n/N[a]	Mean [b]	Min	Max	n/N[a]	Mean [b]	Min	Max
NESHAP Building								
Pre-Demolition	3/3	20	13	31	3/3	1.6	8.4	26
Post-Demolition	2/3	2.3	0	3.6	1/3	2.8	0	1.7
AACM Building								
Pre-Demolition	3/3	28	9.0	38	2/3	8.6	0	14
Post-Demolition	2/3	3.1	0	5.2	2/3	1.5	0	2.6
Post-Excavation	2/3	11	0	32	1/3	0.7	0	2.2

[a] Denotes number of samples at or above analytical sensitivity/total number of samples. The analytical sensitivity ranged from 2.19×10^6 to 1.07×10^7 s/gPM$_{10}$. The ISO limit of detection for asbestos is equal to three times the analytical sensitivity (<6.6×10^6 s/cm^3 to 3.2×10^7 s/cm^3) for TEM.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

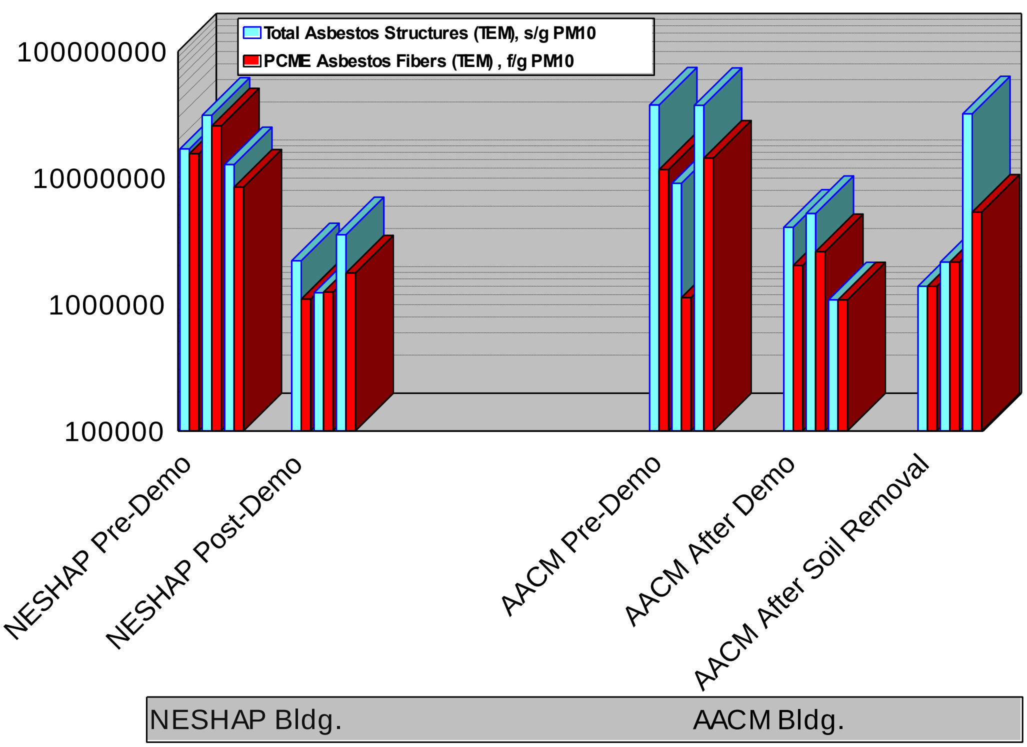

Figure 6-14. Soil elutriation air concentrations of asbestos (TEM).

6.1.4.4 Visible Emissions

A brief visible emission was observed during the removal of a concrete foundation structure during the NESHAP demolition, but it was not an asbestos-containing material. No visible emissions were observed during the AACM demolition.

6.1.5 Workers

Workers were monitored during all phases of the study, including abatement of the NESHAP building, demolition of both buildings, and ―*walkers*" attending the sampling stations during the demolitions. Individual sample results are presented in Table A-9 of Appendix A.

6.1.5.1 Asbestos (TEM) and Fibers (PCM)

6.1.5.1.1 Demolition and Abatement Workers

Table 6-15 presents the descriptive statistics for the personal breathing zone concentrations of asbestos (TEM) and total fibers (PCM) measured during demolition of the NESHAP and AACM buildings.

The demolition worker samples were analyzed by TEM and by PCM (Table 6-15). All the AACM worker breathing zone samples were non-detect for total asbestos (all asbestos structures >0.5 microns in length and ≥3:1 aspect ratio) at the 0.005 s/cm^3 analytical sensitivity level. The NESHAP demolition worker samples showed only a few fibers of asbestos and those were <5 microns in length. Overall, none of the worker samples showed detectable PCME asbestos structures (>5 microns in length and ≥3:1 aspect ratio) during the demolitions. Time-weighted averages, based upon the PCM fiber counts above, were all below the OSHA Personal Exposure Limit (PEL) of 0.1 f/cm^3. Table 6-16 presents the descriptive statistics for the personal breathing zone concentrations of total fibers and asbestos measured during abatement of the NESHAP buildings. Results from the sampling of the negative-air HEPA-filtration units are also presented.

The breathing zone samples from the abatement workers, which are part of the NESHAP process, indicated total asbestos concentrations as high as 0.093 s/cm^3.

The highest concentration of total fibers (0.12 f/cm^3) expressed as an eight-hr time-weighted average (TWA), was equal to the OSHA Personal Exposure Limit (PEL) of 0.10 f/cm^3.

Figure 6-15 illustrates the breathing zone concentrations for the abatement workers.

It is apparent in Figure 6-15 that PCM measurements have no relationship to the asbestos concentrations. The highest PCM concentration had a much lower PCME concentration (the asbestos fibers that are in the size range measured by PCM). Also, there are considerably more small fibers than PCME fibers in the abatement. This is consistent with previous studies

Table 6-15. Personal breathing zone concentrations of asbestos (TEM) and total fibers (PCM) during demolition of the NESHAP and AACM buildings.

Worker	Total Asbestos, s/cm³				PCME Asbestos, s/cm³				Total Fibers, f/cm³			
	n/N[a]	Mean[b]	Min	Max	n/N[a]	Mean[b]	Min	Max	n/N	Mean[b]	Min	Max/ (TWA)
Demolition of NESHAP Building												
Excavator and hose operators; laborers	2/5	0.002	0	0.005	0/5	0	0	0	5/5	0.019	0.009	0.036/ (0.05)
Truck drivers	0/3	0	0	0	0/3	0	0	0	3/3	0.061	0.042	0.086/ (0.07)
Walkers	0/3	0	0	0	0/3	0	0	0	3/3	0.022	0.009	0.031/ (0.02)
Demolition of AACM Building												
Excavator operator; laborers	0/5	0	0	0	0/5	0	0	0	5/5	0.009	0.004	0.016/ (0.03)
Truck drivers	0/3	0	0	0	0/3	0	0	0	3/3	0.011	0.007	0.017/ (0.01)
Walkers	0/3	0	0	0	0/3	0	0	0	3/3	0.013	0.008	0.018/ (0.01)

[a] Denotes number of samples at or above analytical sensitivity/total number of samples.
The analytical sensitivity was 0.0049 s/cm³ for TEM and 0.001 f/cm³ for PCM. The ISO limit of detection for asbestos is equal to three times the analytical sensitivity (<0.015 s/cm³) for TEM.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

Table 6-16. Concentrations of asbestos (TEM) and total fibers (PCM) during abatement of the NESHAP building.

Sample Description	Asbestos(TEM), s/cm³				Total Fibers(PCM), f/cm³				
	n/N[a]	Mean[b]	Min	Max	n/N	Mean	Min	Max	TWA Max
Asbestos Abatement of NESHAP Building									
Abatement Workers	4/6	0.032	0	0.071	4/6	0.052	0	0.12	0.10
Load-out of Containerized ACM from NESHAP Building									
Abatement Load-out Workers[c]	3/3	0.065	0.041	0.093	3/3	0.018	0.009	0.024	NA
HEPA-Filtration Units in NESHAP Building									
Discharge Air[d]	0/4	0	0	0	2/4	0.0007	0	0.002	NA

[a] Denotes number of samples at or above analytical sensitivity/total number of samples.
The analytical sensitivity was 0.0049 s/cm³ for TEM and 0.001 f/cm³ for PCM. The ISO reportable detection limit for asbestos was <0.015 s/cm³ for TEM.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.
[c] The sample was integrated over three days with each sampling period being <one hour.
[d] Discharge air from each HEPA-filtration unit was sampled isokinetically.

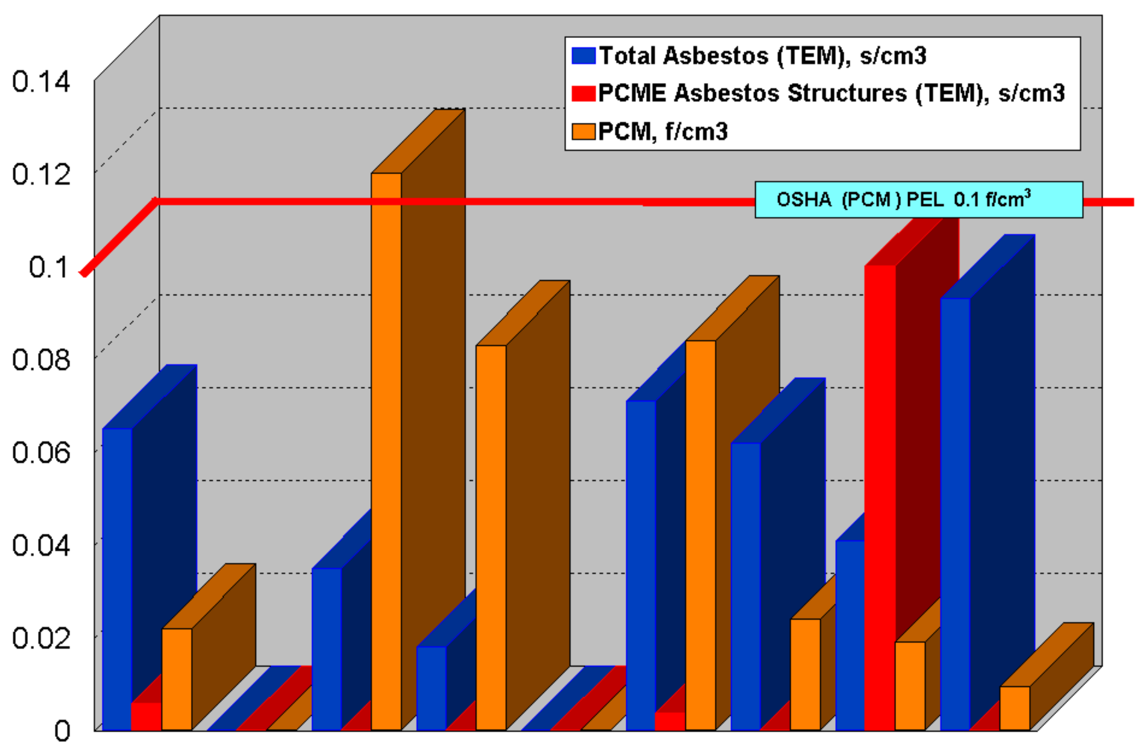

Figure 6-15. Abatement worker personal breathing zone concentrations of asbestos and total fibers.

(Wilmoth et al 1993) which showed that as many as 99 percent of the asbestos fibers during abatement activities are less than five microns in length.

The statistical analyses (Section 7.7) showed that the worker breathing zone fiber concentrations (PCM) from the AACM are not equal to the worker breathing zone fiber concentrations (PCM) from the NESHAP Method. Based on descriptive statistics, one would conclude the worker breathing zone fiber concentrations (PCM) from the AACM are less than the worker breathing zone fiber concentrations (PCM) from the NESHAP Method.

Based on the observed proportion of detects (Section 7.8), the worker breathing zone asbestos concentrations (TEM) from the AACM are less than the worker breathing zone asbestos concentrations (TEM) from the NESHAP method.

6.1.5.1.2 Walkers

The walkers were members of the contractor team who continually surveyed and inspected the performance of the samplers, both personal and stationary. All walker samples for both demolitions were non-detect for asbestos at the 0.005 s/cm^3 analytical sensitivity level (Table

6-15). PCM analysis of the same filters showed total fiber concentrations that ranged from 0.008 to 0.018 f/cm^3 with an average concentration of 0.013 f/cm^3.

All walker samplers showed a calculated eight-hr time-weighted average (TWA) concentration which was far below the OSHA PEL.

6.1.5.1.3 Worker Summary

Worker breathing zone samples for the abatement workers, which constituted the longest time component (by a factor of nine) of the NESHAP Method, registered elevated levels of asbestos by TEM and fibers by PCM (one equaling the OSHA PEL). In one instance, an EPA observer entered the containment area during the abatement and observed an abatement worker who had removed his respirator and was working without respiratory protection.

Demolition worker breathing zone samples for asbestos were almost all non-detect for both the NESHAP Method and the AACM.

Figure 6-16 illustrates the relative magnitude of both total and PCME asbestos concentrations for all demolition worker breathing zone samples, which include results from the landfill workers

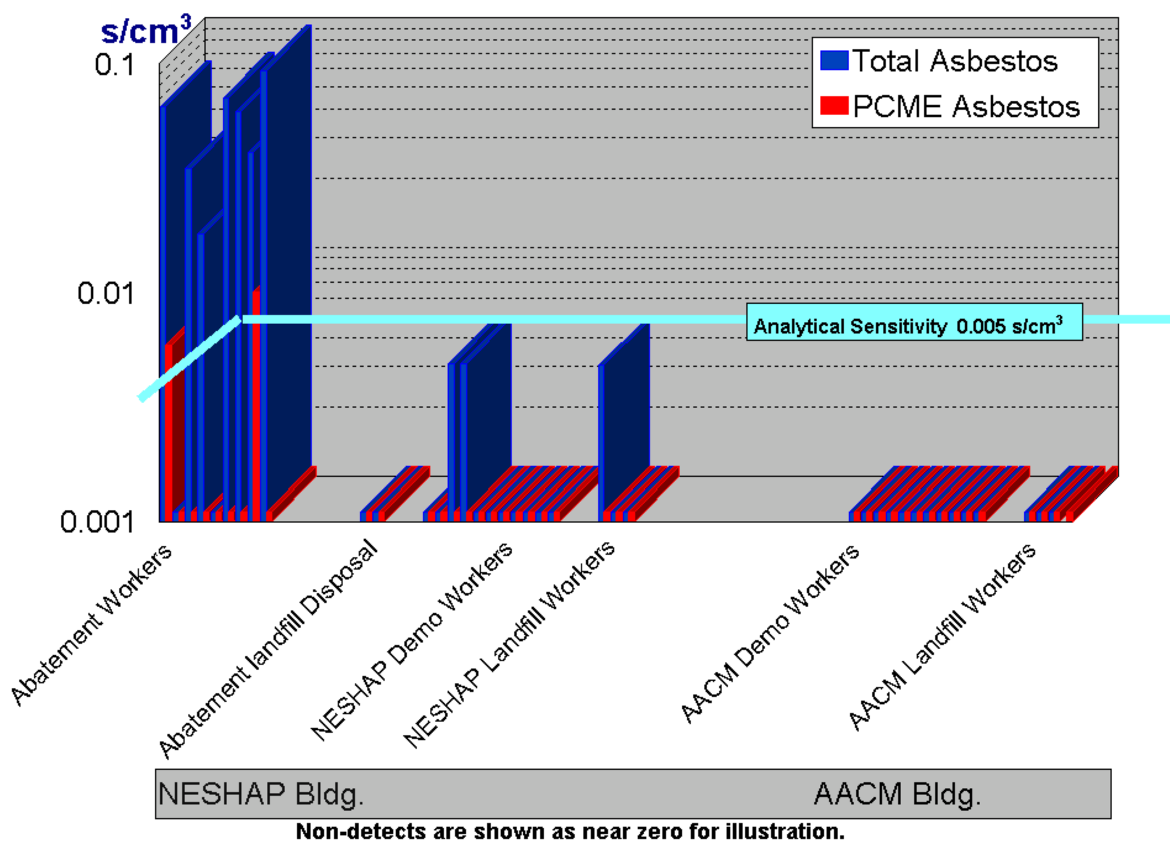

Figure 6-16. Worker breathing zone asbestos (TEM) data from the NESHAP and AACM demolition processes.

that are discussed in Section 6.2.3. Since the NESHAP process includes the abatement process, the AACM offers a significant improvement in the reduction of workplace asbestos concentrations as compared to the overall NESHAP process.

6.1.5.2 Lead (Pb)

Personal breathing zone samples were collected on the same workers sampled for asbestos and total fibers. Lead was not present in any of the samples at an analytical limit of detection of one µg per sample, which is equivalent to a volume adjusted detection limit of <2 µg/m^3.

6.2 Results From Landfilling Demolition Debris

6.2.1 Meteorology

The wind speed and wind direction sensors of the meteorological station located at the landfill malfunctioned during the study. Fortunately, the Fort Smith Airport Weather Station was about 1000 ft away and the meteorological data were obtained from this station and were used for the disposal portion of the study. Figure 6-17 illustrates the wind rose for the NESHAP disposal. Figure 6-18 illustrates the wind rose for the AACM disposal.

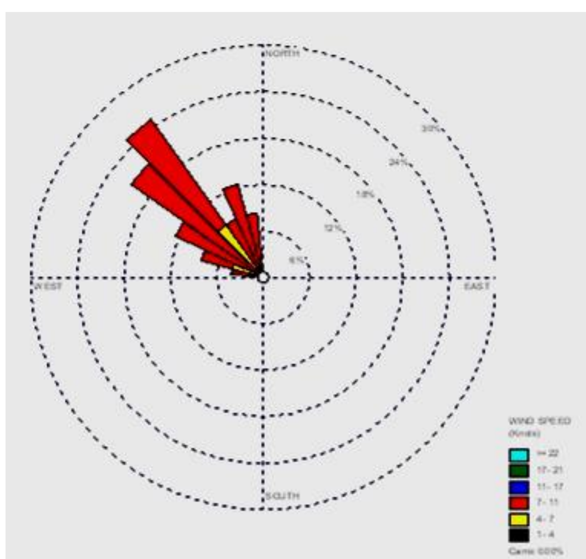

Figure 6-17. Landfill wind rose during the NESHAP debris disposal.

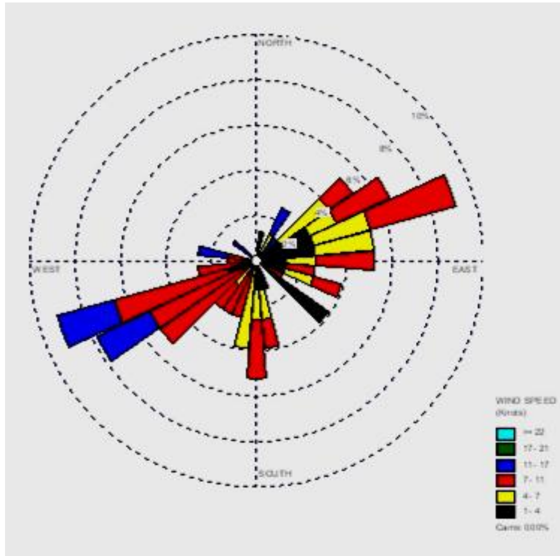

Figure 6-18. Landfill wind rose during the AACM debris disposal.

6.2.2 Perimeter Air

At the landfill, perimeter air samples for asbestos and total fibers were collected. Table 6-17 presents the descriptive statistics for the background airborne asbestos and total fiber concentrations measured prior to landfilling of the NESHAP and AACM building debris. Individual sample results are presented in Table A-4 of Appendix A. One of the six samples showed an asbestos concentration at the analytical sensitivity of 0.00049 s/cm^3.

Table 6-18 presents the descriptive statistics for the airborne asbestos and total fiber concentrations measured during landfilling of the NESHAP and AACM building debris, which includes soil from the AACM building. Individual sample results are presented in Table A-5 of Appendix A.

The asbestos results indicate concentrations at or near background levels. Similar to the asbestos concentrations, the fiber concentrations, as measured by PCM, were low values near the analytical sensitivity; however, in contrast to the asbestos results, there were fibers detected at all sampling stations but one.

Table 6-17. Background air levels of asbestos (TEM) and total fibers (PCM) prior to landfill of demolition debris from NESHAP and AACM buildings.

Asbestos, s/cm^3				Total Fibers, f/cm^3			
n/N[a]	Mean[b]	Minimum	Maximum	n/N	Mean[b]	Minimum	Maximum
1/6	0.00008	0	0.00049	3/6	0.0020	0	0.0052

[a] Denotes number of samples at or above analytical sensitivity/total number of samples.
The analytical sensitivity was 0.00049 s/cm^3 for TEM and 0.002 f/cm^3 for PCM. The ISO limit of detection for asbestos is equal to three times the analytical sensitivity (<0.0015 s/cm^3) for TEM.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

Table 6-18. Airborne asbestos (TEM) and Total Fibers (PCM) during landfilling of NESHAP and AACM buildings demolition debris.

Asbestos , s/cm^3				**Total Fibers, f/cm^3**			
n/N[a]	**Mean [b]**	**Minimum**	**Maximum**	**n/N**	**Mean [b]**	**Minimum**	**Maximum**
NESHAP Building							
0/9	0	0	0	8/9	0.0022	0	0.0032
AACM Building – Day 1							
1/9	0.00005	0	0.00048	9/9	0.0021	0.0010	0.0031
AACM Building – Day 2							
1/9	0.00005	0	0.00049	9/9	0.0039	0.0022	0.0076

[a] Denotes number of samples at or above analytical sensitivity/total number of samples.
The analytical sensitivity ranged from 0.00047 to 0.00049 s/cm^3 for TEM and 0.001 f/cm^3 for PCM. The ISO reportable detection limit for asbestos was <0.0015 s/cm^3 for TEM.
[b] Calculated based on the use of zero for values less than the analytical sensitivity.

Because of the large proportion of non-detects, it was not possible to conduct meaningful inferential statistical tests or use the descriptive statistics to make conclusions using the TEM data.

6.2.3 Workers

6.2.3.1 Asbestos and Total Fibers

Personal breathing zone samples were collected from the workers at the landfill, including the bulldozer operator and the compactor operator. The data for these samples are presented in Table 6-19. Individual sample results are presented in Table A-10 of Appendix A.

The eight-hr TWA for this study was calculated by multiplying the observed breathing zone fiber (PCM) concentration by the number of hours in that working environment and dividing that by eight hours (the basis for the PEL is an eight-hr workday). In this study, the filters were operated the entire time that a worker was involved in the task.

Table 6-19. Personal breathing zone concentrations of asbestos (TEM) and total fibers (PCM) during landfilling of demolition debris from NESHAP and AACM buildings.

	Asbestos, s/cm^3	**Total Fibers, f/cm^3**	
		Sample Period	Eight-hr TWA
Landfill of NESHAP Building Demolition Debris			
Bulldozer Operator	0.0048	0.043	0.06
Compactor Operator	0	0.16	0.26
Landfill of AACM Building Demolition Debris			
Bulldozer Operator	0	0.023	0.02
Compactor Operator	0	0.053	0.22

The analytical sensitivity ranged from 0.0048 to 0.0049 s/cm^3 for TEM and 0.001 f/cm^3 for PCM. The ISO limit of detection for asbestos is equal to three times the analytical sensitivity (<0.015 s/cm^3) for TEM.

The eight-hr TWA concentration of total fibers during landfilling of the demolition debris exceeded the OSHA PEL for the compactor operator for both the NESHAP and AACM demolition debris disposal situations. However, it should be noted that these fibers were not asbestos since the analysis of the same filter by TEM indicated asbestos values at or below the analytical sensitivity.

Because of the large proportion of non-detects, it was not possible to conduct meaningful inferential statistical tests or use the descriptive statistics to make conclusions using the TEM data.

6.2.3.2 Lead (Pb)

All landfill worker samples for lead were non-detect at an analytical sensitivity of 4 $\mu g/m^3$.

SECTION 7 STATISTICAL ANALYSES

Due to the large number of non-detect data, the statistical methods proposed in the QAPP were not always employed. For the inferential tests discussed in this section, the following approaches were used for the treatment of non-detects:

- In cases where there were less than five percent non-detect data and substituting one-half the detection limit would not affect the conclusions of the inferential test, the parametric methods proposed in the QAPP were employed, unless the assumptions of the parametric test were not met.

- In cases where the percent of non-detects was between 5 and 90, nonparametric methods based on ranks and adjusted for ties (Lehmann 2006, Chapter 1, Section 4) were employed.

- In cases where there were greater than 90% non-detect data for either method, no statistical analyses were conducted.

- As previously discussed in Section 6 (Results), zeros were substituted for the non-detects in calculating the descriptive statistics.

The data from Ring 1 were used in performing the statistical analyses as required in the QAPP.

7.1 Primary Objective 1

Null hypothesis: The airborne asbestos (TEM) concentrations from the AACM are equal to the airborne asbestos (TEM) concentrations from the NESHAP Method.

7.1.1 Day 1 NESHAP vs. Day 1 and 2 AACM

The total asbestos data consists of measurements at two heights at eighteen monitoring locations. Data for the NESHAP method were collected on one day and consist of thirty-six measurements (duplicate measurements are identical, all are non-detects). Thirty-two of the thirty-six total asbestos measurements are non-detects (89% of the data are censored). Data for the AACM were collected on two days and consist of seventy-two measurements (duplicate measurements are identical, all are non-detects). Fifty-nine of the seventy-two total asbestos measurements are non-detects (82% of the data are censored).

Prior to calculating descriptive statistics and conducting an inferential test for method differences, the AACM data for days one and two were combined by sampling location. The data were combined as follows:

- if Day 1 was a detect and Day 2 was a non-detect, the detect value was kept;
- if Day 1 was a non-detect and Day 2 was a detect, the detect value was kept;
- if both days were non-detects, the larger non-detect value was kept;
- if both days were detects, the detect values were summed.

The data from both methods are provided in Table 7-1.

Table 7-1. Airborne Asbestos Concentrations (s/cm^3) for Total Asbestos (TEM) and PCME (TEM) Structures for the AACM (Days 1 and 2 Combined) and NESHAP Method and Ranks for the Wilcoxon Rank-Sum Test.

Monitor	Height	TOTAL ASBESTOS (s/cm^3)		PCME ASBESTOS (s/cm^3)	
		AACM	NESHAP	AACM	NESHAP
1	1	ND* / 54	ND / 10	ND	ND
2	1	ND / 10	ND / 10	ND	ND
3	1	0.00145 / 71	ND / 54	0.00049	ND
4	1	0.00049 / 54	ND / 28.5	ND	ND
5	1	0.00049 / 54	ND / 54	ND	ND
6	1	ND / 10	ND / 54	ND	ND
7	1	ND / 54	ND / 10	ND	ND
8	1	0.00049 / 54	ND / 28.5	ND	ND
9	1	0.00049 / 54	ND / 28.5	ND	ND
10	1	ND / 10	ND / 54	ND	ND
11	1	ND / 28.5	ND / 28.5	ND	ND
12	1	ND / 28.5	ND / 10	ND	ND
13	1	ND / 28.5	ND / 10	ND	ND
14	1	ND / 28.5	ND / 28.5	ND	ND
15	1	ND / 54	0.00049 / 54	ND	0.00049
16	1	0.00049 / 54	ND / 28.5	ND	ND
17	1	ND[1] / 54	ND / 10	ND[1]	ND
18	1	0.00049 / 54	ND / 28.5	0.00049	ND
1	2	ND / 54	ND / 10	ND	ND
2	2	0.00049 / 54	ND / 54	ND	ND
3	2	0.00194 / 72	0.00049 / 54	0.00048	ND
4	2	ND / 10	ND / 10	ND	ND
5	2	0.00049 / 54	ND / 28.5	ND	ND
6	2	ND / 54	0.00049 / 54	ND	0.00049
7	2	ND / 54	ND / 54	ND	ND
8	2	0.00049 / 54	ND / 10	0.00049	ND
9	2	0.00049 / 54	0.00049 / 54	ND	0.00049
10	2	ND / 10	ND / 10	ND	ND
11	2	ND / 54	ND / 10	ND	ND
12	2	ND / 54	ND / 54	ND	ND
13	2	0.00049 / 54	ND / 28.5	ND	ND
14	2	ND / 10	ND / 54	ND	ND
15	2	ND / 28.5	ND / 10	ND	ND
16	2	ND / 28.5	ND / 10	ND	ND
17	2	ND / 54	ND / 28.5	ND	ND
18	2	ND / 28.5	ND / 28.5	ND	ND

*ND = 0.00033, 0.00048, or 0.00049 s/cm^3

[1] Sample 17 was inadvertently not changed out at the end of Day 1, but operated for the entire sampling period; however, no asbestos structures were seen.

To evaluate the null hypothesis, the Wilcoxon Rank-Sum test (Bickel 1977) was conducted using the total asbestos concentrations. The total asbestos concentration ranks used to calculate the test statistic are displayed in Table 7-1. The Wilcoxon Rank-Sum test statistic provided a p-value of 0.006; therefore, it was concluded that *the airborne asbestos (TEM) concentrations from the AACM are not equal to the airborne asbestos (TEM) concentrations from the NESHAP Method.*

Due to the large proportion of censored data for both methods, an additional nonparametric test was employed to test the null hypothesis that the proportion of NDs for the two methods are equivalent (proportion of NDs for AACM = 0.64 (23 out of 36) versus the proportion of NDs for NESHAP = 0.89 (32 out of 36)). The Chi-Square statistic for difference in proportions (Bickel and Doksum, 1977, Section 8.3) was conducted and provided a test statistic of $\chi^2 = 6.24$ and p-value = 0.004; therefore, it was concluded that *the proportion of non-detects for the two methods is not equivalent.*

A parametric evaluation of the total asbestos data was conducted assuming a Poisson distribution. In addition to the two nonparametric tests applied, the AACM and NESHAP Method can also be compared using fiber count data from the TEM analyses. The model for this comparison is as follows. For a single TEM analysis, we will use the notation below:

A = Effective filter area;
a = Area viewed by the TEM (randomly selected);
V = Air volume drawn through the filter;
N = True total number of asbestos fibers on the filter;
C = Observed TEM asbestos fiber count.

When fibers are sparse, the observed count C has approximately a Poisson distribution with parameter (mean) $\lambda = a*N/A$, the expected number of fibers in the (small) area examined by TEM. The detection limit (DL) for the analysis (estimated airborne asbestos concentration corresponding to a single observed fiber) is

$$DL = A*a/V$$

The estimated airborne asbestos concentration for the sample is

$$(C*A)/(a*V) = C*DL$$

In the air analyses conducted for this project, the area of each filter examined by TEM was varied to ensure a constant detection limit of 0.00049 for all the samples. Thus, the estimated mean airborne asbestos concentration for all the AACM samples is given by

$$\text{Mean airborne asbestos concentration} = DL*(\sum C_i)/36$$

where C_i, i = 1,...,36 are the individual sample results. This formula reduces to Mean AACM airborne asbestos concentration = (Total AACM fiber count)*constant where the constant = DL/36 = $1.35*10^{-5}$. Since the individual TEM analyses are independent, the total fiber count also has a Poisson distribution (Bickel and Doksum, 1977).

The mean NESHAP airborne asbestos concentration is proportional to the total NESHAP fiber count, and the proportionality constant is the same, because the DL and the number of samples are the same for both methods. Thus, under the null hypothesis that the AACM concentrations are equal to the NESHAP concentrations, the total fiber counts for the two methods are independent Poisson random variables with the same parameter. The null hypothesis will therefore be rejected when the total AACM fiber count is sufficiently larger than the total NESHAP fiber count.

Let C(A) and C(N) be the total fiber counts for the two methods. Although the parameter of the common Poisson distribution is not known, and therefore cannot be used to determine the statistical test, there is a conditional test which is independent of the value of the Poisson parameter. Specifically, if C(A) and C(N) are independent Poisson variables with the same parameter, the conditional distribution of C(A), given the combined total C(A)+C(N), has a binomial distribution with parameters C(A)+C(N) and 0.5. This binomial distribution can be used to determine the one-sided critical value for C(A), as follows. Referring to Table 7-1, samples listed as non-detect (ND) had 0 fibers counted, those at 0.00049 had one fiber, 0.000145 had three fibers and 0.00194 had four fibers. The total fiber count for AACM was 18, and for NESHAP, 4. Under the null hypothesis, the AACM count would be binomial with parameters 22 and 0.5. The probability of a value of 18 or greater is 0.002. The null hypothesis is therefore rejected with $p = 0.002$.

Since the Poison analysis confirms the conclusions reached by the Chi-Square and Wilcoxon tests, it was *concluded that the airborne asbestos (TEM) concentrations from the AACM are not equal to the airborne asbestos (TEM) concentrations from the NESHAP Method. In fact, the empirical evidence (the proportion of non-detects and the maximum values) from the investigation suggests airborne asbestos (TEM) concentrations from the AACM are greater than the airborne asbestos (TEM) concentrations from the NESHAP Method.*

The PCME data in Table 7-1 were collected under the same conditions as total asbestos and received the same data treatment prior to any analyses. In this case, since 89% of the NESHAP measurements and 92% of the AACM measurements are censored, *no statistical analysis was conducted*.

7.1.2 Day 1 Comparisons: AACM versus NESHAP

In order to better understand the difference in total asbestos concentrations between the two methods, a comparison was conducted using only the data from the actual building demolitions (Table 7-2). As stated previously, thirty-two of the thirty-six total asbestos measurements for the NESHAP method are non-detects (89% of the data are censored). Thirty-three of the thirty-six total asbestos measurements for the AACM are non-detects (92% of the data are censored). Although neither nonparametric test is appropriate for analyzing these data, the observed proportion of detects would lead one to conclude that for this demonstration the difference between the two methods is a function of the AACM Day 2 activities (soil excavation and removal).

Table 7-2. Airborne Asbestos Concentrations (s/cm^3) for Total Asbestos (TEM) for the AACM and NESHAP Method by Day.

Monitor	Height	AACM Day 1	NESHAP Day 1	AACM Day 2
1	1	ND	ND	ND
2	1	ND	ND	ND
3	1	0.00096	ND	0.00049
4	1	ND	ND	0.00049
5	1	ND	ND	0.00049
6	1	ND	ND	ND
7	1	ND	ND	ND
8	1	ND	ND	0.00049
9	1	ND	ND	0.00049
10	1	ND	ND	ND
11	1	ND	ND	ND
12	1	ND	ND	ND
13	1	ND	ND	ND
14	1	ND	ND	ND
15	1	ND	0.00049	ND
16	1	0.00049	ND	ND
17	1	ND[1]	ND	ND[1]
18	1	ND	ND	0.00049
1	2	ND	ND	ND
2	2	ND	ND	0.00049
3	2	ND	0.00049	0.00194
4	2	ND	ND	ND
5	2	ND	ND	0.00049
6	2	ND	0.00049	ND
7	2	ND	ND	ND
8	2	ND	ND	0.00049
9	2	ND	0.00049	0.00049
10	2	ND	ND	ND
11	2	ND	ND	ND
12	2	ND	ND	ND
13	2	0.00049	ND	ND
14	2	ND	ND	ND
15	2	ND	ND	ND
16	2	ND	ND	ND
17	2	ND	ND	ND
18	2	ND	ND	ND

ND = 0.00048, or 0.00049 s/cm^3

[1] Sample 17 was inadvertently not changed out at the end of Day 1, but operated for the entire sampling period; however, no asbestos structures were seen.

7.2 Primary Objective 2

Null hypothesis: The post-excavation asbestos concentrations in the soil from the AACM are equal to the post-demolition asbestos concentrations in the soil from the NESHAP Method.

For each method and phase of the project (PRE-demolition, POST-demolition and POST-excavation (AACM only)), ten composite soil samples were collected. Three fractions (soil, rocks/organics, and building debris) of each composite sample were analyzed for asbestos. For Primary Objective 2, the comparison of the AACM and NESHAP methods was based on the number of asbestos structures per gram (s/g) of soil in the first fraction, as determined by TEM (Table 7-3). Table 7-3 shows that the soil fraction was more than 95% of the sample by weight in most cases. Within each method and phase, there is considerable variation (at least an order of magnitude) in asbestos concentrations between different composites. Since each composite represents, in theory, the average asbestos soil concentration within the bermed area for the phase in question, the variation in reported levels is due to a combination of spatial variation in asbestos soil concentrations, sub-sampling variability during sample preparation, and variability of the TEM structure count.

Two of the ten structure count measurements for the post-demolition NESHAP method are non-detects (20% of the data are censored). Seven of the ten structure count measurements for the post-excavation AACM are non-detects (70% of the data are censored). The Wilcoxon Rank - Sum test was used to evaluate the null hypothesis. The structure count ranks used to calculate the test statistic are displayed in Table 7-3 for AACM post-excavation and NESHAP post-demolition observations. The test provided a test statistic value of 2.1322 and p-value of 0.033; therefore *one would conclude the post-excavation asbestos concentrations in the soil from the AACM are not equal to the post-demolition asbestos concentrations in the soil from the NESHAP Method.* Examination of the descriptive statistics for the structure counts reveals that the AACM

Table 7-3. Asbestos in Soil (s/g) by TEM by the AACM and NESHAP Method / Ranks for the Wilcoxon Rank-Sum Test (NESHAP POST vs. AACM POST-EXCAV).

Method	Phase	Composite No.	Weight %	Asbestos (s/g)	Structure Count/ Rank
NESHAP	PRE	1	99.3	ND*	0
NESHAP	PRE	2	100	6.59E+07	2
NESHAP	PRE	3	99.7	ND	0
NESHAP	PRE	4	99.6	ND	0
NESHAP	PRE	5	98.5	3.29E+08	22
NESHAP	PRE	6	98.2	2.54E+07	3
NESHAP	PRE	7	99.2	5.73E+06	1
NESHAP	PRE	8	100	ND	0
NESHAP	PRE	9	98.6	7.75E+06	1
NESHAP	PRE	10	97.9	5.84E+07	2
NESHAP	POST	1	91.5	8.96E+06	1 / 12.5

Table 7-3. Asbestos in Soil (s/g) by TEM by the AACM and NESHAP Method / Ranks for the Wilcoxon Rank-Sum Test (NESHAP POST vs. AACM POST-EXCAV). (Continued)

Method	Phase	Composite No.	Weight %	Asbestos (s/g)	Structure Count/ Rank
NESHAP	POST	2	97.5	1.56E+08	71 / 19
NESHAP	POST	3	95.8	ND	0 / 5
NESHAP	POST	4	96.2	ND	0 / 5
NESHAP	POST	5	97.4	5.79E+06	1 / 12.5
NESHAP	POST	6	96.3	4.06E+06	1 / 12.5
NESHAP	POST	7	96.6	1.60E+09	119 / 20
NESHAP	POST	8	95.3	1.52E+07	2 / 16.5
NESHAP	POST	9	95.3	9.17E+06	1 / 12.5
NESHAP	POST	10	96.1	2.37E+07	2 / 16.5
AACM	PRE	1	98.7	ND	0
AACM	PRE	2	98.7	1.90E+07	3
AACM	PRE	3	98.6	ND	0
AACM	PRE	4	96.5	1.09E+07	1
AACM	PRE	5	97.8	ND	0
AACM	PRE	6	95.8	1.02E+07	1
AACM	PRE	7	98.7	ND	0
AACM	PRE	8	96.7	4.25E+07	4
AACM	PRE	9	98.7	1.51E+07	2
AACM	PRE	10	99.1	1.15E+10	136
AACM	POST	1	90.9	ND	0
AACM	POST	2	85.3	4.34E+07	6
AACM	POST	3	93.0	1.76E+08	13
AACM	POST	4	90.1	2.11E+08	24
AACM	POST	5	92.0	9.67E+06	1
AACM	POST	6	95.0	ND	0
AACM	POST	7	96.1	2.97E+07	4
AACM	POST	8	96.4	2.68E+07	4
AACM	POST	9	96.2	ND	0
AACM	POST	10	94.3	1.02E+07	1
AACM	POST-EXCAV	1	94.5	8.07E+06	1 / 12.5
AACM	POST-EXCAV	2	92.6	ND	0 / 5
AACM	POST-EXCAV	3	94.9	ND	0 / 5
AACM	POST-EXCAV	4	96.2	7.99E+06	1 / 12.5
AACM	POST-EXCAV	5	95.2	1.51E+08	11 / 18
AACM	POST-EXCAV	6	93.8	ND	0 / 5
AACM	POST-EXCAV	7	93.7	ND	0 / 5
AACM	POST-EXCAV	8	95.3	ND	0 / 5
AACM	POST-EXCAV	9	95.9	ND	0 / 5
AACM	POST-EXCAV	10	93.4	ND	0 / 5

*Note that composite samples for which the TEM structure count is zero are considered non-detects (ND).

Table 7-4. Descriptive Statistics for the AACM (POST-EXCAVATION) and NESHAP (POST-DEMOLITION) Structure Counts.

Method	Minimum	1st Quartile	Median	3rd Quartile	Maximum
NESHAP	0	1	1	2	119
AACM	0	0	0	1	11

has lower counts for the 1st, 2nd (median), and 3rd quartiles as well as the maximum (Table 7-4). Therefore, the empirical evidence from this investigation suggests *the post-excavation asbestos concentrations in the soil from the AACM are less than the post-demolition asbestos concentrations in the soil from the NESHAP Method.*

7.3 Secondary Objective 2

Null hypothesis: The airborne fiber (PCM) concentrations from the AACM are equal to the airborne fiber (PCM) concentrations from the NESHAP Method.

Table 7-5 displays the total fiber concentrations, as measured by PCM, for the AACM and NESHAP method.

Prior to conducting a hypothesis test, the background data from both methods were evaluated. The six background values surrounding the buildings to be demolished by each method are displayed using box plots[5] in Figure 7-1. The box plots show that the background concentration in the area of the AACM demolition is higher than the area of the NESHAP demolition. The AACM background median is 0.0025 f/cm^3 and NESHAP background median is 0.0014 f/cm^3. Therefore prior to conducting any inferential tests, the appropriate median background concentration was subtracted from the empirical values displayed in Table 7-5.

The null hypothesis was evaluated by conducting a Wilcoxon Rank Sum test (due to the non-normality of the data), using the data from Day 1 for the NESHAP Method and the combined data from Days 1 and 2 for the AACM, adjusted for background. The median adjusted data along with the ranks used to calculate the test statistics are displayed in Table 7-6. The Wilcoxon test provided a test statistic of -1.211 and a p-value of 0.2259; therefore, one would *conclude there is insufficient information to reject the null hypothesis that the airborne fiber (PCM) concentrations from the AACM are equal to the airborne fiber (PCM) concentrations from the*

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[5] A *box plot* is a rectangle in which the top and bottom of the rectangle represent the upper and lower quartiles of the data and the horizontal line within the rectangle represents the median. Lines, in the shape of a ―T", extend from the box to the nearest value not beyond a *standard span* from the quartiles. These lines are often referred to as whiskers. Values beyond the end of the whiskers are drawn individually.

The *standard span* is 1.5·Inter-Quartile Range (IQR) , where the *upper quartile* is the 75th quantile, Q(.75), the *lower quartile* is the 25th quantile, Q(.25) and the *IQR* = Q(.75) Q(.25).

The box plot of a set of observations that are normally distributed will be symmetric with the median in the center of the box.

Table 7-5. Total Fiber Concentrations by PCM (f/cm^3) for the AACM and NESHAP Method by Day.

Monitor	Height	NESHAP (f/cm^3)	AACM (f/cm^3)		
		DAY 1	DAY 1	DAY 2	TOTAL
1	5-ft	ND*	0.0032	0.0029	0.0061
2	5-ft	0.0014	0.0034	0.0023	0.0057
3	5-ft	ND	0.0033	0.0037	0.0070
4	5-ft	0.0016	0.0024	0.0035	0.0059
5	5-ft	0.0022	0.0021	0.0028	0.0049
6	5-ft	0.0013	0.0012	0.0041	0.0053
7	5-ft	0.0017	0.0015	0.0026	0.0041
8	5-ft	0.0018	0.0042	0.0011	0.0053
9	5-ft	0.0062	0.0044	0.0046	0.0090
10	5-ft	0.0045	0.0018	0.0021	0.0039
11	5-ft	0.0021	0.0040	0.0048	0.0088
12	5-ft	0.0034	0.0031	0.0046	0.0077
13	5-ft	0.0017	0.0024	0.0041	0.0065
14	5-ft	0.0029	0.0037	0.0012	0.0049
15	5-ft	0.0024	0.0020	0.0023	0.0043
16	5-ft	0.0025	0.0029	0.0055	0.0084
17	5-ft	0.0023	--[1]	--[1]	0.0017
18	5-ft	ND	0.0035	0.0022	0.0057
1	15-ft	0.0023	0.0021	0.0024	0.0045
2	15-ft	0.0013	0.0029	0.0018	0.0047
3	15-ft	0.0014	0.0053	0.0036	0.0089
4	15-ft	0.0032	0.0013	0.0019	0.0032
5	15-ft	0.0020	0.0026	0.0017	0.0043
6	15-ft	0.0011	0.0020	0.0033	0.0053
7	15-ft	0.0024	0.0023	0.0027	0.0050
8	15-ft	0.0039	0.0022	0.0160	0.0182
9	15-ft	0.0045	0.0023	0.0024	0.0047
10	15-ft	0.0022	0.0029	0.0019	0.0048
11	15-ft	0.0021	0.0027	0.0024	0.0051
12	15-ft	0.0030	0.0040	0.0044	0.0084
13	15-ft	0.0022	0.0038	0.0036	0.0074
14	15-ft	0.0035	0.0029	0.0029	0.0058
15	15-ft	ND	0.0027	0.0021	0.0048
16	15-ft	0.0056	0.0012	0.0034	0.0046
17	15-ft	0.0019	0.0028	0.0033	0.0061
18	15-ft	0.0017	0.0032	0.0024	0.0056

*ND = 0.0012 f/cm^3.

[1] Sample 17 was inadvertently not changed out at the end of Day 1, but operated for the entire sampling period.

Table 7-6. Median Adjusted Total Fiber Concentrations by PCM (f/cm^3) for the AACM and NESHAP / Ranks for the Wilcoxon Rank-Sum Test.

Monitor	Height	NESHAP (f/cm^3) [Day 1 – Median] * / Rank	AACM (f/cm^3) [Day 1 + Day 2 – 2*Median] / Rank
1	5-ft	-0.0002 / 15.5	0.0011 / 51.5
2	5-ft	0 / 23	0.0007 / 39.5
3	5-ft	-0.0002 / 15.5	0.002 / 57.5
4	5-ft	0.0002 / 26	0.0009 / 45
5	5-ft	0.0008 / 43	-0.0001 / 18.5
6	5-ft	-0.0001 / 20.5	0.0003 / 29.5
7	5-ft	0.0003 / 29.5	-0.0009 / 4
8	5-ft	0.0004 / 33	0.0003 / 29.5
9	5-ft	0.0048 / 71	0.004 / 69
10	5-ft	0.0031 / 63.5	-0.0011 / 3
11	5-ft	0.0007 / 37.5	0.0038 / 67
12	5-ft	0.002 / 57.5	0.0027 / 62
13	5-ft	0.0003 / 29.5	0.0015 / 53
14	5-ft	0.0015 / 54	-0.0001 / 18.5
15	5-ft	0.001 / 48.5	-0.0007 / 5.5
16	5-ft	0.0011 / 50	0.0034 / 65.5
17	5-ft	0.0009 / 46.5	-0.0033 / 1
18	5-ft	-0.0002 / 15.5	0.0007 / 39.5
1	15-ft	0.0009 / 46.5	-0.0005 / 7
2	15-ft	-0.0002 / 15.5	-0.0003 / 10
3	15-ft	0 / 23	0.0039 / 68
4	15-ft	0.0018 / 56	-0.0018 / 2
5	15-ft	0.0006 / 36	-0.0007 / 5.5
6	15-ft	-0.0003 / 10	0.0003 / 29.5
7	15-ft	0.001 / 48.5	0 / 23
8	15-ft	0.0025 / 61	0.0132 / 72
9	15-ft	0.0031 / 63.5	-0.0003 / 10
10	15-ft	0.0008 / 43	-0.0002 / 15.5
11	15-ft	0.0007 / 37.5	0.0001 / 25
12	15-ft	0.0016 / 55	0.0034 / 65.5
13	15-ft	0.0008 / 43	0.0024 / 60
14	15-ft	0.0021 / 59	0.0008 / 41
15	15-ft	-0.0002 / 15.5	-0.0002 / 15.5
16	15-ft	0.0042 / 70	-0.0004 / 8
17	15-ft	0.0005 / 34	0.0011 / 51.5
18	15-ft	0.0003 / 29.5	0.0006 / 35

NESHAP Method. Figure 7-2 displays box plots for the median adjusted airborne fiber (PCM) concentrations for the AACM and NESHAP Method on Day 1, the AACM on Day 2, and the AACM where both days are combined. The box plots confirms the result from the hypothesis test, the box plots for the NESHAP Method Day1 and the AACM combined do not appear to differ.

A Day 1 comparison of the airborne fiber (PCM) concentrations between the two methods was conducted using the Wilcoxon Rank-Sum test. Like the conclusion from PO1, the test provided a significant p-value of 0.0167; therefore, one would conclude the airborne fiber (PCM) concentrations for the two methods are not equal on Day 1. Based on the box plots displayed in Figure 7-1 *one would conclude that the airborne fiber (PCM) concentrations for the AACM are less than the airborne fiber (PCM) concentrations for the NESHAP for the demolition day.*

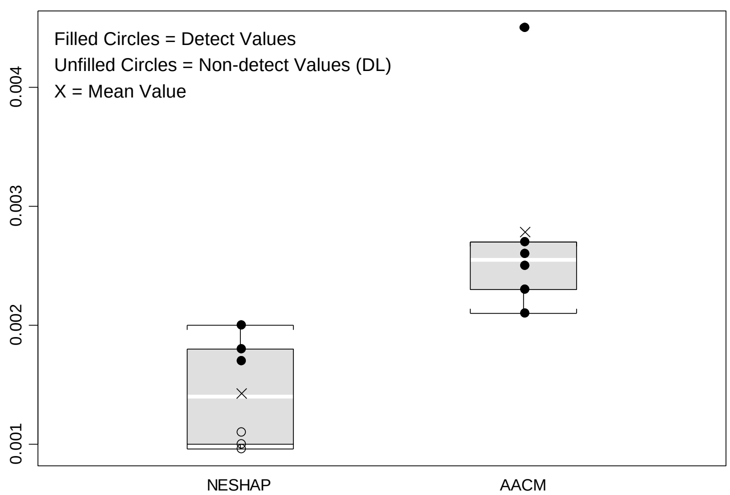

Figure 7-1. Box plots for the Background Total Fiber Concentrations by PCM (f/cm^3) for the AACM and NESHAP Method.

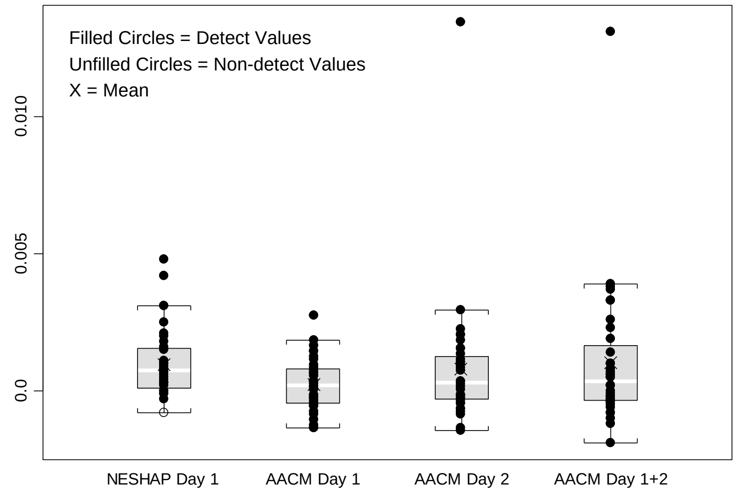

Figure 7-2. Box plots for the Background Total Fiber Concentrations by PCM (f/cm^3) Adjusted for Background AACM and NESHAP Methods by Day.

7.4 Secondary Objectives 4 and 5

Null hypothesis 4: The NESHAP airborne asbestos (TEM) concentrations downwind are equal to the NESHAP airborne asbestos concentrations upwind.

Null hypothesis 5: The AACM airborne asbestos (TEM) concentrations downwind are equal to the AACM airborne asbestos concentrations upwind.

During the NESHAP demolition, the wind blew from west-southwest approximately 75% of the time, and from northeast-north the other 25% of the time. For the AACM demolition, the wind blew between west and south approximately 50% of the time, between east and south approximately 30% of the time, and between East and East-Northeast 20% of the time. For the

AACM soil excavation and removal, the wind was between south and southeast 100% of the time. Since the wind direction was variable during the processes for both methods, the terms –upwind” and –downwind” are not unambiguously defined for the entire duration of the process. Therefore, Secondary Objectives 4 and 5 cannot be directly evaluated using the study data. However, as suggested in the QAPP, it may still be of interest to determine whether there is a relationship between the airborne asbestos concentration at a sampling location and the amount of time that location was downwind from the demolition site.

Figure 4-1 and Figure 4-2 show the inner ring of samplers (monitors) approximately equally spaced on a rectangle around the building. The monitors are numbered in clockwise order, starting with M1 located at the northwest corner of the ring. Using this figure and the three wind roses for the NESHAP and AACM, the percent of time each monitor was downwind of the building was estimated. For the AACM, the percent of time downwind is an average for the two days. Table 7-7 shows the results, as well as the total airborne asbestos concentration at each monitor. Data treatment prior to constructing Table 7-7 and conducting analyses are identical to Primary Objective 1.

The data in Table 7-7 are displayed by method in Figure 7-3 and Figure 7-4, where the unfilled circles display the non-detect values and the filled circles display the detect values. (Note the non-detect measurements were given a value of zero for plotting in order to better distinguish the non-detects from detect values). Based on Figure 7-3 and Figure 7-4, the data are inconclusive with regard to Secondary Objectives 4 and 5. *One would conclude the data from this investigation are not sufficient to establish a relationship between percent of time downwind and total airborne asbestos concentration.*

Table 7-7. Total Airborne Asbestos Concentrations (TEM) and Percent of Time Downwind, for AACM (Days 1 and 2 Combined) and NESHAP Method.

MONITOR	NESHAP		AACM	
	DOWNWIND	**TOT. ASB. (s/cm^3)**	**DOWNWIND**	**TOT. ASB. (s/cm^3)**
1	0%	ND*	64%	ND
2	12%	ND	77.5%	0.00049
3	67%	0.00049	87.5%	0.00339
4	74%	ND	87.5%	0.00049
5	74%	ND	87.5%	0.00098
6	74%	0.00049	84%	ND
7	74%	ND	23.5%	ND
8	67%	ND	13.5%	0.00098
9	67%	0.00049	13.5%	0.00098
10	0%	ND	0%	ND
11	20%	ND	0%	ND
12	27%	ND	2.5%	ND
13	27%	ND	2.5%	0.00049
14	27%	ND	2.5%	ND
15	27%	0.00049	2.5%	ND
16	27%	ND	2.5%	0.00049
17	14%	ND	9%	ND
18	0%	ND	70.5%	0.00049

*ND = 0.00033, 0.00048, or 0.00049 s/cm^3

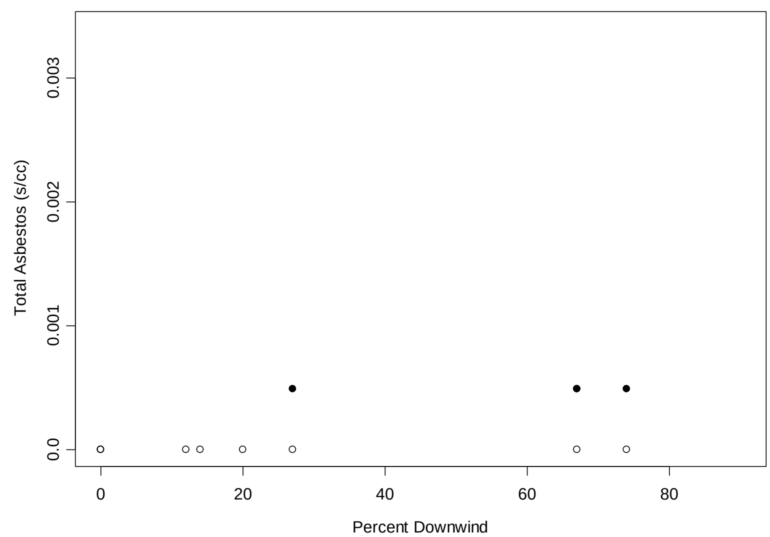

Figure 7-3. NESHAP Total Airborne Asbestos Concentrations (TEM) by Percent of Time Downwind. (Filled Circles = Detect Values; Unfilled Circles = Non-detect Values).

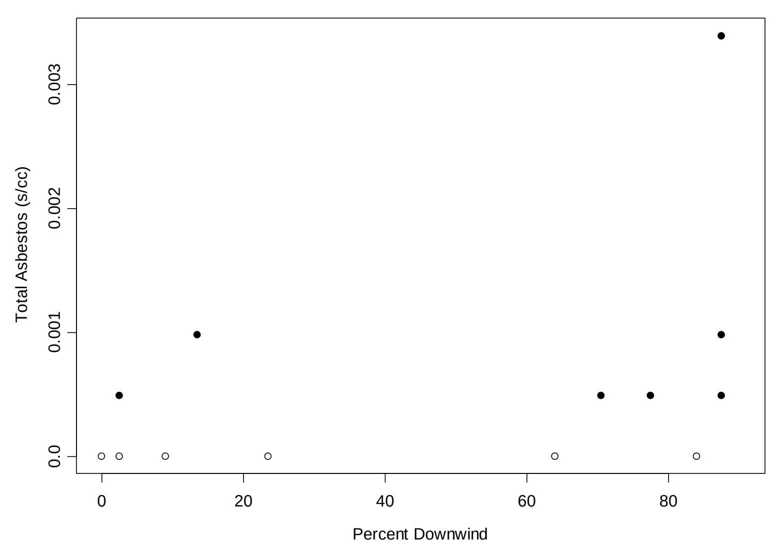

Figure 7-4. AACM Total Airborne Asbestos Concentrations (TEM) (Days 1 and 2 Combined) by Percent of Time Downwind. (Filled Circles = Detect Values; Unfilled Circles = Non-detect Values).

7.5 Secondary Objective 6

Null hypothesis: The asbestos loadings in the settled dust (TEM) from the AACM are equal to the asbestos loadings in the settled dust (TEM) from the NESHAP Method.

Table 7-8 shows asbestos loadings in settled dust (s/cm^2) in the inner ring of monitoring stations for each method. Despite a low percent of censored data, five percent (one out of 18) of the NESHAP measurements and twenty-two percent (four out of 18) of the AACM data are censored, the null hypothesis was evaluated by conducting a Wilcoxon Rank Sum test due to the non-normality of the distributions. The Wilcoxon test provided a test statistic value of 0.3164 and a p-value of 0.7517; therefore, *one would conclude there is insufficient information to reject the null hypothesis that the asbestos loadings in the settled dust (TEM) from the AACM are equal to the asbestos loadings in the settled dust (TEM) from the NESHAP Method.*

Examining the data using the empirical cumulative distributions would lead one to conclude there is no difference in the settled dust distributions of the two methods (see Figure 7-5). The Kolmogorov-Smirnov test, which tests the relationship between two distributions (the null hypothesis is there is no difference in the empirical distributions), confirms this observation with a test statistic value of 0.2222 and p-value of 0.781. The descriptive statistics (Table 7-9) show a slight difference at the lower quartiles, and at the upper quartiles the AACM concentrations are less than the NESHAP. *Based on Figure 7-5, Table 7-9, and the results of the Kolmogorov-Smirnov test, one would conclude there is no difference in the settled dust distributions of the two methods.*

Table 7-8. Asbestos Loadings (TEM) in Settled Dust (s/cm^2) in the Inner Ring.

MONITOR	AACM	NESHAP
1	243	ND*
2	10,852	ND
3	11,158	463
4	21,625	ND
5	485	ND
6	1,455	980
7	19,976	4,862
8	728	8,005
9	2,547	46,771
10	243	424
11	849	10,882
12	1,698	6,020
13	9,302	15,050
14	1,941	9,262
15	2,426	10,825
16	926	3,396
17	ND	2,084
18	4,851	212

* ND = 212, 222, 232 s/cm^2.

Table 7-9. Descriptive Statistics for Asbestos Loadings in the Settled Dust (s/cm^2) in the Inner Ring for the AACM and NESHAP Method (Sample Size=18).

Method	Minimum	1st Quartile	Median	3rd Quartile	Maximum
NESHAP	106	265	2740	8948	46771
AACM	116	758	1819	8189	21625

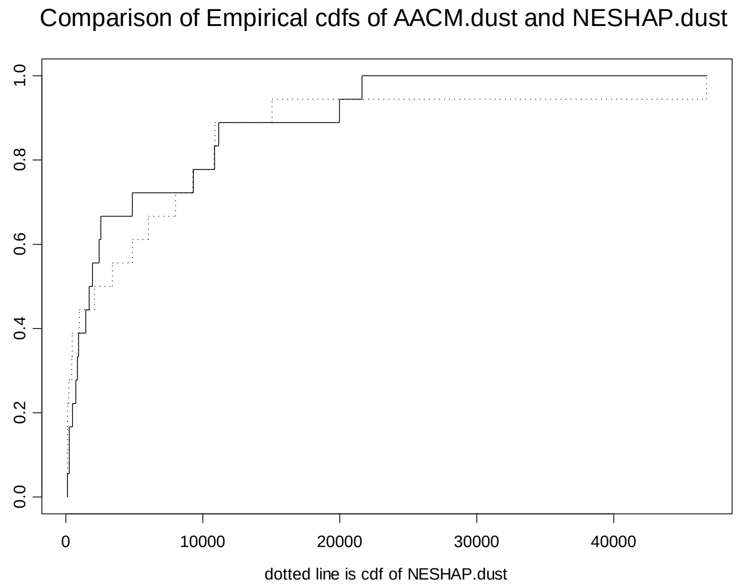

Figure 7-5. Empirical Cumulative Distributions for the Asbestos Loadings in the Settled Dust (s/cm^2) in the Inner Ring for the AACM and NESHAP Method.

7.6 Secondary Objective 7

Null hypothesis: The total particulate concentrations (as collected and measured by NIOSH Method 5000) from the AACM are equal to the total particulate concentrations from the NESHAP Method.

Table 7-10 shows total particulate concentrations (mg/m^3) by monitor in the inner ring for the NESHAP and AACM buildings. Since fifty-five percent (ten out of 18) of the NESHAP measurements and five percent (one out of 18) of the AACM measurements are censored, the Wilcoxon Rank Sum test was used to evaluate the null hypothesis. . The total particulate concentration ranks used to calculate the test statistic are displayed in Table 7-10. The Wilcoxon Rank Sum test statistic provided a p-value of 0.002; therefore, *one would reject the null hypothesis and conclude the total particulate concentrations (as collected and measured by*

Table 7-10. Total Particulate Concentrations (mg/m^3) for the AACM and NESHAP Method Methods / Ranks for the Wilcoxon Rank-Sum Test.

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MONITOR	AACM	NESHAP
1	0.15 / 35.5	0.11 / 31
2	0.14 / 33	0.07 / 24
3	0.14 / 33	ND* / 14
4	0.04 / 5	ND / 1.5
5	0.15 / 35.5	ND / 14
6	0.1 / 29.5	ND / 14
7	0.14 / 33	ND / 8.5
8	0.096 / 28	ND / 14
9	0.067 / 20	0.06 / 14
10	0.048 / 6	ND / 14
11	0.072 / 26	0.07 / 24
12	ND / 14	ND / 8.5
13	0.068 / 22	ND / 8.5
14	0.062 / 18	0.1 / 29.5
15	0.067 / 20	ND / 8.5
16	0.03 / 3.5	0.07 / 24
17	0.083 / 27	0.03 / 3.5
18	0.067 / 20	ND / 1.5

*ND = 0.02, 0.05, and 0.06 mg/m^3.

NIOSH Method 5000) from the AACM are not equal to the total particulate concentrations from the NESHAP Method.

Based on the observed proportion of detects, one would conclude that for this demonstration the total particulate concentration from the AACM are higher than the total particulate concentration from the NESHAP method.

7.7 Secondary Objective 8

Null hypothesis: The worker breathing zone fiber concentrations (PCM) from the AACM are equal to the worker breathing zone fiber concentrations (PCM) from the NESHAP Method.

Table 7-11 displays the worker breathing zone data (PCM) during demolition operations for the two methods. The ―Walker" samples were collected on personal monitors of personnel walking the two rings of samplers to check for personal breathing zone asbestos concentrations during that activity. Since these samples were not taken on typical workers who would be involved in either a NESHAP or AACM demolition, they were excluded from the analysis. A two-sample t-test was used to evaluate the null hypothesis, since there were no non-detects for the AACM and two out of seventeen non-detects for the NESHAP Method. The t-test statistic provided a test statistic value of -2.604 and a p-value of 0.015; therefore, *one would reject the null hypothesis and conclude the worker breathing zone fiber concentrations (PCM) from the AACM are not equal to the worker breathing zone fiber concentrations (PCM) from the NESHAP Method.*

Table 7-11. Total Fibers (f/cm^3 by PCM) on Worker Personal Monitors Measured at NESHAP and AACM Buildings during Demolition and Removal of Debris.

WORKER	AACM	NESHAP
Excavator Operator	0.0038	0.023
Hose Operator 1	0.0073	0.017
Hose Operator 2	0.0051	0.0089
Laborer 1	0.013	0.012
Laborer 2	0.016	0.036
Truck Operator 1	0.0091	0.042
Truck Operator 2	0.017	0.056
Truck Operator 3	0.0070	0.086
Walker 1	0.0077	0.027
Walker 2	0.013	0.0090
Walker 3	0.018	0.031
Abatement Worker 1	N/A	0.022
Abatement Worker 2	N/A	ND*
Abatement Worker 3	N/A	0.12
Abatement Worker 4	N/A	0.083
Abatement Worker 5	N/A	ND
Abatement Worker 6	N/A	0.084

*ND = 0.001 f/cm^3.

Figure 7-6 displays the box plots for worker fiber breathing zone concentrations (PCM) for the two methods. Based on Figure 7-6, one would conclude *the worker breathing zone fiber concentrations (PCM) from the AACM are less than the worker breathing zone fiber concentrations (PCM) from the NESHAP Method.*

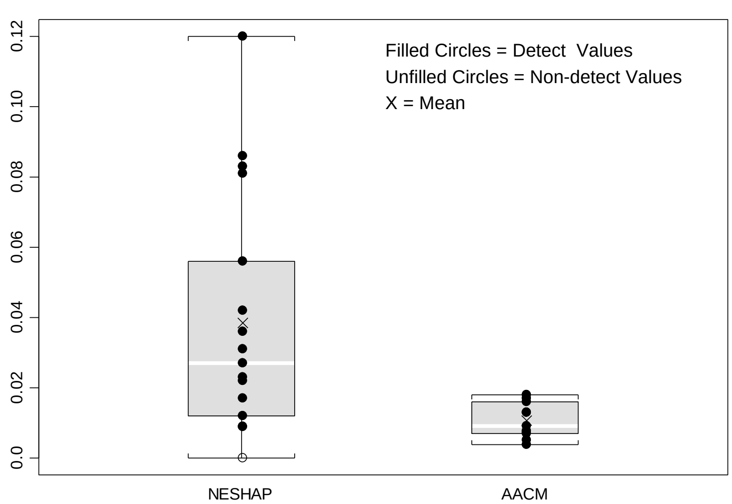

Figure 7-6. Box plots for Total Fibers (f/cm^3 by PCM) on Worker Personal Monitors during Demolition and Removal of Debris.

Note that there were too few samples (n=4 for AACM and n=3 for NESHAP) from landfill workers to conduct an inferential test (Appendix A, Table A-9). A similar trend (NESHAP was higher than the AACM) was observed in the data, where the mean of the NESHAP Method is 0.115 f/cm^3 and the mean of the AACM is 0.032 f/cm^3.

7.8 Secondary Objective 9

Null hypothesis: The worker breathing zone asbestos concentrations (TEM) from the AACM are equal to the worker breathing zone asbestos concentrations (TEM) from the NESHAP Method.

Table 7-12 displays the total asbestos concentrations measured on worker personal monitors during all phases of both methods. Since 100 percent (eight out of eight) of the AACM measurements and 50 percent (seven out of 14) of the NESHAP measurements are censored, *no inferential test was conducted. Based on the observed proportion of detects, one would conclude that for this demonstration the worker breathing zone asbestos concentrations (TEM) from the AACM are less than the worker breathing zone asbestos concentrations (TEM) from the NESHAP method.*

Table 7-12. Total Asbestos (s/cm^3 by TEM) on Worker Personal Monitors Measured at NESHAP and AACM Buildings During Abatement, Building Demolition, and Removal of Debris.

WORKER	AACM	NESHAP
Excavator Operator	ND*	ND
Hose Operator 1	ND	ND
Hose Operator 2	ND	0.00049
Laborer 1	ND	0.00048
Laborer 2	ND	ND
Truck Operator 1	ND	ND
Truck Operator 2	ND	ND
Truck Operator 3	ND	ND
Abatement Worker 1	N/A	0.06500
Abatement Worker 2	N/A	0.00190
Abatement Worker 3	N/A	0.03500
Abatement Worker 4	N/A	0.01800
Abatement Worker 5	N/A	ND
Abatement Worker 6	N/A	0.07100

*ND = 0.00041, 0.00046, 0.00047, 0.00048, and 0.00049 s/cm^3

7.9 Secondary Objectives 11, 12, and 13

Null hypothesis 11: The post-excavation asbestos concentration in the soil from the AACM are equal to the pre-demolition asbestos concentration for the AACM.

Null hypothesis 12: The post-demolition asbestos concentration in the soil from the NESHAP Method are equal to the pre-demolition asbestos concentration for the NESHAP Method.

Null hypothesis 13: The post-excavation asbestos concentration in the soil from the AACM are equal to the post -demolition asbestos concentration for the AACM.

The data are displayed in Table 7-3. The percent censoring for each of the three secondary objectives is displayed in Table 7-13.

For Secondary Objectives 11, 12, and 13, the Wilcoxon Rank-Sum test was used to evaluate the null hypothesis. In each case, the null hypothesis was not rejected. The structure counts as well as the structure counts ranks used to calculate the test statistic are displayed in Table 7-14. The p-values are 0.94, 0.32, and 0.98 for Secondary Objectives 11, 12 and 13, respectively.

One would conclude there was insufficient information to reject the null hypotheses that: the post-excavation asbestos concentrations in the soil from the AACM are equal to the pre-demolition asbestos concentrations for the AACM; the post-demolition asbestos concentrations in the soil from the NESHAP Method are equal to the pre-demolition asbestos concentrations for the NESHAP Method; and the post-excavation asbestos concentrations in the soil from the AACM are equal to the post-demolition asbestos concentrations for the AACM.

Table 7-13. Degree of Censoring for Secondary Objectives 11, 12, and 13.

Secondary Objective 11	Post-Excavation AACM 80% censored (8 out of 10)	Pre-Demolition AACM 40% censored (4 out of 10)
Secondary Objective 12	Post-Demolition NESHAP 20% censored (2 out of 10)	Pre-Demolition NESHAP 40% censored (4 out of 10)
Secondary Objective 13	Post-Excavation AACM 70% censored (7 out of 10)	Post-Demolition AACM 30% censored (3 out of 10)

Table 7-14. Asbestos Structure Counts in Soil (s/g) by TEM by the AACM and NESHAP Methods / Ranks for the Wilcoxon Rank-Sum Tests.

SO11		SO12		SO13	
AACM PRE	**AACM POST-EXCAV**	**NESHAP PRE**	**NESHAP POST**	**AACM POST**	**AACM POST-EXCAV**
0 / 6	1 / 13.5	0 / 3.5	1 / 9.5	0 / 5.5	1 / 12.5
3 / 17	0 / 6	2 / 14.5	71 / 19	3 / 17	0 / 5.5
0 / 6	0 / 6	0 / 3.5	0 / 3.5	13 / 19	0 / 5.5
1 / 13.5	1 / 16.5	0 / 3.5	0 / 3.5	24 / 20	1 / 12.5
0 / 6	11 / 19	22 / 18	1 / 9.5	1 / 12.5	11 / 18
1 / 13.5	0 / 6	3 / 17	1 / 9.5	0 / 5.5	0 / 5.5
0 / 6	0 / 6	1 / 9.5	119 / 20	4 / 15.5	0 / 5.5
4 / 18	0 / 6	0 / 3.5	2 / 14.5	4 / 15.5	0 / 5.5
2 / 16	0 / 6	1 / 9.5	1 / 9.5	0 / 5.5	0 / 5.5
136 / 20	0 / 6	2 / 14.5	2 / 14.5	1 / 12.5	0 / 5.5

The descriptive statistics in Table 7-15, show that: *the AACM pre-demolition soil concentrations are greater than the post-excavation soil concentrations in the upper tails of the distributions*; *the NESHAP pre-demolition soil concentrations are less than the post-demolition soil concentrations in the upper tails of the distributions;* and *the AACM post-demolition soil concentrations are greater than the AACM post-excavation soil concentration in the upper tails of the distributions.*

Table 7-15. Asbestos in Soil (s/g) by TEM by the AACM and NESHAP Method.

Method	**Minimum**	**1st Quartile**	**Median**	**3rd Quartile**	**Maximum**
NESHAP Pre-Demolition	0	0	1	2	22
NESHAP Post-Demolition	0	1	1	2	119
AACM Pre-Demolition	0	0	1	2.73	136
AACM Post-Demolition	0	0	3	6	24
AACM Post-Excavation	0	0	0	0	11

7.10 Secondary Objectives 14, 15, 16, and 17

Null hypothesis 14: The post-excavation asbestos concentration from elutriator test on soil from the AACM is equal to the post-demolition asbestos concentration from elutriator test on soil from the NESHAP Method.

Null hypothesis 15: The post-excavation asbestos concentration from elutriator test on soil from the AACM is equal to the pre-demolition asbestos concentration from elutriator test on soil from the AACM.

Null hypothesis 16: The post-demolition asbestos concentration from elutriator test on soil from the NESHAP Method is equal to the pre-demolition asbestos concentration from elutriator test on soil from the NESHAP Method.

Null hypothesis 17: The post-excavation asbestos concentration from elutriator test on soil from the AACM is equal to the post-demolition asbestos concentration from elutriator test on soil from the AACM.

Table 7-16 displays the asbestos concentrations from soil elutriator tests (millions of structures per gram PM_{10}), by method and phase. Three of the ten composite soil samples (see Primary Objective 2) were analyzed using the elutriator test for each method and phase. Non-detects (zero asbestos fibers counted) are reported as ND.

Due to the small sample sizes (n=3), *no inferential tests were conducted*.

Table 7-16. Asbestos Soil Concentrations (TEM) from Elutriator Tests.

METHOD	PHASE	COMPOSITE	TOTAL ASBESTOS (10^6 s/gPM_{10})
NESHAP	PRE	2	16.9
NESHAP	PRE	5	31.2
NESHAP	PRE	8	12.7
NESHAP	POST	2	2.21
NESHAP	POST	5	ND*
NESHAP	POST	8	3.55
AACM	PRE	2	37.6
AACM	PRE	5	9.04
AACM	PRE	8	37.3
AACM	POST	2	4.06
AACM	POST	5	5.22
AACM	POST	8	ND
AACM	POST-EXCAV	2	ND
AACM	POST-EXCAV	5	2.19
AACM	POST-EXCAV	8	32.0

*ND = 2.19E+06, 2.47E+06, and 2.78E+06 millions of structures/g PM_{10}.

7.11 Secondary Objectives 20, 21, and 22

Null hypothesis 20: The airborne asbestos concentrations (TEM) at the landfill during the disposal of debris from the AACM are equal to the airborne asbestos concentrations (TEM) at the landfill during the disposal of debris from the NESHAP Method.

Null hypothesis 21: The landfill worker breathing zone fiber concentrations (PCM) from the AACM are equal to the landfill worker breathing zone fiber concentrations (PCM) from the NESHAP Method.

Null hypothesis 22: The landfill worker breathing zone asbestos concentrations (TEM) from the AACM are equal to the landfill worker breathing zone asbestos concentrations (TEM) from the NESHAP Method.

A total of 27 samples were taken during disposal operations at the landfill, of which only two showed detectable concentrations of airborne asbestos by TEM (one fiber observed for each method). Since over ninety percent of the data are censored, *no inferential test was conducted for Secondary Objective 20*.

With regard to worker exposure during landfill operations, all TEM samples were non-detect. Since 100 percent of the data are censored, *no inferential test was conducted for Secondary Objective 21*.

With regard to worker exposure during landfill operations, the number of PCM samples was too small (n=2) for a meaningful comparison, so *no inferential test was conducted for Secondary Objective 22*.

7.12 Additional Secondary Objective

Null hypothesis: The post-excavation percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the AACM is equal to the post-demolition percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the NESHAP Method.

Table 7-17 displays the percent by weight of asbestos-containing material (ACM) in the ten composite samples from the post-excavation phase of the AACM compared to the post-demolition phase of the NESHAP Method. A two sample t-test was conducted to evaluate the null hypothesis. Since the t-test statistic provided a test statistic of 4.279 and a p-value of 0.0005, *one would reject the null hypothesis and conclude the post-excavation percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the AACM is not equal to the post-demolition percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the NESHAP Method.* In fact, based on the box plots in Figure 7-7, one would conclude *the post-excavation percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the AACM is less than to the post-demolition percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the NESHAP Method.*

Table 7-17. Percent by Weight of Asbestos-Containing Material (ACM) in Soil Samples for the NESHAP Method and AACM.

METHOD	PHASE	COMPOSITE	% ACM BY WEIGHT
NESHAP	POST	1	0.172
NESHAP	POST	2	0.047
NESHAP	POST	3	0.071
NESHAP	POST	4	0.013
NESHAP	POST	5	0.115
NESHAP	POST	6	0.115
NESHAP	POST	7	0.064
NESHAP	POST	8	0.020
NESHAP	POST	9	0.104
NESHAP	POST	10	0.141
AACM	POST-EXCAV	1	0.038
AACM	POST-EXCAV	2	0.007
AACM	POST-EXCAV	3	0
AACM	POST-EXCAV	4	0
AACM	POST-EXCAV	5	0.023
AACM	POST-EXCAV	6	0.011
AACM	POST-EXCAV	7	0
AACM	POST-EXCAV	8	0.016
AACM	POST-EXCAV	9	0.023
AACM	POST-EXCAV	10	0.020

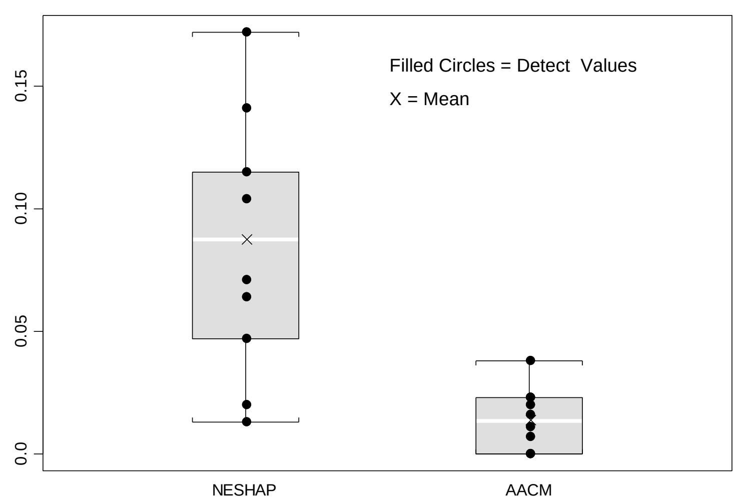

Figure 7-7. Box plots for Percent by Weight of Asbestos-Containing Material (ACM) in Soil Samples for the NESHAP Method and AACM.

7.13 Summary of Statistical Conclusions

OBJ.	CONCLUSION	STATISTICAL TEST	p-VALUE
PO1	*Reject the null hypothesis and conclude the airborne asbestos (TEM) concentrations from the AACM are not equal to the airborne asbestos (TEM) concentrations from the NESHAP Method. The empirical evidence (the proportion of non-detects and the maximum values) from the investigation suggests airborne asbestos (TEM) concentrations from the AACM are greater than the airborne asbestos (TEM) concentrations from the NESHAP Method.*	Wilcoxon Rank-Sum Chi-square	0.0006 0.004
PO2	*Reject the null hypothesis and conclude the post-excavation asbestos concentrations in the soil from the AACM are not equal to the post-demolition asbestos concentrations in the soil from the NESHAP Method. Based on descriptive statistics, one would conclude the post-excavation asbestos concentrations in the soil from the AACM are less than the post-demolition asbestos concentrations in the soil from the NESHAP Method.*	Wilcoxon Rank-Sum	0.033
SO2	*Conclude there is insufficient information to reject the null hypothesis that the airborne fiber (PCM) concentrations from the AACM are equal to the airborne fiber (PCM) concentrations from the NESHAP Method. Based on descriptive statistics one would conclude the fiber (PCM) concentrations for the two methods are equivalent.*	Wilcoxon Rank-Sum	0.2259
SO4	*Based on scatter plots, one would conclude there is no relationship between the NESHAP airborne asbestos (TEM) concentrations downwind and the NESHAP airborne asbestos concentrations upwind.*	No inferential test conducted due to censored data.	
SO5	*Based on scatter plots, one would conclude there is no relationship between the AACM airborne asbestos (TEM) concentrations downwind and the AACM airborne asbestos concentrations upwind.*	No inferential test conducted due to censored data.	

OBJ.	CONCLUSION	STATISTICAL TEST	p-VALUE
SO6	*Conclude there is insufficient information to reject the null hypothesis that the asbestos loadings in the settled dust (TEM) from the AACM are equal to the asbestos loadings in the settled dust (TEM) from the NESHAP Method. Based on descriptive statistics, plots of the empirical CDFs, and the K-S test, one would conclude the AACM asbestos loadings in settled dust are equal to the NESHAP asbestos loadings in settled dust.*	Wilcoxon Rank-Sum	0.7517
SO7	*Reject the null hypothesis and conclude the total particulate concentrations (as collected and measured by NIOSH Method 0500) from the AACM are not equal to the total particulate concentrations from the NESHAP Method. Based on the observed proportion of detects, conclude that for this demonstration the total particulate concentrations from the AACM are higher than the total particulate concentrations from the NESHAP Method.*	Wilcoxon Rank-Sum	0.002
SO8	*Reject null hypothesis and conclude the worker breathing zone fiber concentrations (PCM) from the AACM are not equal to the worker breathing zone fiber concentrations (PCM) from the NESHAP Method. Based on descriptive statistics, one would conclude the worker breathing zone fiber concentrations (PCM) from the AACM are less than the worker breathing zone fiber concentrations (PCM) from the NESHAP Method.*	Two Sample t-test	0.015
SO9	*Based on the observed proportion of detects, conclude that for this demonstration the worker breathing zone asbestos concentrations (TEM) from the AACM are less than the worker breathing zone asbestos concentrations (TEM) from the NESHAP method.*	No inferential test conducted due to greater than 90% censored data.	
SO11	*Conclude there is insufficient information to reject the null hypothesis that the post-excavation asbestos concentration in the soil from the AACM are equal to the pre-demolition asbestos concentrations. The descriptive statistics show that the AACM pre-demolition soil concentrations are greater than the AACM post-excavation soil concentrations in the upper tails of the distributions.*	Wilcoxon Rank-Sum	0.94

OBJ.	CONCLUSION	STATISTICAL TEST	p-VALUE
SO12	*Conclude there is insufficient information to reject the null hypothesis that the post-demolition asbestos concentration in the soil from the NESHAP Method are equal to the pre-demolition asbestos concentrations. The descriptive statistics show that the NESHAP pre-demolition soil concentrations are less than the post-demolition soil concentrations in the upper tails of the distributions.*	Wilcoxon Rank-Sum	0.32
SO13	*Conclude there is insufficient information to reject the null hypothesis that the post-excavation asbestos concentrations in the soil from the AACM are equal to the post-demolition asbestos concentrations. The descriptive statistics show that the AACM post-demolition soil concentrations are greater than the AACM post-excavation soil concentration in the upper tails of the distributions.*	Wilcoxon Rank-Sum	0.98
SO14	*Insufficient data to evaluate the null hypothesis that the post-excavation asbestos concentrations from elutriator test on soil from the AACM are equal to the post-demolition asbestos concentrations from elutriator test on soil from the NESHAP Method.*	No inferential test conducted due to small sample size (n=3).	
SO15	*Insufficient data to evaluate the null hypothesis that the post-excavation asbestos concentrations from elutriator test on soil from the AACM are equal to the pre-demolition asbestos concentrations from elutriator test on soil from the AACM.*	No inferential test conducted due to small sample size (n=3).	
SO16	*Insufficient data to evaluate the null hypothesis that the post-demolition asbestos concentrations from elutriator test on soil from the NESHAP Method are equal to the pre-demolition asbestos concentrations from elutriator test on soil from the NESHAP Method.*	No inferential test conducted due to small sample size (n=3).	
SO17	*Insufficient data to evaluate the null hypothesis that the post-excavation asbestos concentrations from elutriator test on soil from the AACM are equal to the post-demolition asbestos concentrations from elutriator test on soil from the AACM.*	No inferential test conducted due to small sample size (n=3).	

OBJ.	CONCLUSION	STATISTICAL TEST	p-VALUE
SO20	*Unable to conduct inferential test to evaluate the null hypothesis the airborne asbestos concentrations (TEM) at the landfill during the disposal of debris from the AACM are equal to the airborne asbestos concentrations (TEM) at the landfill during the disposal of debris from the NESHAP Method.*	No inferential test conducted due to greater than 90% censored data.	
SO21	*Unable to conduct inferential test to evaluate the null hypothesis the landfill worker breathing zone fiber concentrations (PCM) from the AACM are equal to the landfill worker breathing zone fiber concentrations (PCM) from the NESHAP Method.*	No inferential test conducted due to greater than 90% censored data.	
SO22	*Unable to conduct inferential test to evaluate the null hypothesis the landfill worker breathing zone asbestos concentrations (TEM) from the AACM are equal to the landfill worker breathing zone asbestos concentrations (TEM) from the NESHAP Method.*	No inferential test conducted due to greater than 90% censored data.	
ADD. SO	*Reject the null hypothesis and conclude the post-excavation percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the AACM is not equal to the post-demolition percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the NESHAP Method. Additional analyses using box plots lead one to conclude the post-excavation percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the AACM is less than the post-demolition percent by weight of asbestos-containing material (ACM) (primarily vinyl asbestos tile (VAT)) in the soil from the NESHAP Method.*	Two Sample t-test	0.0005

SECTION 8 COST COMPARISON OF DEMOLITION OF NESHAP AND AACM BUILDINGS

The costs associated with the building demolitions were documented and analyzed to clearly and transparently assign the appropriate cost element to the individual demolition. Costs attributable to conducting the research effort were excluded from these demolition costs. Ultimately, the total costs per cost element were obtained and summarized for both the NESHAP demolition and the AACM demolition. This allowed for effective costs comparisons between the total cost of both processes as well as the cost elements in each process.

Specifically, the demolition costs presented include:

- The cost of all labor, materials, and supplies to perform the abatement of the NESHAP building. These costs included: preparation of asbestos abatement specifications by a licensed Asbestos Project Designer; removal of the RACM by a licensed asbestos abatement contractor; oversight of the abatement, worker exposure monitoring (asbestos and lead), and clearance testing by a licensed asbestos consultant; transportation and disposal of the RACM to a licensed asbestos disposal facility.

- The cost of all labor, materials, and supplies to perform the post-abatement demolition of the NESHAP building. These costs included: demolition of the structure, transportation and disposal of the construction debris, and grading for future use.

- The cost of all labor, materials, and supplies to demolish the AACM building. These costs included: pre-demolition wetting of the structure; demolition of the structure using asbestos-trained workers and NESHAP-trained observers; personal protective equipment and OSHA-mandated monitoring for asbestos and lead; transportation and disposal of all construction debris as asbestos-containing waste at a licensed landfill; post-demolition excavation of soil; and transportation and disposal of soil as asbestos-containing waste at the Fort Smith landfill.

- The cost of all federal, state, and local enforcement activities relative to each method of demolition and disposal.

8.1 Methodology

A cost comparison was performed of the demolition of Building 3602 (NESHAP) and Building 3607 (AACM). In order to provide a fair comparison of the two methods, research project-related sampling effort (labor and equipment), site preparation costs related to the sampling effort, redundant equipment onsite due to the research effort that would not normally be required for a typical demolition project, other redundancies (excess workers), and down time of demolition equipment and personnel due to delays caused by non-demolition related items (e.g., work delay due to unacceptable weather conditions) were excluded from the demolition costs. Specific costs items excluded from the presented demolition costs include:

- Project planning and QAPP development.
- Sampling related to the research effort that would not normally be required.
- Site preparation such as roadwork, installation of sampling stations, onsite trailers, fencing, plastic cover for surrounding buildings.
- Redundant capabilities not typical on demolition projects.
- Onsite electrical installed for sampling equipment.
- Downtime due to weather delays or truck delays (in case of AACM Building).
- Onsite security for sampling equipment.
- Other miscellaneous costs not directly related to the demolition.

Invoices from contractors and material purchases, time sheets, trucking invoices, and waste disposal tickets were used to develop the demolition costs. As such, the costs were the actual costs incurred during the demolition of Buildings 3602 and 3607 and reflected labor and equipment rates available in Fort Smith, Arkansas. It should be noted that construction crew stand-by costs resulting from weather-related delays were excluded from the presented demolition costs. For similar demolition activities performed in other locations, the cost may increase or decrease depending on local conditions and the competitiveness of firms offering these services.

Costs that apply to both buildings include the pre-demolition Asbestos NESHAP (40 CFR §61, Subpart M) compliance inspection, site mobilization and demobilization, labor and equipment for demolition, and transportation and disposal of demolition wastes.

Method-specific demolition costs for the NESHAP building included asbestos abatement, including preparation of the specification and the abatement oversight and monitoring, plus OSHA Compliance monitoring for lead (29 CFR §1926.62).

Method-specific demolition costs for the AACM building included the presence of a NESHAP observer during the demolition, rental of the scaffolding required to line the trucks and the liners, and OSHA Compliance monitoring for asbestos (29 CFR §1926.1101) and lead (29 CFR §1926.62).

The costs for removal of the pipe wrapping beneath both buildings, which was done many years earlier, was not included in this cost comparison. The comparison between the NESHAP and the AACM dealt with the buildings as they were at the time, not how they had been in the past. Inclusion of hypothetical costs for the removal of pipe wrap that had been accomplished many years earlier is not appropriate because EPA does not know the quantity of pipe wrap that was removed nor the cost for removing it. If the amount of pipe wrap did not exceed the NESHAP limits (260 linear feet), then NESHAP would not have required it to be removed for the NESHAP building but the AACM would have required its removal prior to the AACM demolition. In this case, there would have been an extra cost for the AACM. If the amount of pipe wrap exceeded the NESHAP threshold, it would have been removed in both cases and the costs for TSI removal from each building would have been the same; thus there would have been little impact on the cost advantage of the AACM.

8.2 Cost Items

The following sections provide the details of the individual cost items that are summarized in Table 8-1, which is located at the end of this section.

8.2.1 Pre-Demolition Asbestos Compliance Inspection

A pre-demolition asbestos NESHAP compliance inspection was required for both the NESHAP and the AACM building, which typically costs $2,400 each. This cost is based on an estimate from Environmental Enterprises Group (EEG), who performed this service on the buildings at Fort Chaffee Redevelopment Authority. This cost includes collection of up to 40 bulk building samples for asbestos analysis by PLM and a written inspection report.

8.2.2 NESHAP Abatement

The NESHAP method requires that RACM be removed from any regulated building that is to be demolished. This cost did not apply to this AACM demolition at the Fort Chaffee Redevelopment Authority.

8.2.2.1 Abatement Specification

An asbestos abatement specification was prepared for obtaining competitive bids for the asbestos abatement and to provide instructions for the selected abatement contractor. The cost of this item ($4,272) is based on the cost of the labor hours required to develop the specification, issue the bid, conduct pre-bid conference, evaluate bids, and award the contract.

8.2.2.2 Asbestos Abatement

The abatement contractor was selected based on low bid, which ranged from $58,725 to $82,700 including ACM disposal. The general contractor overhead costs (ten percent) and fee (an additional ten percent on the original plus overhead or 21 percent of the original) were added to the asbestos abatement cost of $58,725 for a total loaded cost of $71,057. To compare actual ACM disposal costs between the two buildings, the cost of ACM disposal, $5,893 (based on 78 actual tons of ACM, including barrels, at $75.55 per ton) was subtracted from the total loaded abatement cost and included on the ACM cost line item in Table 8-1. Therefore, the amount of the abatement minus the cost item for disposal is $65,164 ($71,057 -$5,893) and this is shown in the Asbestos Abatement category in Table 8-1.

8.2.2.3 Abatement Oversight and Monitoring

Abatement oversight and monitoring task was performed by EEG. The cost of $11,977 is the amount invoiced from EEG to perform these activities.

8.2.3 OSHA Compliance Monitoring

The cost of OSHA compliance monitoring (lead) for the NESHAP demolition includes 12 hours of monitoring and the collection and analysis of three lead samples. The cost of the OSHA monitoring for the abatement portion of the NESHAP was previously included above. The cost of OSHA compliance monitoring (lead and asbestos) for the AACM demolition includes 12 hours of monitoring and the collection and analysis of five lead samples and five asbestos samples.

8.2.4 Site Mobilization and Demobilization

Site mobilization and demobilization includes the delivery and removal of equipment prior to and at the end of the demolition. Mr. Larry Weatherford with Crawford Construction provided an estimate of $4,000 (includes both mobilization and demobilization) for either the NESHAP or AACM building.

8.2.5 Demolition

Demolition costs include the cost of the excavator and operator and labor for both the NESHAP and AACM buildings and the cost of a NESHAP observer for the AACM demolition. The excavator was billed at $95/hr and the excavator operator was billed at $55/hr (total $150/hr). Labor hours required for both NESHAP and AACM demolitions are based on reported hours on timesheets and an average labor cost of $45/hr. Labor hours during delays caused by weather and the research sampling effort are not included.

The demolition of the NESHAP building required eight hours for eight workers (64 hours) for a total of $2,880, not including operation of the excavator. The excavator operated for eight hours during the demolition of the NESHAP building for a total coast of $1,200.

Labor for the AACM took place over a four-day period from April 30 to May 3, 2006 and totaled 223 hours. The AACM building required pre-wetting the interior and rafters of the building on April 30 for about two hours and re-wetting the rafters on May 1 for about one hour prior to the demolition (three workers each). The demolition and debris cleanup required about 11 hours for 16 workers on May 1 and another three hours for 12 workers on May 2. Due to soil sample collection required by the research project, the final removal of surface soil did not take place until the morning of May 3. Soil excavation required another two hours for one worker (does not include trucking). At an average rate of $45/hr, the labor cost of the AACM demolition was $10,035, not including operation of the excavator. The excavator operated for 16 hours during the demolition of the AACM building for a total cost of $2,400.

8.2.6 Water and Amended Water Surfactant

Water spray was used during the NESHAP demolition to control dust. Water containing a surfactant with a foaming agent was used during the AACM demolition to control dust and prevent the release of asbestos into the air. Water was supplied through a hydrant operated by the city of Fort Smith. Hydrant charges over the test program were $168.24. The water usage costs for each of the buildings was based on 10.8-percent use for the NESHAP building ($18) and 89.2-percent use ($150) for the AACM building. The cost of the wetting agent, used only for the AACM building, was based on actual surfactant use of 170 gallons at a cost of $11.85 per gallon or $2,015.

8.2.7 Demolition Debris Transportation and Disposal (asbestos and non-asbestos)

The costs of transportation and disposal include cost of the trucks and truck drivers and the disposal of asbestos and non–ACM wastes at the Fort Smith landfill. Field notes, landfill invoices, disposal manifests, and contractor invoices were reconciled to determine disposal weights and costs.

8.2.7.1 Trucking Costs

Trucks used in this effort were either owned and operated by Crawford Construction or obtained from independent local contractors. The billing rate for truck and driver was $65/hr and was used for all the trucks.

For the NESHAP demolition, trucking use was 59 hours for a total cost of $3,835. For the AACM, total truck use was 94.5 hours for a total cost of $6,143.

8.2.7.2 Lining the Trucks

Liners were used in the truck beds hauling asbestos waste for the AACM building only. Scaffolding was necessary for installing two liners in each truck. The liners were sealed with glue and tape after the asbestos waste was loaded in the trucks. The costs for the scaffolding and liners are not applicable to the NESHAP demolition.

For the AACM demolition, the cost of the liners is based on the use of 142 liners plus glue and tape. Crawford Construction purchased 200 liners (typically used to line rolloff boxes) at $44.08 plus the cost of glue and tape for a total cost of $9,688. A ratio of 142 divided by 200 was used to obtain the cost of the liners ($6,878). An allowance of $200 was included for the rental of the scaffolding.

8.2.7.3 Cost of Disposal

The costs for disposal of asbestos and non-asbestos waste were based upon invoices from the City of Fort Smith Landfill Department. The cost of disposal of general (non-asbestos) waste was $26 per ton. The cost of disposal of ACM was $75.55 per ton. Tonnages were determined at the landfill by originally determining the weight of the load for the first two shipments for each truck, averaging those, and then counting the number of loads each truck delivered to the landfill. The total weight was then the number of trips per truck times the average load for that particular truck.

8.2.7.3.1 NESHAP Building

During abatement of the NESHAP building, 78 tons of ACM (including containers) was disposed at a cost of $5,893. Debris from the demolition of the NESHAP building included some soil that was commingled with the debris. Based on the demolition contractor records, NESHAP demolition waste (all non-ACM) totaled 217 additional tons, for a disposal cost of $5,642.

8.2.7.3.2 AACM Building

Disposal of debris from the AACM building occurred over a three-day period due to the requirement to collect soil samples after building demolition and a weather delay on the second day. On the first day of the demolition process, a total of 142 tons of asbestos-containing building demolition debris was disposed at the landfill. There was a rain delay on the morning of the second day, and disposal operations began at about noon. On the second day, approximately 30 additional tons of asbestos-containing building debris/soil mixture was disposed. In addition, easily-segregated concrete piers and the large gravel-filled concrete structure were disposed as non-asbestos-containing building debris, totaling 103 tons. Soil excavation occurred on the third day, following the post-demolition sampling. Approximately 75 tons of soil was disposed as ACM. The total disposal tonnages and costs for the AACM building were 103 tons of non-ACM at a cost of $2,678 and 247 tons of ACM at a cost of $18,660. Water should have been applied during the soil removal phase but inadvertently was not; an additional $500 was estimated for this cost.

Water that collected within the bermed containment area was filtered and pumped to a 2,400 gallon holding tank for storage prior to being trucked to the City of Fort Smith Wastewater Treatment Plant. The cost for on-site filtering and containment of water collected during the demolition was $2,031.85 for one month's rental of the holding tank and particle filters, including the cost of the filter cartridges; and $146.68 for rental of the sump pump. The cost of trucking water from the site to the wastewater treatment plant was included as part of the demolition and not broken out separately. There was no cost for disposing of the 4,100 gallons of water collected during the demolition of the AACM building at the wastewater treatment facility. The total additional cost for collection, treatment, and disposal of the collected water was $2,277.53 for the one-month rental of the sump pump, on-site filtering equipment and holding tank. The project cost for this equipment was determined by pro-rating the total cost for the one month rental based upon the need for the equipment at the site for the two days of building demolition and one day of soil excavation, and one day each for mobilization and demobilization, or five days. As a result, the cost of wastewater treatment and collection entered in the table was $570, obtained by prorating the monthly cost, assuming 20 working days per month.

8.3 Summary

Table 8-1 presents the comparative costs of the demolition of Buildings 3602 and 3607 by the NESHAP Method and AACM, respectively.

Table 8-1. Cost comparison of NESHAP and AACM Building Demolitions at Fort Chaffee, AR.

Cost Item	**Costs, $**	
	NESHAP Building #3602	**AACM Building #3607**
Pre-Demolition		
Pre-demolition Asbestos NESHAP inspection	2,400	2,400
Asbestos abatement specifications (Preparation and bidding)	4,272	NA
Asbestos abatement	65,164	NA
Asbestos abatement oversight and monitoring	11,977	NA
OSHA compliance monitoring (asbestos and lead)	1,050	1,235
Site mobilization and demobilization by General Contractor	4,000	4,000
Building Demolition		
Excavator	1,200	2,400
Labor	2,880	10,035
Hydrant flush water and surfactant	18	2,165
Construction Debris T&D (asbestos and non-asbestos)		
Transportation	3,835	6,143
Scaffold for lining of trucks and liners	NA	7,078
Asbestos waste disposal	5,893	18,660
Non-asbestos waste disposal	5,642	2,678
Water collection and disposal	0	570
Miscellaneous Costs		
Watering during soil removal	0	500
Totals		
Total cost	108,331	57,864
Unit cost, $/ft^2 (based on 4,500 ft^2)	24.07	12.86

The cost of the NESHAP demolition was approximately $108,331 and the cost of the AACM demolition was approximately $57,864 or about 53 percent of the cost of the NESHAP demolition. The cost per square foot was $24.07/ft^2 for the NESHAP and $12.86/ft^2 for the AACM.

8.4 Applicability of Costs for Different Sites

The costs for these demolitions at the Fort Chaffee Redevelopment Authority are very site specific and may vary at other sites according to building type, size, asbestos type and extent, etc. The AACM building at Fort Chaffee did not contain ACM that would require abatement prior to demolition. Different buildings at different locations may have greater or lesser cost differences between the NESHAP process and the AACM process, As the proportion of the building's contents that require removal under the AACM increase (e.g., sprayed-on TSI, vermiculite attic insulation, large quantities of pipe wrap, etc), the cost advantage of the AACM relative to the cost of the NESHAP will decrease. Conversely, some local regulations exceed the requirements of the NESHAP and mandate the removal of vinyl asbestos floor tile; this was not the case at Fort Chaffee. If the VAT had been removed as required by several local statutes, the cost and time requirements of the abatement would have significantly increased and the cost and time advantages of the AACM observed in this study would have been far greater. The ultimate choice of the NESHAP vs. the AACM will be made based upon cost and time considerations. There will always be some structures where the NESHAP will be more practical to apply than the AACM.

SECTION 9 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) RESULTS

Due to the potential use of the results of this research study in assisting in the evaluation of an alternative method to current regulations, the project was designated a NRMRL QA Category 2. Based on this designation, QA/QC activities for the study included the development of a detailed quality assurance project plan (QAPP), field and laboratory audits, analysis of multiple QA/QC samples, and data validation.
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9.1 QAPP Development

The QAPP was prepared to conform to EPA QA/R-5, *Requirements for QAPPs, EPA/240/B-01/003, March 2001*. Input was provided by an EPA Technical Development Team, which included asbestos experts from across the Agency. Following internal reviews, the QAPP was submitted for public and peer review comments. The peer review panel provided composited comments which included those received from the public; these composited comments were then addressed prior to finalizing the QAPP.

9.2 Audits

A field audit and two laboratory audits (Clayton Group Services, who analyzed the air samples, and Lab/Cor, who analyzed the soil samples) were conducted.

9.2.1 Field Audit

This audit was conducted on April 24, 2006, the planned first day of the demolition of the building using the NESHAP method. However, weather delayed the demolition and the audit was limited to an assessment of the planned activities (i.e., a readiness review). The audit was conducted by Dr. Ching Chen, PE, CIH of Science Applications International Corporation (SAIC), through a subcontract agreement with Neptune and Co., Inc., under a Quality Support Contract with the EPA. Audit activities were overseen by Lauren Drees, the EPA NRMRL QA Manager.

The EQ personnel interviewed included Mr. John Kominsky, Project Manager, and Julie Wagner, Field Data Manager. The audit evaluated sampling activities at the demolition site at Ft. Chaffee, Arkansas and the City of Ft. Smith, Arkansas Class D landfill site. The audit included reviews of the following:

- Detailed review of flow meter calibration procedure and record
- Review of the records of completed background asbestos air and soil sampling
- Inspection of sampling pole and sampling equipment set up at both the demolition and landfill sites
- Inspection of the weather monitoring stations at both the demolition and landfill sites
- Review of sampling data forms

Table 9-1 provides a summary of the Observations that were identified during the audit. These Observations did not have a significant effect on data quality, but, when corrected, data collection efficiency was improved and ambiguity was minimized.

9.2.2 Laboratory Audit for Air Samples

An audit of Clayton Group Services in Kennesaw, GA was conducted on May 11, 2006 by Owen Crankshaw of RTI International through a subcontract agreement with EQ. Audit activities were overseen by Lauren Drees, the EPA NRMRL QA Manager.

The Clayton laboratory would be conducting analysis of air samples collected for asbestos and fibers by TEM and PCM, respectively. The audit focused on the following key areas:

- personnel qualifications
- laboratory equipment
- understanding of the project
- sample preparation procedures
- sample analysis procedures
- quality assurance and calibration of all data
- project-specific data handling and reporting
- sample handling and disposition

All aspects of sample preparation and analysis were discussed with laboratory personnel, and the lab was in compliance with project QAPP requirements. In some instances, specific QA procedures documented in the project QAPP were clarified to make the data more meaningful.

The following items represent clarifications/recommendations that resulted from the audit:

- The audit team spent adequate time with lab director Alan Segrave to ensure that all analytical requirements of the QAPP would be met by the laboratory staff. The lab was told to contact the contractor and the EPA QA staff should issues arise that need method modification.
- Indirect prep is to be avoided, as all samples should share the same prep procedures. If a sample is overloaded with particulate material (or marginally overloaded), John Kominsky is to be contacted for direction.
- Lab will utilize a comprehensive laboratory information management system (LIMS) for log in, recording of sample prep, analytical data, QA, and reporting.
- Audit team ensured that QC assignments will target appropriate sample batches and agreed on the assignment scheme with Alan Segrave.
- For QC samples (replicates, duplicates, intralaboratory and interlaboratory verified samples, and interlaboratory duplicates), lab will assign QC to achieve good batch representation, and will make sure at least one QC sample is assigned to each batch.

Table 9-1. Summary of Audit Observations, Recommendations, and Resolution.

No.	Observation	Recommendation	Resolution
1	Lack of QAPP Training Record	Document the QAPP training for all field personnel	Training of all field personnel was documented by signature on a QAPP acknowledgement form.
2	Insufficient documentation of flow meter calibration	Record the following information on calibration datasheets: Model and serial number of the primary standard flow meter used Name of person who performed the calibration Time and date of calibration Location of calibration Type of filter cassette used for calibration	The individual flow meter calibration sheets were updated to include the model and serial number of the primary standard used; name of person who performed the calibration; time and date of calibration; location of calibration, and type of filter cassette used for calibration.
3	Insufficient clarity in sampling data forms	Insert additional data columns on sampling forms to clearly record the flow meter readings and corresponding flow rates at pump start and stop time; label the columns accordingly Clearly identify the flow meter data recorded on the form during the 2-hr checks of pump operation, where applicable, as flow meter readings Re-check all datasheets for the background air sampling completed to ensure that correct flow rates are used in calculating sample volume	The air sampling data forms were revised to include columns to document the start and stop times and corresponding flow rate. The flow meter performance check form was updated to include the time and flow rate for each 2-hour check. The sampling datasheets for the background sampling were reviewed and verified that the correct flow rates were used in the air sample volumes.
4	Malfunctioning wind direction sensor at the landfill site weather station	Replacement sensor (temperature and wind direction) is on order and is expected to arrive within a few days.	Meteorological data was obtained from a NWS Station and from Fort Smith City airport, which were approximately 0.5 and 0.2 miles from the landfill monitoring area.
5	Lack of formal documentation of QAPP changes	Document all changes to the QAPP as an addendum. Changes identified so far have included: Integrated, instead of daily, samples during abatement monitoring Soil sampling grid changes Potential deletion of duplicate samples for the low-volume standby asbestos air samples Representative photo documentation of sampling poles, instead of photos for all sampling poles No immediate pre-abatement sampling; background sampling was conducted in January 2006 Updated sampling data forms	A written addendum to the QAPP documented the note changes to the QAPP. It also includes the following post-audit changes: Integrated air and settled dust samples for the AACM building on Day 2 and Day 3 due to the brief activities (soil removal) which occurred on these days. Increasing the air sampling flow rate to 7 liter/min for the Day 2 and 3 AACM building perimeter samples for the aforementioned reason. Based on the EPA audit of the soil laboratory, developed a standard operating procedure (SOP) for drying and mixing the soil; the SOP is an addendum to the QAPP.

- Verified analysis will be conducted on samples containing asbestos, if available. Preference will be given to appropriately loaded samples (5-10 structures per grid opening). Ten grid openings will be analyzed for each verified count, all on the same grid. When possible, intralaboratory and interlaboratory verified counts will be performed on the same grid openings.
- For any samples with high asbestos concentrations, lab can apply ISO 10312 stopping rules.
- Calculations are done by LIMS; lab will hand calculate 2% of all analytical results (for all analyses).
- Lab needs input from EPA and EQ regarding number of grid openings to analyze when volumes on samples are lower than were projected for those samples. These samples need higher numbers of grid openings to be counted to meet analytical sensitivity specifications.
- All records will be backed up daily to the central server and copied to CD.
- Sample filters, slides, and grids will be stored until the end of the project in the lab director's office.
- Lab will send individual batch reports and a comprehensive Excel spreadsheet with a summary of all results.
- The two liter/min samples collected at the five-ft height in Ring 1 for the AACM Method were not marked as requiring archival. This was documented by Lauren Drees on the COC form at the time of the audit.
- Lab will use an independent chain of custody for QC samples going to and from the QC lab. All QC samples will be returned to Clayton.

It was concluded that the laboratory operates under a comprehensive and appropriate QA system, has qualified personnel, has a comprehensive LIMS system, and has all necessary and appropriate equipment.

9.2.3 Laboratory Audit for Soil Samples

An audit of Lab/Cor in Seattle, WA (soil prep, TEM ,and elutriator analyses) and Lab/Cor in Portland, OR (PLM) was conducted on May 1 and 2, 2006 by Owen Crankshaw of RTI International through a subcontract agreement with EQ. Audit activities were overseen by Lauren Drees, the EPA NRMRL QA Manager.

The Lab/Cor laboratory would be conducting analysis of soil samples collected for asbestos as noted above. The audit focused on the following key areas:

- personnel qualifications
- laboratory equipment (including unique equipment for elutriation of soil)
- understanding of the project
- sample preparation procedures
- sample analysis procedures
- quality assurance and calibration of all data
- project-specific data handling and reporting

- sample handling and disposition
- development of a project-specific standard operating procedure (SOP) for sample preparation and analysis

The laboratories had recently been audited by NVLAP (and successfully completed the audits with no deficiencies), which helped allow the auditors to spend adequate time on critical aspects of the soil preparation and analysis procedures. All aspects of sample preparation and analysis were worked out and agreed upon with laboratory personnel. In some instances, specific QA procedures documented in the project QAPP were clarified to make the data more meaningful.

The following items represent clarifications/recommendations that resulted from the audit:

- The soil SOP for this project was developed by the lab representatives and the audit team before, during, and after the audit. This SOP will replace Section B4.4 of the QAPP. Lab needs to ensure that all analysts have an approved copy of the SOP prior to conducting any analysis. Considerable effort and time was spent by the audit team to refine the SOP such that the analysis conducted will be properly conducted and has appropriate QC measures. The audit team is satisfied at this point that the SOP addresses all issues that can reasonably be anticipated. Lab will be expected to contact the contractor and the EPA QA staff should issues arise that need method modification.
- Portland staff does analysis only; all soil sample preparation will be conducted in Seattle to a stage suitable for point counting by PLM.
- John Harris will be principal tracking person for the overall contract and for the Seattle lab; Amber Basting will be the sample tracking person for the Portland lab.
- Due to the large sample quantities received, it is necessary that Lab/Cor utilize the larger hoods at the Region 10 Port Orchard facility. All drying of soils (initial drying) will be done in the Port Orchard, WA USEPA laboratory, following standard chain of custody for sample delivery both directions.
- All wet soils received were being maintained at 0-8 °C, which was a difficult task. The soil SOP was modified to clarify that only samples that will undergo elutriation will be maintained at that temperature per the elutriation method.
- The Seattle lab is currently not set up to perform PLM analyses. However, visual estimation by PLM of the original soil, as well as the dried/split soil, is needed. Provisions will be made so that the Seattle lab can perform these analyses.
- Balances and ovens are in Seattle where all sample preparation will be conducted. Lab agrees to calibrate balances daily using traceable weights. Balances are also calibrated by an independent agency.
- Kate March will be responsible for selection of QC samples in Seattle (concentrating on AACM post-excavation and NESHAP post demolition samples), and Darvey Santner will be in charge of sample assignment in Portland. QC checks will meet percentage criteria, and will be split among personnel to maximize the utility of the data.
- Lab will prepare 0.1% AND 1% spikes (using chrysotile) for each of the five sets of ten soil samples. The QAPP only required the 0.1% spike, but since the 1% spike will be prepared for the elutriation analyses, it was agreed that it would also be analyzed by PLM/TEM. The same spikes above will be analyzed by the elutriation method. These spikes will not be

prepared using the background soils sieved to PM10 as this was determined to be impractical. The background soil will be dried, split, and ground and then spiked.

- Two types of elutriator duplicates will be utilized: a re-preparation of a filter by a different analyst (preferably a sample that had measurable asbestos), and a re-elutriation of a 60g soil split. Two of each of these duplicates are required.
- A soil duplicate for TEM will start with the two-gram aliquot from which 100 mg were suspended, and will suspend a new 100-mg sub-aliquot.
- Samples will arrive in batches of ten, and will be processed as much as possible in batches.

- Lab will choose samples 2, 5, and 8 from each batch of ten soil samples for elutriator preparation.
- Lab will use electronic data entry by PC at the microscope.
- Lab will prepare 20 slide mounts for each PLM point-count.
- All PLM point count calculations will be rechecked. Because TEM and elutriation calculations are done by spreadsheet, each TYPE of calculation will be rechecked by hand on a regular basis.
- Lab will use ISO 10312 counting rules for elutriator samples. Stopping rules will be 100 asbestos structures or when an analytical sensitivity of 1×10^6 structures/gram is reached.
- During PLM analysis, analysts will identify chrysotile and amphibole, and quantify independently and in combination. Identification of any non-asbestos fibrous material will be attempted, but is not required. Non-asbestos fibrous material will not be point counted. The lab will, however, provide a visual estimate of non-asbestos fiber (<1% if trace, and visual estimation if >1%; no further quantification below 1% will be provided).
- PLM slides will not be archived or mounted in permount.
- Portland lab will receive from Seattle, along with samples data regarding sample reduction so that final calculations related to original sample (post drying but prior to sample reduction) can be performed.
- Portland lab will report anything unusual found in the samples during PLM analysis.
- Portland lab may count less than 1000 point counts if sample reduction level justifies it, as long as 0.1% analytical sensitivity is achieved.
- All soil samples analyzed by Portland will be returned to Seattle by John Harris (utilizing chain of custody) and stored with other project archival material.
- Portland lab will create one master spreadsheet for all PLM data to accompany individual analytical reports.
- Portland lab will use sample numbers initiated in Seattle.
- Warehouse space will be used for original soil samples and splits; all other materials will be stored in the Seattle lab (including point-counted soil samples).
- All soil samples for PLM analysis will be delivered in person (both directions) by John Harris. A new chain of custody will be used for sample transportation to and from Portland. Chain of custody will also be maintained when transferring samples to and from the Region 10 Port Orchard facility.

It was concluded that the laboratory operates under a comprehensive and appropriate QA system, has qualified personnel, and has all necessary and appropriate equipment.

9.3 Asbestos QA/QC Sample Results

QA/QC samples were analyzed for each sample type, i.e., air (including worker), soil, settled dust, and water, as described in the QAPP. These QA/QC samples included lot blanks; field blanks; field duplicates; laboratory method blanks, replicates, duplicates, verified counts, and spiked samples; and interlaboratory duplicates and verified counts. The results of the analyses are provided in the following sections, as applicable for the different sample types.

For each matrix, in cases where two analyses have the same analytical sensitivity, variability was calculated using the following equation:

$$Variability = \frac{S1 - S2}{b\sqrt{S1 + S2}} \qquad \text{\{Equation 1\}}$$

where S1 and S2 are the two total structure counts observed.

For each matrix, in cases where the two analyses have different analytical sensitivities, variability was calculated using the following equation:

$$Variability = \frac{|S1 - S2 - a(S1 + S2)|}{b\sqrt{S1 + S2}} \qquad \text{\{Equation 2\}}$$

Where:

$$a = \frac{(MDL2 - MDL1)}{(MDL2 + MDL1)}$$

and

$$b = 2\sqrt{\frac{(MDL1 - MDL2)}{(MDL1 + MDL2)}}$$

MDL is the method detection limit (i.e., analytical sensitivity). Note that all variabilities were calculated using {Equation 1} unless otherwise noted.

9.3.1 Air QA/QC Results

The QAPP specified the required numbers of QA/QC samples. The minimum required number of each type of QA/QC sample was met in all cases. In many cases, the number of QA/QC samples analyzed exceeded the required number. Table 9-2 summarizes the total air samples collected and the QA/QC samples analyzed. The number of QA/QC samples analyzed exceeded the required number in all cases, except for the interlaboratory verified count. As no problems were encountered for the one interlaboratory verified count sample analyzed (Table 9-7, below), data quality is not affected.

Table 9-2. Total Air QA/QC Samples

		Field Duplicates	Field Blanks	TEM Lot Blanks	TEM Replicates	TEM Duplicates	TEM Verified Counts	TEM Interlab Duplicates	TEM Interlab Verified Counts
Total Samples	259	23	52	12	14	18	3	16	1
Required by QAPP		None Specified	None Specified	2%	3%	3%	1%	5%	1%
Samples Actually Analyzed		8.9%	20.1%	4.6%	5.4%	6.9%	1.2%	6.2%	0.4%

9.3.1.1 Lot Blanks

All lot blanks had non-detected asbestos concentrations at less than 0.0005 s/cm^3.

9.3.1.2 Field Blanks

A field blank is a filter cassette that has been transported to the field, opened for a short time (≤30 seconds), and then sent to the laboratory. All field blanks had non-detected asbestos concentrations at <7 s/mm^2.

9.3.1.3 Field Duplicates

A field duplicate is a second sample collected concurrently at the same location as the original sample (co-located). Results for field duplicates are presented in Table 9-3. All field duplicates met the acceptance criteria for variability.

9.3.1.4 Method Blanks

All method blanks had non-detected asbestos concentrations less than 7 s/mm^2.

Table 9-3. Field Duplicates for Air Samples

Sample ID	Method	Sample Result	Duplicate Result	Actual Variability	Acceptable Variability
AIR-AACM-ASB-4L-BG-R1-M13	ISO	0	0	0	2.5
AIR-AACM-ASB-4L-D1-R1-H1-M17	ISO	0	0	0	2.5
AIR-AACM-ASB-4L-D1-R1-H1-M5	ISO	0	0	0	2.5
AIR-AACM-ASB-4L-D1-R1-H2-M12	ISO	0	0	0	2.5
AIR-AACM-ASB-4L-D1-R1-H2-M2	ISO	0	0	0	2.5
AIR-AACM-ASB-4L-D1-R2-H1-M1	ISO	0	0	0	2.5
AIR-AACM-ASB-4L-D1-R2-H1-M15	ISO	1	0	1	2.5
AIR-AACM-ASB-7L-D2-R1-H1-M12	ISO	0	0	0	2.5
AIR-AACM-ASB-7L-D2-R1-H1-M17	ISO	0	0	0	2.5
AIR-AACM-ASB-7L-D2-R1-H1-M2	ISO	1	0	1	2.5
AIR-AACM-ASB-7L-D2-R1-H1-M5	ISO	1	0	1	2.5
AIR-AACM-ASB-7L-D2-R2-H1-M1	ISO	0	0	0	2.5
AIR-AACM-ASB-7L-D2-R2-H1-M15	ISO	0	1	1	2.5
AIR-LANDFILL-ASB-4L-BG-M8	ISO	0	0	0	2.5
AIR-LF-AACM-ASB-4L-D1-H1-M8	ISO	0	0	0	2.5
AIR-LF-AACM-ASB-4L-D2-H1-M8	ISO	0	0	0	2.5
AIR-LF-NESH-ASB-4L-D1-H1-M8	ISO	0	0	0	2.5
AIR-NESHAP-ASB-4L-BG-R1-M5	ISO	0	0	0	2.5
AIR-NESH-ASB-4L-D1-R1-H1-M17	ISO	0	0	0	2.5
AIR-NESH-ASB-4L-D1-R1-H1-M5	ISO	0	0	0	2.5
AIR-NESH-ASB-4L-D1-R1-H2-M12	ISO	0	0	0	2.5
AIR-NESH-ASB-4L-D1-R1-H2-M2	ISO	0	0	0	2.5
AIR-NESH-ASB-4L-D1-R2-H1-M1	ISO	3	0	1.7	2.5
AIR-NESH-ASB-4L-D1-R2-H1-M15	ISO	0	0	0	2.5

9.3.1.5 Replicates

A replicate analysis is a second analysis of the same preparation, but not necessarily the same grid openings, by the same microscopist as the original analyses. Results for replicates are presented in Table 9-4. All replicates met the acceptance criteria for variability.

Table 9-4. Replicates for Air Samples.

Sample ID	**Method**	**Sample Result**	**QA/QC Result**	**Actual Variability**	**Acceptable Variability**
AIR-AACM-ASB-4L-D1-R1-H1-M16	ISO	1	1	0	1.96
AIR-AACM-ASB-4L-D1-R1-H2-M5	ISO	0	0	0	1.96
AIR-AACM-ASB-4L-D1-R2-H1-M12	ISO	0	0	0	1.96
AIR-AACM-ASB-7L-D2-R1-H1-M5	ISO	1	1	0	1.96
AIR-AACM-ASB-7L-D2-R1-H2-M15	ISO	0	0	0	1.96
AIR-AACM-ASB-7L-D2-R2-H1-M4	ISO	0	0	0	1.96
AIR-LF-AACM-ASB-4L-D1-H1-M4	ISO	0	0	0	1.96
AIR-LF-NESH-ASB-4L-D1-H1-M6	ISO	0	0	0	1.96
AIR-NESHAP-ASB-4L-BG-R1-M8	ISO	0	0	0	1.96
AIR-NESH-ASB-4L-D1-R1-H1-M2	ISO	0	0	0	1.96
AIR-NESH-ASB-4L-D1-R1-H2-M2	ISO	0	0	0	1.96
AIR-NESH-ASB-4L-D1-R2-H1-M5	ISO	0	0	0	1.96
WORKER-AACM-ASB-D1-E01	ISO	0	0	0	1.96
WORKER-NESHAP-ASB-D1-H02	ISO	1	1	0	1.96

9.3.1.6 Duplicates

A duplicate is an analysis of a second TEM grid preparation prepared from a different area of the sample filter performed by the same microscopist as the original analyses. Results for duplicates are presented in Table 9-5. All duplicates met the acceptance criteria for variability.

Table 9-5. Duplicates for Air Samples

Sample ID	**Method**	**Sample Result**	**QA/QC Result**	**Actual Variability**	**Acceptable Variability**
AIR-AACM-ASB-4L-D1-R1-H1-M3	ISO	2	1	0.58	2.24
AIR-AACM-ASB-4L-D1-R1-H2-M6	ISO	0	0	0	2.24
AIR-AACM-ASB-4L-D1-R2-H1-M13	ISO	0	0	0	2.24
AIR-AACM-ASB-7L-D2-R1-H1-M4	ISO	1	0	1	2.24
AIR-AACM-ASB-7L-D2-R2-H1-M8	ISO	0	0	0	2.24
AIR-LANDFILL-ASB-4L-BG-M1	ISO	0	0	0	2.24
AIR-LF-AACM-ASB-4L-D1-H1-M-3	ISO	0	0	0	2.24
AIR-LF-NESH-ASB-4L-D1-H1-M5	ISO	0	0	0	2.24
AIR-NESHAP-ASB-4L-BG-R1-M8	ISO	0	0	0	2.24
AIR-NESH-ASB-4L-D1-R1-H1-M15	ISO	0	0	0	2.24
AIR-NESH-ASB-4L-D1-R1-H2-M3	ISO	0	1	1	2.24
AIR-NESH-ASB-4L-D1-R2-H1-M1	ISO	3	0	1.73	2.24
AIR-NESH-ASB-4L-D1-R2-H1-M12	ISO	0	0	0	2.24
AIR-NESH-ASB-4L-D1-R2-H1-M16	ISO	0	0	0	2.24
WORKER-AACM-ASB-D1-LA2	ISO	0	0	0	2.24
WORKER-NESHAP-ABATE-ASB-4	ISO	5	10	1.29	2.24
WORKER-NESHAP-ABATE-B3602-ASB-1	ISO	12	21	1.57	2.24
WORKER-NESHAP-ASB-D1-DUP1	ISO	1	0	1	2.24

9.3.1.7 Verified Counts

Verified counting involves the re-examination of the same grid openings by a different microscopist. Results for verified counts are presented in Table 9-6. All verified counts met the acceptance criteria.

Table 9-6. Verified Counts for Air Samples

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
AIR-AACM-ASB-7L-D2-R1-H1-M4	ISO	1	1	100% True Positives	>80% True Positives <20% False Negatives <20%False Positives
AIR-NESH-ASB-4L-D1-R2-H1-M1	ISO	3	3	100% True Positives	
WORKER-NESHAP-ABATE-ASB-4	ISO	5	5	100% True Positives	

9.3.1.8 Interlaboratory QA/QC

After analysis by Clayton, selected filters and grid preparations were sent to RTI for analysis as an independent QA/QC check. Interlaboratory QA/QC sample analyses for the air samples included duplicates and verified counts by TEM. These results are summarized in Table 9-7 and

Table 9-8. All interlaboratory duplicates and the interlaboratory verified count analysis met the acceptance criteria.

Table 9-7. Interlaboratory Verified Counts

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
AIR-NESH-ASB-4L-D1-R2-H1-M1	TEM	2	2	100% True Positives	>80% True Positives <20% False Negatives <20%False Positives

Table 9-8. Interlaboratory Duplicates for Air Samples

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
AIR-AACM-ASB-4L-D1-R1-H2-M11	TEM	0	0	0	2.24
AIR-LF-AACM-ASB-4L-D1-R1-H1-M3	TEM	0	0	0	2.24
AIR-LF-NESH-ASB-4L-D1-H1-M5	TEM	0	0	0	2.24
AIR-NESH-ASB-4L-D1-R1-H2-M3	TEM	1	0	1	2.24
AIR-AACM-ASB-7L-D2-R1-H1-M3	TEM	1	2	0.57	2.24
AIR-AACM-ASB-7L-D2-R1-H2-M2 (Dup)	TEM	0	0	0	2.24
AIR-NESH-ASB-4L-BG-R1-M8	TEM	0	1	1	2.24
AIR-NESH-ASB-4L-D1-R1-H1-M15	TEM	1	1	0	2.24
AIR-AACM-ASB-4L-D1-R2-H1-M13	TEM	0	0	0	2.24
AIR-AACM-ASB-7L-D2-R2-H1-M3	TEM	0	0	0	2.24
WORKER-NESH-ASB-D1-Dup1	TEM	1	0	1	2.24
WORKER-AACM-LF-ASB-D2-FB1	TEM	0	0	0	2.24
WORKER-NESH-ABATE-B3602-ASB-1	TEM	12	7	1.1	2.24
AIR-AACM-ASB-4L-D1-R1-H2-M6	TEM	1	0	1	2.24
AIR-LF-ASB-4L-BG-M1	TEM	1	1	0	2.24
WORKER-AACM-ASB-D1-LA2	TEM	0	0	0	2.24

9.3.2 Soil QA/QC Results

The QAPP specified the required numbers of QA/QC samples for the soil samples. Table 9-9 summarizes the total soil samples collected and the QA/QC samples analyzed.

Table 9-9. Number of Soil QA/QC Samples

	No. Samples	PLM Replicate	PLM Duplicate	PLM Laboratory Control Sample	TEM Replicate	TEM Duplicate	TEM Laboratory Control Sample	TEM Inter-laboratory Duplicates
Total Samples	50	3	2	2	2	2	2	2
Required By QAPP		5%	5%	1/batch	5%	5%	1/batch	5%
Actually Analyzed		6%	4%[a]	1/batch	4%[a]	4%[a]	1/batch	4%[a]

[a] During the laboratory audit, it was agreed that QC would be performed on one post-demolition NESHAP sample and one post-excavation AACM sample.

9.3.2.1 Method Blanks

All method blanks had non-detected asbestos concentrations at less than <7 s/mm^2.

9.3.2.2 Replicates

A replicate is an analysis from the same sample prep performed by the same analyst. Results for replicates are presented in Table 9-10. All replicates met the acceptance criteria for variability.

Table 9-10. Replicates for Soil Samples.

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
SOIL-AACM-POST-DEMO-COMP-2	TEM	6	12	1.41	2.24
SOIL-NESHAP-POST-DEMO-2	TEM	71	90	1.50	2.24
SOIL-NESHAP-PRE-COMP-9	PLM	0	0.10	0.32	2.24
SOIL-AACM-PRE-COMP-10	PLM	0.33	0.20	0.18	2.24
SOIL-AACM-POST-DEMO-COMP-2	PLM	0.33	0.10	0.35	2.24

9.3.2.3 Duplicates

A duplicate is an analysis from different sample preps performed by the same analyst. Results for duplicates are presented in Table 9-11. One of the duplicate TEM analyses did not meet the acceptance criteria for variability and the other, while acceptable, was variable. Since replicate analyses were acceptable (Table 9-10), this appears to be due to the combined sample preparation and analysis process. The preparation involves suspending a portion of the soil in water and filtering this suspension through a filter, which is then subjected to TEM analysis. Only a small portion of the soil can be suspended so that the filter is not overloaded. It may have been difficult to obtain filter samples that were consistently loaded. In addition, only a very small area of the filter was examined. The variability of soil TEM results must be considered in any project conclusions.

Table 9-11. Duplicates for Soil Samples.

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
SOIL-NESHAP-POST-COMP-2	TEM	71	40	2.94	2.50
SOIL-AACM-POST-EVAC-4	TEM	11	24	2.20	2.50
SOIL-NESHAP-POST-COMP-2	PLM	0	0	0	2.50
SOIL-AACM-POST-EXCAV-COMP-4	PLM	0	0	0	2.50

9.3.2.4 Spiked Samples

Background soil from Ft. Chaffee was spiked with chrysotile fibers at concentrations of 0.1% and 1%. These spiked soils were analyzed by PLM and TEM to provide a measure of recovery for the methods. Results for spiked samples are presented in Table 9-12. While no acceptance criteria were specified, the results indicate that recoveries were generally good, meaning that these concentrations could be accurately measured, if present.

Table 9-12. Spikes for Soil Samples.

Sample ID	Method	Actual Value	QA/QC Result	% Recovery	Acceptable Recovery
0.1% Chrysotile spike	TEM	0.1%	0.11%	110%	None specified
1.0% Chrysotile spike	TEM	1.0%	0.51%	51%	None specified
0.1% Chrysotile spike	PLM	0.1%	0.09%	90%	None specified
1.0% Chrysotile spike	PLM	1.0%	0.86%	86%	None specified

9.3.2.5 Interlaboratory QA/QC

After analysis by Lab/Cor, selected soil samples were sent to RTI for analysis as an independent QA/QC check. Interlaboratory QA/QC sample analyses for the soil samples included duplicates by both PLM and TEM. These results are summarized in Table 9-13. One of the interlaboratory PLM duplicates exceeded the acceptance criteria for variability, which again may be attributed to the difficulty of obtaining consistent soil suspensions.

Table 9-13. Interlaboratory Duplicates for Soil Samples.

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
SOIL-NESHAP-POST-COMP-2	TEM	71	22	0.89[a]	2.50
SOIL-AACM-POST-EXCAV-COMP-5	TEM	11	3	2.4[a]	2.50
SOIL-NESHAP-POST-COMP-2	PLM	0	1	1	2.50
SOIL-AACM-POST-EXCAV-COMP-5	PLM	0	8	2.8	2.50

[a]QA/QC result analytical sensitivity was different than the sample result analytical sensitivity Equation 2 was used.

9.3.3 Elutriation QA/QC

9.3.3.1 Replicates

A replicate is an analysis from the same sample prep performed by the same analyst. Results for replicates are presented in Table 9-14.

Table 9-14. Replicates for Elutriation Samples.

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
SOIL-AACM-PRE-OMP-28	TEM	13	13	0	2.24

9.3.3.2 Duplicates

Elutriation duplicates included both analysis of different preps of the same filter (filter duplicate) and reprocessing of soil samples through the elutriation procedure (elutriation duplicate). These duplicates are summarized in Table 9-15. All elutriation duplicates met the acceptance criteria for variability.

Table 9-15. Duplicates for Elutriation Samples.

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
SOIL-NESHAP-POST-COMP-8 (filter dup)	TEM	2	1	0.58	2.50
SOIL-AACM-POST-EXCAV-COMP-5 (filter dup)	TEM	1	0	1	2.50
SOIL-NESHAP-POST-COMP-8 (elutriation dup)	TEM	2	2	0	2.50
SOIL-AACM-POST-EXCAV-COMP-5 (elutriation dup)	TEM	1	2	0.58	2.50

9.3.3.3 Elutriation Spikes

No standards are available for the elutriation method. In order to provide some information about the recovery of asbestos from PM_{10} particulates, spiked standards were prepared using background soil from Ft. Chaffee subjected to the elutriation method. Refer to Section 9.3.2.4. The results of these spikes are presented in Table 9-16. While no true elutriation values for the spikes are known, it is noted that the results for the one -percent spike are only approximately twice the results for the 0.1-percent spike; however, these results do provide evidence that significant fibers can be released from the Ft. Chaffee matrix, if present in the quantities used for spiking.

Table 9-16. Spikes for Elutriation Samples.

Sample ID	Method	Actual Value	QA/QC Result, s/gPM_{10}	Acceptable Recovery
0.1% Chrysotile spike	TEM	0.1%	8.95E+09	None specified
1.0% Chrysotile spike	TEM	1.0%	1.84E+10	None specified

9.3.4 Settled Dust QA/QC

9.3.4.1 Field Blanks

A field blank is prepared by placing a sample container in the field, removing the lid, and immediately replacing the lid. All field blanks had non-detected asbestos concentrations at less than 200 s/cm^2.

9.3.4.2 Field Duplicates

A field duplicate is a second sample collected concurrently at the same location as the original sample. Results for field duplicates are presented in Table 9-17. One settled dust field duplicate exceeded the acceptance criteria for variability. The laboratory noted that several of the dust containers had evidence of dried particulate on the inner sides (possibly from splashing into the container). The highly variable sample below contained a significant amount of this dried particulate. This indicates that some of the asbestos measured in the settled dust samples may have come from splashing during demolition activities.

Table 9-17. Field Duplicates for Settled Dust Samples.

Sample ID	Method	Sample Result	Duplicate Result	Actual Variability	Acceptable Variability
SDUST-NESH-ASB-R1-H1-M4	TEM	0	5	2.2	2.50
SDUST-NESH-ASB-R1-H1-M16	TEM	16	8	1.6	2.50
SDUST-NESH-ASB-R2-H1-M2	TEM	1	2	0.58	2.50
SDUST-NESH-ASB-R2-H1-M15	TEM	1	1	0	2.50
SDUST-AACM-ASB-R1-H1-M4	TEM	9	18	1.7	2.50
SDUST-AACM-ASB-R1-H1-M16	TEM	4	248	15	2.50
SDUST-AACM-ASB-R2-H1-M2	TEM	6	4	0.63	2.50
SDUST-AACM-ASB-R2-H1-M15	TEM	5	1	1.6	2.50

9.3.4.3 Method Blanks

All method blanks had non-detected asbestos concentrations at less than 10 s/mm^2.

9.3.4.4 Replicates

A replicate analysis is a second analysis of the same preparation, but not necessarily the same grid openings, by the same microscopist as the original analysis. Results for replicates are presented in Table 9-18. All replicate analyses met the acceptance criteria for variability.

Table 9-18. Replicates for Settled Dust Samples

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
SDUST-NESH-ASB-R2-H1-M2	TEM	1	1	0	2.24
SDUST-NESH-ASB-R2-H1-M15	TEM	1	1	0	2.24
SDUST-AACM-ASB-R1-H1-M4	TEM	9	9	0	2.24

9.3.4.5 Duplicates

A duplicate analysis is the analysis of a second aliquot of the original dust sample aqueous suspension. Results for duplicates are presented in Table 9-19. All duplicate analyses met the acceptance criteria for variability.

Table 9-19. Duplicates for Settled Dust Samples

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
SDUST-NESH-ASB-R1-H1-M16	TEM	16	15	0.18	2.50
SDUST-AACM-ASB-R1-H1-M6	TEM	6	6	0	2.50
SDUST-AACM-ASB-R2-H1-M15	TEM	5	7	0.58	2.50

9.3.5 Water QA/QC Results

9.3.5.1 Field Blank

A field blank is a clean sample container with approximately 800 mL of laboratory water which is opened in the field for approximately 30 seconds. The field blank had a non-detected asbestos concentration of less than 10 s/mm^2.

9.3.5.2 Field Duplicate

A field duplicate is a second sample collected concurrently at the same location as the original sample. Results for the field duplicate are presented in Table 9-20. This duplicate met the acceptance criteria for variability.

Table 9-20. Field Duplicate for Water Samples.

Sample ID	Method	Sample Result	Duplicate Result	Actual Variability	Acceptable Variability
Water-AACM-Day1-Surface-AM	EPA100.2	106	104	0.14	None Specified

9.3.5.3 Method Blank

The method blank had a non-detected asbestos concentration of less than 10 s/mm^2.

9.3.5.4 Replicates

A replicate analysis is a second analysis of the same preparation, but not necessarily the same grid openings, by the same microscopist as the original analysis. Results for the replicate are presented in Table 9-21. The replicate analysis met the acceptance criteria for variability.

Table 9-21. Replicate for Water Samples.

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
Water-NESHAP-Day1-Source-Predemo	EPA100.2	0	0	0	2.24

9.3.5.5 Duplicates

A duplicate analysis is the analysis of a second aliquot of the original water sample. Results for the duplicate are presented in Table 9-22. The duplicate analysis met the acceptance criteria for variability.

Table 9-22. Duplicate for Water Samples.

Sample ID	Method	Sample Result	QA/QC Result	Actual Variability	Acceptable Variability
Water-AACM-Day1-Surface-AM	EPA100.2	106	111	0.34	2.50

9.4 QA/QC Summary

All air and water QA/QC samples for asbestos met acceptance criteria and can be used with confidence in making project conclusions using the air and water results. Some variability was observed for some soil QA/QC samples and this variability should be considered in making project conclusions using for the soil results. For the settled dust samples, a highly variable field duplicate was observed, indicating possible splashing into the dust containers from the demolition activities, which should be considered in making project conclusions using the settled dust results.

SECTION 10 CONCLUSIONS

Conclusions

The following conclusions are relevant to the demolitions of the identical structures at Fort Chaffee Redevelopment Authority:

Primary Objectives

- The airborne asbestos concentrations measured by transmission electron microscopy (TEM) during both the NESHAP and the AACM demolition processes were orders of magnitude below any EPA existing health or performance criterion. At an analytical sensitivity of 0.0005 asbestos structures per cubic centimeter of air (s/cm^3), the maximum asbestos air concentration was 0.0005 s/cm^3 (one structure observed) for the NESHAP process and 0.0019 s/cm^3 (four structures observed) for the AACM process.

- The airborne asbestos (TEM) concentrations were near or below the limit of detection. The statistical analyses for the demolition phase of both processes showed that the airborne asbestos (TEM) concentrations from the AACM were equal to the NESHAP (based upon the observed proportion of detects). The statistical analyses comparing both total processes (including the soil removal phase of the AACM) showed that the airborne asbestos (TEM) concentrations from the AACM were not equal to the airborne asbestos (TEM) concentrations from the NESHAP Method ($p=0.0006$, where p represents a strength of evidence that the null hypothesis is true. The smaller the p-value, the stronger the evidence is that the null hypothesis should be rejected. In this study, the null hypothesis was rejected for p values less than 0.05.). The empirical evidence (the proportion of non-detects and the maximum values) from the investigation suggests airborne asbestos (TEM) concentrations from the AACM were greater than the airborne asbestos (TEM) concentrations from the NESHAP Method. Based upon the observed proportion of detects, it was concluded that the difference between the two methods is a function of the Day 2 AACM activities (soil excavation and removal). This was likely due to an operational error where no water was added during the soil removal stage of the process.

- The statistical analyses showed that the post-excavation asbestos TEM concentrations in the soil from the AACM were not equal to the post-demolition asbestos concentrations in the soil from the NESHAP Method ($p=0.033$). Based on descriptive statistics, it was concluded that the post-excavation asbestos concentrations in the soil from the AACM were less than the post-demolition asbestos concentrations in the soil from the NESHAP Method. Polarized Light Microscopy (PLM) analyses for all soil samples from both processes indicated very low concentrations of asbestos; the NESHAP post-demolition soil had only one of ten samples with detectable asbestos (0.3 percent) whereas the AACM post-excavation soil had no samples with detectable asbestos at an analytical sensitivity of 0.1 percent.

- The cost of the NESHAP demolition process ($108,331) was approximately twice the cost of the AACM demolition process ($57,864) for this site. Costs specific to conducting the research were not included.

Secondary Objectives

- Based upon descriptive statistics, the fiber concentrations in air from the AACM as measured by phase contrast microscopy (PCM) were equal to the fiber concentrations from the NESHAP Method.

- A brief visible emission was observed during the removal of a concrete foundation structure during the NESHAP demolition, but it was not an asbestos-containing material. No visible emissions were observed during the AACM demolition.

- Settled dust asbestos loadings during the AACM demolition were equal to the settled dust loadings during the NESHAP demolition.

- The statistical analyses showed that the total particulate concentrations, as collected and measured by NIOSH's Method 0500, from the AACM were not equal to the total particulate concentrations from the NESHAP Method. Based on the observed proportion of detects, the total particulate concentrations from the AACM were higher than the total particulate concentrations from the NESHAP Method. This is attributed the extended sampling period for the AACM process, which included soil removal and disposal. Since wetting was inadvertently not performed during the soil removal, it is possible that this increased the particulate loading.

- Based on the observed proportion of non-detects, the worker breathing zone asbestos concentrations (TEM) from the AACM were less than the worker breathing zone asbestos concentrations (TEM) from the NESHAP method. This was due to the concentrations encountered by workers during the abatement required by the NESHAP. The maximum breathing zone asbestos concentration was 0.093 s/cm^3 for the NESHAP process (abatement phase) whereas no asbestos was detected on any of the AACM worker breathing zone samples (<0.005 s/cm^3).

- One NESHAP worker had an Eight-Hour Time-Weighted Average (TWA) fiber (PCM) concentration which equaled the OSHA PEL (Personal Exposure Limit) of 0.1 f/cm^3. The maximum TWA fiber concentration for the AACM was 0.03 f/cm^3.

- Based on descriptive statistics, the NESHAP post-demolition soil asbestos (TEM) concentrations are greater than the NESHAP pre-demolition soil concentrations; the AACM pre-demolition soil asbestos (TEM) concentrations are greater than the post-excavation soil concentrations; and the AACM post-demolition soil asbestos (TEM) concentrations are greater than the AACM post-excavation soil concentrations.

- The time required to perform the AACM process (1½ days) was about one-fifth the time required to perform the NESHAP process (ten days) for this site. The abatement phase of the NESHAP process was very labor intensive (nine days) and took nine times longer than the demolition itself (one day) for this site.

- Both the NESHAP and the AACM processes left minimal amounts of small fragments of asbestos-containing material (ACM) debris, primarily vinyl asbestos floor tile, in the soil at the completion of the processes; however, the AACM process (post-excavation) left less ACM debris than the NESHAP process (post-demolition).

A summary comparison is presented in Table 10-1.

Table 10-1. Summary Comparison of the Results of the NESHAP and AACM Demolitions at Fort Chaffee

PARAMETER	NESHAP	AACM	Comment
Asbestos(TEM) in Air[1] (Range)	$0.000054\ s/cm^3$ (0 to $0.00049\ s/cm^3$)	$0.00012\ s/cm^3$ (0 to $0.0019\ s/cm^3$)	All concentrations near or below the limit of detection; however, AACM greater than NESHAP[2]
Asbestos(PLM) in Soil[1] (Range)	0.03 % (0 to 0.34 %)	0% (0 to 0 %)	No statistical tests performed
Asbestos (TEM) in Soil[1] (Range)	$1.81x10^8$ s/g (0 to $1.6x10^9$ s/g)	$1.67x10^7$ s/g (0 to $1.5x10^8$ s/g)	AACM less than NESHAP
Cost	$108,331	$57,864	
Visible Emissions	One Observed (not from ACM)	None Observed	
Fibers(PCM) in Air[1] (Range)	$0.002\ f/cm^3$ (0 to $0.006\ f/cm^3$)	$0.003\ f/cm^3$ (0 .001 to $0.016\ f/cm^3$)	No statistical difference
Asbestos (TEM) in Dust [1] (Range)	$6{,}650\ s/cm^2$ (0 to $46{,}800\ s/cm^2$)	$5{,}080\ s/cm^2$ (0 to $21{,}600\ s/cm^2$)	No statistical difference
Asbestos (TEM) in Worker Breathing Zone (max)	$0.093\ s/cm^3$	$0\ s/cm^3$	
Fibers (PCM) in Worker Breathing Zone (max TWA)	$0.10\ f/cm^3$	$0.03\ f/cm^3$	NESHAP had one concentration at PEL
Particulate in Air[1] (Range)	$0.032\ mg/m^3$ (0 to $0.11\ mg/m^3$)	$0.084\ mg/m^3$ (0 to $0.15\ mg/m^3$)	AACM greater than NESHAP
Time	10 days	1½ days	
Asbestos (PLM) Debris in Soil[1] (Range)	0.07% (0.01 to 0.15 %)	0.01% (0 to 0.03 %)	AACM less than NESHAP

[1] Means

[2] For Day 1 there was no difference between the methods. When Days 1 and 2 were combined for the AACM, a difference was observed, likely due to the lack of wetting during soil removal.

SECTION 11 LESSONS LEARNED

During the course of the implementation of this evaluation, the following lessons were learned:

- The berms and Ring One samplers were placed 15-ft from the structures and 25 ft on the side where the trucks were loaded with debris. This was too close because dried particulate from the demolition and debris loading process was observed in the settled dust containers. A 25-ft distance is more reasonable (35 ft on the loadout side).

- Minimal leakage was observed through the berm of the AACM. It appears that the wetting agent enhanced the permeability of the soil berm. Methods to control leakage need to be employed, such as placing plastic film over the berm.

- A one-percent solution of wetting agent was used to ensure adequate proportioning and measurement of the concentration in this implementation of the AACM process. Consultation with the supplier indicates that the concentration to achieve effective wetting could be 0.5 percent or lower.

- Two 30-gpm nozzles were used at the recommendation of the supplier. Based upon field observations, it is likely an equally effective wetting could be achieved with significantly less water.

- As there appears to be a correlation between airborne asbestos concentrations at the five- and 15-ft heights in the inner ring, and lower concentrations were observed in the outer ring, multiple heights and multiple rings are probably unnecessary for any future monitoring efforts.

- It is critically important to continue the wetting throughout the soil removal and loadout portion of the implementation of the AACM, and particularly during the berm removals.

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APPENDIX A - DATA LISTINGS

Table A-1. Laboratory Data: Sample Key

Label Category	Label ID	ID Description	Relevant Media
MEDIA	AIR	Air	NA
	WATER	Water	NA
	SOIL	Soil	NA
	SDUST	Settled Dust	NA
	WORK	Worker Air	NA
	ISOKINETIC	Isokinetic	NA
LOCATION/ BUILDING	NESH (or NESHAP)	NESHAP Building	ALL
	AACM	Alternative Asbestos Control Method Building	ALL (except Isokinetic)
	LF	Landfill	Air, Worker Air
COPC	ASB	Asbestos	ALL
	PB	Lead	Air, Worker Air
	PART	Particulate	Air
PUMP FLOW RATE	4L	Target Air Flow Rate: 4 LPM	Air
	2L	Target Air Flow Rate: 2 LPM	Air
	7L	Target Air Flow Rate: 7 LPM	Air
TIME	D1 (or DAY1)	Sample Day 1	ALL (except Isokinetic/soil)
	D2 (or DAY2)	Sample Day 2	ALL (except Isokinetic/soil)
	D3 (or DAY3)	Sample Day 3	ALL (except Isokinetic/soil)
	AM	Morning (between 0600-1200 hours)	Water
	PM	Afternoon (after 1200 hours)	Water
	PRE	Pre- (Building) Demolition: NESHAP & AACM	Soil
	POST	Post- (Building) Demolition: NESHAP	Soil
	DEMO	Post- (Building) Demolition: AACM	Soil
	EXCAV	Post-Excavation: AACM	Soil
RING NUMBER	R1	Ring No.1 (inner ring of monitors around building)	Air, Settled Dust
	R2	Ring No.2 (outer ring of monitors around building)	Air, Settled Dust
HEIGHT	H1	Sample Height No.1 (five feet)	Air, Settled Dust
	H2	Sample Height No.2 (15 feet)	Air, Settled Dust

Table A-2 NESHAP Building – Airborne Asbestos and Total Fibers in Rings 1 and 2

Sample Number	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm[3]				Total Fibers (PCM), fibers/cm[3]
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
NESH-ASB-4L-D1-R1-H1-M1	1772	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0011
NESH-ASB-4L-D1-R1-H1-M2	1805	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0014
NESH-ASB-4L-D1-R1-H1-M3	1786	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0011
NESH-ASB-4L-D1-R1-H1-M4	1732	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0016
NESH-ASB-4L-D1-R1-H1-M5	1814	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0022
NESH-ASB-4L-D1-R1-H1-M6	1756	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0013
NESH-ASB-4L-D1-R1-H1-M7	1748	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0017
NESH-ASB-4L-D1-R1-H1-M8	1786	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0018
NESH-ASB-4L-D1-R1-H1-M9	1733	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0062
NESH-ASB-4L-D1-R1-H1-M10	1680	51	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0045
NESH-ASB-4L-D1-R1-H1-M11	1759	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
NESH-ASB-4L-D1-R1-H1-M12	1833	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0034
NESH-ASB-4L-D1-R1-H1-M13	1776	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0017
NESH-ASB-4L-D1-R1-H1-M14	1896	46	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0029
NESH-ASB-4L-D1-R1-H1-M15	1744	50	0	1	<0.00049	0.00049	0.00049	0.00049	0.0024
NESH-ASB-4L-D1-R1-H1-M16	1602	54	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0025
NESH-ASB-4L-D1-R1-H1-M17	1638	53	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
NESH-ASB-4L-D1-R1-H1-M18	1665	52	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0012
NESH-ASB-4L-D1-R1-H1-DUP1 (M5)	1713	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0012
NESH-ASB-4L-D1-R1-H1-DUP2 (M17)	1638	53	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
NESH-ASB-4L-D1-R1-H2-M1	1776	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
NESH-ASB-4L-D1-R1-H2-M2	1794	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0013
NESH-ASB-4L-D1-R1-H2-M3	1786	49	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0014
NESH-ASB-4L-D1-R1-H2-M4	1775	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0032
NESH-ASB-4L-D1-R1-H2-M5	1763	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0020
NESH-ASB-4L-D1-R1-H2-M6	1752	49	1	0	0.00049	<0.00049	0.00049	0.00049	0.0011
NESH-ASB-4L-D1-R1-H2-M7	1794	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0024
NESH-ASB-4L-D1-R1-H2-M8	1737	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0039
NESH-ASB-4L-D1-R1-H2-M9	1775	49	1	0	0.00049	<0.00049	0.00049	0.00049	0.0045
NESH-ASB-4L-D1-R1-H2-M10	1721	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0022
NESH-ASB-4L-D1-R1-H2-M11	1410	61	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021

Table A-2 NESHAP Building – Airborne Asbestos and Total Fibers in Rings 1 and 2 (Continued)

Sample Number	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm³				Total Fibers (PCM), fibers/cm³
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
NESH-ASB-4L-D1-R1-H2-M12	1647	52	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0030
NESH-ASB-4L-D1-R1-H2-M13	1455	59	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0022
NESH-ASB-4L-D1-R1-H2-M14	1720	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0035
NESH-ASB-4L-D1-R1-H2-M15	1664	52	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0012
NESH-ASB-4L-D1-R1-H2-M16	1602	54	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0056
NESH-ASB-4L-D1-R1-H2-M17	1591	54	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0019
NESH-ASB-4L-D1-R1-H2-M18	1623	53	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0017
NESH-ASB-4L-D1-R1-H2-DUP1 (M2)	1746	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0019
NESH-ASB-4L-D1-R1-H2-DUP2 (M12)	1380	62	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0034
NESH-ASB-4L-D1-R2-H1-M1	1758	49	2	1	0.00098	0.00049	0.0015	0.00098	0.0030
NESH-ASB-4L-D1-R2-H1-M2	1746	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0026
NESH-ASB-4L-D1-R2-H1-M3	1735	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0019
NESH-ASB-4L-D1-R2-H1-M4	1775	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0011
NESH-ASB-4L-D1-R2-H1-M5	1724	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0013
NESH-ASB-4L-D1-R2-H1-M6	1814	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
NESH-ASB-4L-D1-R2-H1-M7	1670	52	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0012
NESH-ASB-4L-D1-R2-H1-M8	1752	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0044
NESH-ASB-4L-D1-R2-H1-M9	1744	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0020
NESH-ASB-4L-D1-R2-H1-M10	1786	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0013
NESH-ASB-4L-D1-R2-H1-M11	1782	49	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0017
NESH-ASB-4L-D1-R2-H1-M12	1687	51	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0019
NESH-ASB-4L-D1-R2-H1-M13	1816	49	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0019
NESH-ASB-4L-D1-R2-H1-M14	1714	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0011
NESH-ASB-4L-D1-R2-H1-M15	1665	52	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0017
NESH-ASB-4L-D1-R2-H1-M16	1613	53	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0025
NESH-ASB-4L-D1-R2-H1-M17	1739	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0022
NESH-ASB-4L-D1-R2-H1-M18	1687	51	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0018
NESH-ASB-4L-D1-R2-H1-DUP1 (M1)	1805	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0026
NESH-ASB-4L-D1-R2-H1-DUP2 (M15)	1710	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0015

[1]Grid opening size = 0.0091 mm²; effective filter area = 385 mm².
[2]Less than values represent the analytical sensitivities; detection limits are 2.99 times higher, per ISO 10312.

Table A-3. AACM Building – Airborne Asbestos and Total Fibers in Rings 1 and 2.

Sample Number[1]	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm^3				Total Fibers (PCM), $fibers/cm^3$
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
AACM-ASB-4L-D1-R1-H1-M1	2782	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0032
AACM-ASB-4L-D1-R1-H1-M2	2850	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0034
AACM -ASB-4L-D1-R1-H1-M3	2846	31	2	0	0.00096	<0.00048	0.00096	<0.00048	0.0033
AACM -ASB-4L-D1-R1-H1-M4	2768	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0024
AACM -ASB-4L-D1-R1-H1-M5	2909	30	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0021
AACM -ASB-4L-D1-R1-H1-M6	2827	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0012
AACM -ASB-4L-D1-R1-H1-M7	2748	32	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0015
AACM -ASB-4L-D1-R1-H1-M8	2894	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0042
AACM -ASB-4L-D1-R1-H1-M9	2816	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0044
AACM -ASB-4L-D1-R1-H1-M10	2734	32	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0018
AACM -ASB-4L-D1-R1-H1-M11	2804	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0040
AACM -ASB-4L-D1-R1-H1-M12	2723	32	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0031
AACM -ASB-4L-D1-R1-H1-M13	2789	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0024
AACM -ASB-4L-D1-R1-H1-M14	2859	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0037
AACM -ASB-4L-D1-R1-H1-M15	2782	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0020
AACM -ASB-4L-D1-R1-H1-M16	2632	33	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0029
AACM -ASB-4L-D1-R1-H1-M17[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	-[4]
AACM -ASB-4L-D1-R1-H1-M18	2843	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0035
AACM -ASB-4L-D1-R1-H1-DUP1 (M5)	2760	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0024
AACM -ASB-4L-D1-R1-H1-DUP2 (M17)	2701	32	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0047
AACM-ASB-4L-D1-R1-H2-M1	2861	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
AACM -ASB-4L-D1-R1-H2-M2	2850	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0029
AACM -ASB-4L-D1-R1-H2-M3	2842	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0053
AACM -ASB-4L-D1-R1-H2-M4	2839	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0013
AACM -ASB-4L-D1-R1-H2-M5	2831	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0026
AACM -ASB-4L-D1-R1-H2-M6	2902	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0020
AACM -ASB-4L-D1-R1-H2-M7	2848	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0023
AACM -ASB-4L-D1-R1-H2-M8	2820	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0022
AACM -ASB-4L-D1-R1-H2-M9	2886	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
AACM -ASB-4L-D1-R1-H2-M10	2808	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0029
AACM -ASB-4L-D1-R1-H2-M11	2804	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0027
AACM -ASB-4L-D1-R1-H2-M12	2723	32	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0040

Table A-3. AACM Building – Airborne Asbestos and Total Fibers in Rings 1 and 2.(Continued)

Sample Number[1]	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm[3]				Total Fibers (PCM), fibers/cm[3]
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
AACM -ASB-4L-D1-R1-H2-M13	2789	31	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0038
AACM -ASB-4L-D1-R1-H2-M14	2859	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0029
AACM -ASB-4L-D1-R1-H2-M15	2782	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0027
AACM -ASB-4L-D1-R1-H2-M16	2705	32	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0012
AACM -ASB-4L-D1-R1-H2-M17	2701	32	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0028
AACM -ASB-4L-D1-R1-H2-M18	2766	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0032
AACM -ASB-4L-D1-R1-H2-DUP1 (M2)	2775	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0019
AACM -ASB-4L-D1-R1-H2-DUP2 (M12)	2723	32	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
AACM-ASB-4L-D1-R2-H1-M1	2775	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0026
AACM -ASB-4L-D1-R2-H1-M2	2779	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0028
AACM -ASB-4L-D1-R2-H1-M3	2917	30	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0027
AACM -ASB-4L-D1-R2-H1-M4	2839	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0018
AACM -ASB-4L-D1-R2-H1-M5	2760	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0024
AACM -ASB-4L-D1-R2-H1-M6	2906	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0015
AACM -ASB-4L-D1-R2-H1-M7	2678	32	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0034
AACM -ASB-4L-D1-R2-H1-M8	2823	31	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0035
AACM -ASB-4L-D1-R2-H1-M9	2745	32	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0028
AACM -ASB-4L-D1-R2-H1-M10	2890	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0022
AACM -ASB-4L-D1-R2-H1-M11	2812	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0029
AACM -ASB-4L-D1-R2-H1-M12	2808	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0033
AACM -ASB-4L-D1-R2-H1-M13	2804	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
AACM -ASB-4L-D1-R2-H1-M14	2874	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0028
AACM -ASB-4L-D1-R2-H1-M15	2720	32	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0017
AACM -ASB-4L-D1-R2-H1-M16	2642	33	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0025
AACM -ASB-4L-D1-R2-H1-M17	2855	30	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0014
AACM -ASB-4L-D1-R2-H1-M18	2851	30	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0038
AACM -ASB-4L-D1-R2-H1-DUP1 (M1)	2925	30	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0024
AACM -ASB-4L-D1-R2-H1-DUP2 (M15)	2793	31	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
AACM-ASB-7L-D2-R1-H1-M1	2088	41	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0029
AACM-ASB-7L-D2-R1-H1-M2	2104	41	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
AACM -ASB-7L-D2-R1-H1-M3	2098	41	1	0	0.00049	<0.00049	0.00049	0.00049	0.0037
AACM -ASB-7L-D2-R1-H1-M4	2058	42	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0035
AACM -ASB-7L-D2-R1-H1-M5	2155	40	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0028

Table A-3. AACM Building – Airborne Asbestos and Total Fibers in Rings 1 and 2.(Continued)

Sample Number[1]	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm[3]				Total Fibers (PCM), fibers/cm[3]
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
AACM -ASB-7L-D2-R1-H1-M6	2086	41	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0041
AACM -ASB-7L-D2-R1-H1-M7	2097	41	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0026
AACM -ASB-7L-D2-R1-H1-M8	2108	41	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0011
AACM -ASB-7L-D2-R1-H1-M9	2062	42	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0046
AACM -ASB-7L-D2-R1-H1-M10	2062	42	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
AACM -ASB-7L-D2-R1-H1-M11	2083	42	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0048
AACM -ASB-7L-D2-R1-H1-M12	2016	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0046
AACM -ASB-7L-D2-R1-H1-M13	2071	42	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0041
AACM -ASB-7L-D2-R1-H1-M14	2071	42	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0012
AACM -ASB-7L-D2-R1-H1-M15	2026	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
AACM -ASB-7L-D2-R1-H1-M16	1986	44	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0055
AACM -ASB-7L-D2-R1-H1-M17[1]	4140	31	0	0	--[3]	--[3]	--[3]	--[3]	-[4]
AACM -ASB-7L-D2-R1-H1-M18	2040	42	1	0	0.00049	<0.00049	0.00049	0.00049	0.0022
AACM -ASB-7L-D2-R1-H1-DUP1 (M5)	Sample Lost								
AACM -ASB-7L-D2-R1-H1-DUP2 (M17)	2013	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0026
AACM-ASB-7L-D2-R1-H2-M1	2088	41	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0024
AACM -ASB-7L-D2-R1-H2-M2	2104	41	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0018
AACM -ASB-7L-D2-R1-H2-M3	2132	41	4	0	0.0019	<0.00048	0.0019	0.00048	0.0036
AACM -ASB-7L-D2-R1-H2-M4	2092	41	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0019
AACM -ASB-7L-D2-R1-H2-M5	2097	41	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0017
AACM -ASB-7L-D2-R1-H2-M6	2120	41	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0033
AACM -ASB-7L-D2-R1-H2-M7	2074	42	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0027
AACM -ASB-7L-D2-R1-H2-M8	2074	42	1	0	0.00049	<0.00049	0.00049	0.00049	0.016
AACM -ASB-7L-D2-R1-H2-M9	2096	41	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0024
AACM -ASB-7L-D2-R1-H2-M10	2005	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0019
AACM -ASB-7L-D2-R1-H2-M11	1993	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0024
AACM -ASB-7L-D2-R1-H2-M12	1243	70	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0044
AACM -ASB-7L-D2-R1-H2-M13	2038	43	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0036
AACM -ASB-7L-D2-R1-H2-M14	2038	43	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0029
AACM -ASB-7L-D2-R1-H2-M15	2058	42	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
AACM -ASB-7L-D2-R1-H2-M16	1986	44	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0034
AACM -ASB-7L-D2-R1-H2-M17	1980	44	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0033

Table A-3. AACM Building – Airborne Asbestos and Total Fibers in Rings 1 and 2.(Continued)

Sample Number[1]	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm[3]				Total Fibers (PCM), fibers/cm[3]
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
AACM -ASB-7L-D2-R1-H2-M18	2007	44	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0024
AACM -ASB-7L-D2-R1-H2-DUP1 (M2)	2139	40	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0012
AACM -ASB-7L-D2-R1-H2-DUP2 (M12)	2016	44	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0038
AACM-ASB-7L-D2-R2-H1-M1	2028	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0032
AACM -ASB-7L-D2-R2-H1-M2	2016	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0043
AACM -ASB-7L-D2-R2-H1-M3	2049	42	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0029
AACM -ASB-7L-D2-R2-H1-M4	2031	43	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0033
AACM -ASB-7L-D2-R2-H1-M5	2025	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0035
AACM -ASB-7L-D2-R2-H1-M6	2025	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0017
AACM -ASB-7L-D2-R2-H1-M7	1986	44	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0024
AACM -ASB-7L-D2-R2-H1-M8	2046	42	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0015
AACM -ASB-7L-D2-R2-H1-M9	2007	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0014
AACM -ASB-7L-D2-R2-H1-M10	2040	42	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0020
AACM -ASB-7L-D2-R2-H1-M11	2034	43	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0031
AACM -ASB-7L-D2-R2-H1-M12	2006	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
AACM -ASB-7L-D2-R2-H1-M13	2028	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0028
AACM -ASB-7L-D2-R2-H1-M14	2086	41	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0020
AACM -ASB-7L-D2-R2-H1-M15	1983	44	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0015
AACM -ASB-7L-D2-R2-H1-M16	1950	44	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0032
AACM -ASB-7L-D2-R2-H1-M17	2002	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0024
AACM -ASB-7L-D2-R2-H1-M18	2040	44	1	0	0.00048	<0.00048	0.00048	0.00048	0.0034
AACM -ASB-7L-D2-R2-H1-DUP1 (M1)	2062	42	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0033
AACM -ASB-7L-D2-R2-H1-DUP2 (M15)	1950	45	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0021

[1]Grid opening size = 0.0091 mm^2; effective filter area = 385 mm^2.

[2]Less than values represent the analytical sensitivities; detection limits are 2.99 times higher, per ISO 10312.

[3]Sample AACM -ASB-4L-D1-R1-H1-M17 was inadvertently not changed out at the end of Day 1, but operated for the entire sampling period; however, no asbestos structures were seen at an analytical sensitivity of 0.00033 s/cm^3.

[4]Sample AACM -ASB-4L-D1-R1-H1-M17 was inadvertently not changed out at the end of Day 1, but operated for the entire sampling period; however, the total fiber concentration was of 0.0017 f/cm^3.

Table A-4. Background Levels of Airborne Asbestos and Total Fibers – Ring 1 at NESHAP and AACM Buildings, and Landfill

Sample Number	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm^3				Total Fibers (PCM), fibers/cm^3
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
NESHAP-ASB-4L-BG-R1-M2	1847	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0020
NESHAP-ASB-4L-BG-R1-M5	1927	45	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0010
NESHAP-ASB-4L-BG-R1-M8	1919	45	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0017
NESHAP-ASB-4L-BG-R1-M11	1960	44	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0018
NESHAP-ASB-4L-BG-R1-M14	2001	43	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.00096
NESHAP-ASB-4L-BG-R1-M17	1851	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0010
NESHAP-ASB-4L-BG-R1-DUP1 (M5)	1820	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0011
AACM-ASB-4L-BG-R1-M1	1824	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0027
AACM-ASB-4L-BG-R1-M4	1776	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
AACM-ASB-4L-BG-R1-M7	1824	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0025
AACM-ASB-4L-BG-R1-M10	1776	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0045
AACM-ASB-4L-BG-R1-M13	1824	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0026
AACM-ASB-4L-BG-R1-M16	1776	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
AACM-ASB-4L-BG-R1-DUP1 (M13)	1776	49	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0025
LANDFILL-ASB-4L-BG-M1	960	90	1	0	0.00049	<0.00049	0.00049	<0.00049	0.0036
LANDFILL-ASB-4L-BG-M2	960	90	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0034
LANDFILL-ASB-4L-BG-M4	960	90	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0052
LANDFILL-ASB-4L-BG-M5	960	90	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0020
LANDFILL-ASB-4L-BG-M7	936	92	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0021
LANDFILL-ASB-4L-BG-M8	936	92	0	0	<0.00049	<0.00049	<0.00049	<0.00049	<0.0021
LANDFILL-ASB-4L-BG-DUP1 (M8)	912	94	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0033
Pre-Study Background Asbestos Levels at Demolition Site—January 11, 2006									
1-11-FCN-04A	2510	34	0	0	<0.0005	<0.0005	<0.0005	Not analyzed.	
1-11-FCN-04B	2008	43	0	0	<0.0005	<0.0005	<0.0005		
1-11-FCE-05A	2400	36	0	0	<0.0005	<0.0005	<0.0005		
1-11-FCE-05B	1920	45	0	0	<0.0005	<0.0005	<0.0005		
1-11-FCS-06A	2400	36	0	0	<0.0005	<0.0005	<0.0005		
Pre-Study Background Asbestos Levels at Landfill—January 11, 2006									
1-11-LF-01A	2700	32	0	0	<0.0005	<0.0005	<0.0005	Not analyzed	
1-11-LF-01B	2157	40	0	0	<0.0005	<0.0005	<0.0005		
1-11-LF-02A	2680	32	0	0	<0.0005	<0.0005	<0.0005		
1-11-LF-02B	2144	40	0	0	<0.0005	<0.0005	<0.0005		
1-11-LF-03A	2660	32	0	0	<0.0005	<0.0005	<0.0005		
1-11-LF-03B	2128	40	0	0	<0.0005	<0.0005	<0.0005		

[1]Grid opening size = 0.0091 mm^2; effective filter area = 385 mm^2.

[2]Less than values represent the analytical sensitivities; detection limits are 2.99 times higher, per ISO 10312.

Table A-5. Levels of Airborne Asbestos and Total Fibers at Ring 1 – During Landfill of Demolition Debris from NESHAP and AACM Buildings

Sample Number	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm³				Total Fibers (PCM), fibers/cm³
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
LF-NESH-ASB-4L-D1-H1-M1	1884	48	0	0	<0.00047	<0.00047	<0.00047	<0.00047	<0.0010
LF-NESH-ASB-4L-D1-H1-M2	1884	46	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0023
LF-NESH-ASB-4L-D1-H1-M3	1880	46	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0016
LF-NESH-ASB-4L-D1-H1-M4	1814	48	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0021
LF-NESH-ASB-4L-D1-H1-M5	1902	45	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0032
LF-NESH-ASB-4L-D1-H1-M6	1940	45	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0030
LF-NESH-ASB-4L-D1-H1-M7	1840	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0030
LF-NESH-ASB-4L-D1-H1-M8	1836	47	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0025
LF-NESH-ASB-4L-D1-H1-M9	1737	50	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0017
LF-NESH-ASB-4L-D1-H1-DUP1 (M8)	1836	48	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0016
LF-AACM-ASB-4L-D1-H1-M1	2580	34	1	0	0.00048	<0.00048	0.00048	<0.00048	0.0019
LF-AACM-ASB-4L-D1-H1-M2	2584	34	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0031
LF-AACM-ASB-4L-D1-H1-M3	2519	34	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0019
LF-AACM-ASB-4L-D1-H1-M4	2459	35	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0014
LF-AACM-ASB-4L-D1-H1-M5	2592	34	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0029
LF-AACM-ASB-4L-D1-H1-M6	2592	34	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0028
LF-AACM-ASB-4L-D1-H1-M7	2592	34	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0014
LF-AACM-ASB-4L-D1-H1-M8	2717	32	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0010
LF-AACM-ASB-4L-D1-H1-M9	2588	34	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0021
LF-AACM-ASB-4L-D1-H1-DUP1 (M8)	2584	34	0	0	<0.00048	<0.00048	<0.00048	<0.00048	0.0014
LF-AACM-ASB-4L-D2-H1-M1	1089	79	1	0	0.00049	<0.00049	0.00049	0.00049	0.0076
LF-AACM-ASB-4L-D2-H1-M2	1113	77	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0040
LF-AACM-ASB-4L-D2-H1-M3	1124	77	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0033
LF-AACM-ASB-4L-D2-H1-M4	1132	76	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0022
LF-AACM-ASB-4L-D2-H1-M5	1084	79	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0053
LF-AACM-ASB-4L-D2-H1-M6	1089	79	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0028
LF-AACM-ASB-4L-D2-H1-M7	1116	77	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0045
LF-AACM-ASB-4L-D2-H1-M8	1085	79	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0025
LF-AACM-ASB-4L-D2-H1-M9	1080	80	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0028
LF-AACM-ASB-4L-D2-H1-DUP1 (M8)	1080	80	0	0	<0.00049	<0.00049	<0.00049	<0.00049	0.0076

[1]Grid opening size = 0.0091 mm²; effective filter area = 385 mm².
[2]Less than values represent the analytical sensitivities; detection limits are 2.99 times higher, per ISO 10312.

Table A-6. NESHAP and AACM Buildings – Asbestos in Water.

Sample Number	Aliquot Deposited on Filter, mL[1]	Grid Openings Analyzed[2]	Asbestos Structures Counted	Asbestos Concentration, million s/L
NESHAP-Day 1-Source-Pre-Demo	0.5	102	0	<0.36
NESHAP-Day 1-Source-Post-Demo	8	47	0	<0.05
AACM-Day 1-Source-Pre-Demo	0.5	102	0	<0.36
AACM-Day 1-Source-Post-Demo	2	10	0	<0.76
AACM-Day 2-Source-Post-Demo	8	52	0	<0.04
AACM-Day 1-Surface-AM	0.1	7	106	2,767
AACM-Day 1-Surface-PM	0.1	6	108	3,289
AACM-Day 2-Surface-PM	0.02	103	84	745
AACM-Day 1-Surface-Berm-Out1	0.1	12	105	1,599
AACM-Day 1-Surface-Berm-Out2	0.2	4	100	2,284
AACM-Day 2-Surface-Berm-Out1	0.02	106	12	103
1-Amended Water-AACM-Source	500	104	0	<0.0004
2-Amended Water-AACM-Source	500	105	0	<0.0003
AACM-Day 1-Surface-DUP 1	0.1	9	104	2,112
Pre-Study Water from Hydrant – January 10, 2006				
1-10-W-01	1	10	0	<1.91
1-10-W-02	1	10	0	<1.91

[1]Aliquot deposited on filter based on observed particulate loading in water sample.
[2]Grid opening size = 0.0110 mm^2; effective filter area = 201 mm^2.

Table A-7. Asbestos in Settled Dust in Rings 1 and 2 of NESHAP and AACM Buildings

Sample Number	Aliquot Deposited on Filter, mL[1,2]	Grid Openings Analyzed[3]	Structures Counted			Total Asbestos[4], s/cm^2	Sample Time, min	Deposition Rate s/cm^2/hour
			Chrysotile	Amphibole	Total			
SDUST-NESH-ASB-R1-H1-M1	100	12	0	0	0	<212	564	<23
SDUST-NESH-ASB-R1-H1-M2	100	12	0	0	0	<212	559	<23
SDUST-NESH-ASB-R1-H1-M3	50	24	2	0	2	463	557	50
SDUST-NESH-ASB-R1-H1-M4	50	22	0	0	0	<232	555	<25
SDUST-NESH-ASB-R1-H1-M5	50	23	0	0	0	<221	551	<24
SDUST-NESH-ASB-R1-H1-M6	100	13	5	0	5	980	549	107
SDUST-NESH-ASB-R1-H1-M7	100	11	15	6	21	4,862	548	532
SDUST-NESH-ASB-R1-H1-M8	50	22	30	3	33	8,005	546	880
SDUST-NESH-ASB-R1-H1-M9	50	10	77	24	101	46,771	545	5,149
SDUST-NESH-ASB-R1-H1-M10	100	12	2	0	2	424	543	47
SDUST-NESH-ASB-R1-H1-M11	50	21	38	9	47	10,882	538	1,214
SDUST-NESH-ASB-R1-H1-M12	100	11	23	3	26	6,020	535	675
SDUST-NESH-ASB-R1-H1-M13	100	11	53	12	65	15,050	533	1,694
SDUST-NESH-ASB-R1-H1-M14	100	11	31	9	40	9,262	530	1,048
SDUST-NESH-ASB-R1-H1-M15	100	11	38	13	51	10,825	526	1,235
SDUST-NESH-ASB-R1-H1-M16	100	12	7	9	16	3,396	524	389
SDUST-NESH-ASB-R1-H1-M17	100	11	7	2	9	2,084	520	240
SDUST-NESH-ASB-R1-H1-M18	100	12	1	0	1	212	520	24
SDUST-NESH-ASB-R1-H1-DUP1 (M4)	50	21	5	0	5	1,213	556	131
SDUST-NESH-ASB-R1-H1-(M16)	100	13	5	3	8	1,567	523	180
SDUST-NESH-ASB-R2-H1-M1	50	22	9	1	10	2,315	566	245
SDUST-NESH-ASB-R2-H1-M2	100	12	1	0	1	212	564	23
SDUST-NESH-ASB-R2-H1-M3	100	13	0	0	0	<196	562	<21
SDUST-NESH-ASB-R2-H1-M4	100	12	0	0	0	<212	562	<23
SDUST-NESH-ASB-R2-H1-M5	100	12	0	0	0	<212	562	<23
SDUST-NESH-ASB-R2-H1-M6	100	13	0	0	0	<196	560	<21
SDUST-NESH-ASB-R2-H1-M7	50	33	1	0	1	154	560	17
SDUST-NESH-ASB-R2-H1-M8	100	14	3	0	3	546	559	59
SDUST-NESH-ASB-R2-H1-M9	100	11	6	2	8	1,852	557	200
SDUST-NESH-ASB-R2-H1-M10	100	12	6	0	6	1,273	557	137
SDUST-NESH-ASB-R2-H1-M11	100	14	0	0	0	<182	556	<20

Table A-7. Asbestos in Settled Dust in Rings 1 and 2 of NESHAP and AACM Buildings (Continued)

Sample Number	Aliquot Deposited on Filter, mL[1,2]	Grid Openings Analyzed[3]	Structures Counted			Total Asbestos[4], s/cm^2	Sample Time, min	Deposition Rate s/cm^2/hour
			Chrysotile	Amphibole	Total			
SDUST-NESH-ASB-R2-H1-M12	100	12	0	0	0	<212	556	<23
SDUST-NESH-ASB-R2-H1-M13	50	22	1	0	1	232	555	25
SDUST-NESH-ASB-R2-H1-M14	100	14	1	0	1	182	554	20
SDUST-NESH-ASB-R2-H1-M15	250	7	1	0	1	146	554	16
SDUST-NESH-ASB-R2-H1-M16	250	8	1	0	1	127	552	14
SDUST-NESH-ASB-R2-H1-M17	100	13	0	0	0	<196	551	21
SDUST-NESH-ASB-R2-H1-M18	100	13	0	0	0	<196	550	21
SDUST-NESH-ASB-R2-H1-DUP1 (M2)	100	13	2	0	2	392	564	42
SDUST-NESH-ASB-R2-H1-(M15)	250	7	1	0	1	146	554	16
SDUST-AACM-ASB-R1-H1-M1	50	21	1	0	1	243	1287	11
SDUST- AACM -ASB-R1-H1-M2	50	21	43	6	49	10,852	1283	508
SDUST- AACM -ASB-R1-H1-M3	50	21	44	2	46	11,158	1281	523
SDUST- AACM -ASB-R1-H1-M4	1	106	9	0	9	21,625	1281	1,012
SDUST- AACM -ASB-R1-H1-M5	50	21	2	0	2	485	1279	23
SDUST- AACM -ASB-R1-H1-M6	50	21	6	0	6	1,455	1279	68
SDUST- AACM -ASB-R1-H1-M7	1	102	8	0	8	19,976	1277	939
SDUST- AACM -ASB-R1-H1-M8	50	21	3	0	3	728	1278	34
SDUST- AACM -ASB-R1-H1-M9	50	20	9	1	10	2,547	1275	120
SDUST- AACM -ASB-R1-H1-M10	50	21	0	0	0	243	1275	<11
SDUST- AACM -ASB-R1-H1-M11	100	12	4	0	4	849	1274	40
SDUST- AACM -ASB-R1-H1-M12	50	21	2	5	7	1,698	1271	80
SDUST- AACM -ASB-R1-H1-M13	50	22	25	17	42	9,302	1270	440
SDUST- AACM -ASB-R1-H1-M14	50	21	5	3	8	1,941	1269	92
SDUST- AACM -ASB-R1-H1-M15	50	21	10	0	10	2,426	1269	115
SDUST- AACM -ASB-R1-H1-M16	100	11	4	0	4	926	1267	44
SDUST- AACM -ASB-R1-H1-M17	50	22	0	0	0	<232	1267	<11
SDUST- AACM -ASB-R1-H1-M18	50	21	18	2	20	4,851	1265	230
SDUST- AACM -ASB-R1-H1-DUP1 (M4)	1	101	18	0	18	45,391	1282	2,124
SDUST- AACM -ASB-R1-H1-DUP2 (M16)	50	4	245	2	247	314,549	1269	14, 872
SDUST- AACM -ASB-R2-H1-M1	50	21	3	0	3	728	1286	34
SDUST- AACM -ASB-R2-H1-M2	50	22	5	1	6	1,389	1281	65
SDUST- AACM -ASB-R2-H1-M3	50	21	7	5	12	2,911	1280	136
SDUST- AACM -ASB-R2-H1-M4	50	21	4	1	5	1,213	1283	57

Table A-7. Asbestos in Settled Dust in Rings 1 and 2 of NESHAP and AACM Buildings, (Continued)

Sample Number	Aliquot Deposited on Filter, mL[1,2]	Grid Openings Analyzed[3]	Structures Counted: Chrysotile	Structures Counted: Amphibole	Structures Counted: Total	Total Asbestos[4], s/cm^2	Sample Time, min	Deposition Rate s/cm^2/hour
SDUST- AACM -ASB-R2-H1-M5	50	22	2	1	3	695	1283	33
SDUST- AACM -ASB-R2-H1-M6	50	22	2	0	2	463	1281	22
SDUST- AACM -ASB-R2-H1-M7	50	21	0	0	0	<243	1280	<11
SDUST- AACM -ASB-R2-H1-M8	100	12	0	0	0	<212	1279	<10
SDUST- AACM -ASB-R2-H1-M9	100	12	0	0	0	<212	1278	<10
SDUST- AACM -ASB-R2-H1-M10	250	7	0	0	0	<146	1276	<7
SDUST- AACM -ASB-R2-H1-M11	250	7	2	0	2	291	1277	14
SDUST- AACM -ASB-R2-H1-M12	250	7	3	0	3	437	1275	21
SDUST- AACM -ASB-R2-H1-M13	250	5	22	1	23	4,686	1273	221
SDUST- AACM -ASB-R2-H1-M14	250	5	10	0	10	2,038	1273	96
SDUST- AACM -ASB-R2-H1-M15	100	20	5	0	5	637	1272	30
SDUST- AACM -ASB-R2-H1-M16	250	7	1	0	1	146	1270	7
SDUST- AACM -ASB-R2-H1-M17	100	13	1	0	1	196	1268	9
SDUST- AACM -ASB-R2-H1-M18	100	12	2	0	2	424	1267	20
SDUST- AACM -ASB-R2-H1-DUP1 (M2)	50	22	2	2	4	926	1281	43
SDUST- AACM -ASB-R2-H1-DUP2 (M15)	50	22	1	0	1	232	1272	11

[1]All settled dust containers rinsed and brought to 500 mL.
[2]Aliquot deposited on filter based on observed particulate loading in rinsate sample.
[3]Grid opening size = 0.0110 mm^2; effective filter area = 1017 mm^2.
[4]Area sampled = 181.5 cm^2.

Table A-8. NESHAP and AACM Buildings – Airborne Total Particulate in Ring 1

NESHAP Building			AACM Building		
Sample Number	Sample Volume, Liters	Total Particulate mg/m^3	Sample Number	Sample Volume, Liters	Total Particulate mg/m^3
NESH-PART-D1-R1-H1-M1-PVC237	943	0.11	AACM-PART-D1-R1-H1-M1-PVC252	2059	0.15
NESH-PART-D1-R1-H1-M2-PV226	934	0.07	AACM-PART-D1-R1-H1-M2-PVC264	2034	0.14
NESH-PART-D1-R1-H1-M3-PV243	924	<0.05	AACM-PART-D1-R1-H1-M3-PVC267	2059	0.14
NESH-PART-D1-R1-H1-M4-PV236	920	<0.05	AACM-PART-D1-R1-H1-M4-PVC263	1876	0.04
NESH-PART-D1-R1-H1-M5-PV227	916	<0.05	AACM-PART-D1-R1-H1-M5-PVC270	2065	0.15
NESH-PART-D1-R1-H1-M6-PV246	914	<0.05	AACM-PART-D1-R1-H1-M6-PVC249	2082	0.10
NESH-PART-D1-R1-H1-M7-PV240	924	<0.05	AACM-PART-D1-R1-H1-M7-PVC257	2150	0.14
NESH-PART-D1-R1-H1-M8-PV230	905	<0.06	AACM-PART-D1-R1-H1-M8-PVC265	2075	0.096
NESH-PART-D1-R1-H1-M9-PV245	905	0.06	AACM-PART-D1-R1-H1-M9-PVC259	2087	0.067
NESH-PART-D1-R1-H1-M10-PV231	899	<0.06	AACM-PART-D1-R1-H1-M10-PVC251	2070	0.048
NESH-PART-D1-R1-H1-M11-PV242	891	0.07	AACM-PART-D1-R1-H1-M11-PVC262	2092	0.072
NESH-PART-D1-R1-H1-M12-PV228	879	<0.06	AACM-PART-D1-R1-H1-M12-PVC256	2048	<0.02
NESH-PART-D1-R1-H1-M13-PV224	876	<0.06	AACM-PART-D1-R1-H1-M13-PVC250	2069	0.068
NESH-PART-D1-R1-H1-M14-PV241	833	0.1	AACM-PART-D1-R1-H1-M14-PVC253	1933	0.062
NESH-PART-D1-R1-H1-M15-PV238	863	<0.06	AACM-PART-D1-R1-H1-M15-PVC266	2082	0.067
NESH-PART-D1-R1-H1-M16-PV234	851	0.07	AACM-PART-D1-R1-H1-M16-PVC260	2048	0.03
NESH-PART-D1-R1-H1-M17-PV229	853	<0.06	AACM-PART-D1-R1-H1-M17-PVC261	2046	0.083
NESH-PART-D1-R1-H1-M18-PV232	853	0.1	AACM-PART-D1-R1-H1-M18-PVC247	2082	0.067
NESH-PART-D1-R1-H1-DUP1 (M5) PV225	842	0.15	AACM-PART-D1-R1-H1-DUP1 (M5) PVC255	2084	0.12
NESH-PART-D1-R1-H1-DUP2 (M17) PV235	862	0.07	AACM-PART-D1-R1-H1-DUP2 (M17) PVC	1918	0.073

Table A-9. Worker breathing zone samples for airborne asbestos and total fibers during demolition of NESHAP and AACM Buildings and landfill of debris.

Sample Number	Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm^3				Total Fibers (PCM), fibers/cm^3
			Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
NESHAP-ASB-D1-EO1	344	25	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.023
NESHAP-ASB-D1-HO1	305	29	0	0	<0.0048	<0.0048	<0.0048	<0.0048	0.017
NESHAP-ASB-D1-HO2	308	28	1	0	0.0049	<0.0049	0.0049	<0.0049	0.0089
NESHAP-ASB-D1-LA1	326	27	1	0	0.0048	<0.0048	0.0048	<0.0048	0.012
NESHAP-ASB-D1-LA2	322	27	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.036
NESHAP-ASB-D1-TO1	361	24	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.042
NESHAP-ASB-D1-TO2	232	37	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.056
NESHAP-ASB-D1-TO3	379	24	0	0	<0.0047	<0.0047	<0.0047	<0.0047	0.086
NESHAP-ASB-D1-DUP1	333	26	1	0	0.0049	<0.0049	0.0049	<0.0049	0.059
NESHAP-ASB-D1-WLK1	370	25	0	0	<0.0046	<0.0046	<0.0046	<0.0046	0.027
NESHAP-ASB-D1-WLK2	361	24	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.0090
NESHAP-ASB-D1-WLK3	356	25	0	0	<0.0048	<0.0048	<0.0048	<0.0048	0.031
NESHAP-LF-ASB-D1-BDO	367	24	1	0	0.0048	<0.0048	0.0048	<0.0048	0.043
NESHAP-LF-ASB-D1-CPO	283	30	0	0	<0.0048	<0.0048	<0.0048	<0.0048	0.16
NESHAP-LF-ASB-D1-CPCAB	286	30	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.14
AACM-ASB-D1-EO1	860	10	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.0038
AACM -ASB-D1-HO1	545	16	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.0073
AACM -ASB-D1-HO2	536	16	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.0051
AACM -ASB-D1-LA1	637	14	0	0	<0.0047	<0.0047	<0.0047	<0.0047	0.013
AACM -ASB-D1-LA2	552	16	0	0	<0.0048	<0.0048	<0.0048	<0.0048	0.016
AACM -ASB-D1-TO1	633	14	0	0	<0.0048	<0.0048	<0.0048	<0.0048	0.0091
AACM -ASB-D1-TO2	545	16	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.017
AACM -ASB-D1-TO3	500	18	0	0	<0.0047	<0.0047	<0.0047	<0.0047	0.0070
AACM -ASB-D1-DUP1	579	18	0	0	<0.0041	<0.0041	<0.0041	<0.0041	0.010
AACM -ASB-D1-WLK1	648	14	0	0	<0.0047	<0.0047	<0.0047	<0.0047	0.0077
AACM -ASB-D1-WLK2	656	14	0	0	<0.0046	<0.0046	<0.0046	<0.0046	0.013
AACM -ASB-D1-WLK3	651	14	0	0	<0.0046	<0.0046	<0.0046	<0.0046	0.018
AACM-LF-ASB-D1-BDO	719	12	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.023
AACM-LF-ASB-D1-BDCAB	580	15	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.011
AACM-LF-ASB-D1-CPO	117	74	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.053
AACM-LF-ASB-D1-CPCAB	116	74	0	0	<0.0049	<0.0049	<0.0049	<0.0049	0.052

[1]Grid opening size = 0.0091 mm^2; effective filter area = 385 mm^2.

[2]Less than values represent the analytical sensitivities; detection limits are 2.99 times higher, per ISO 10312.

Table A-10. Asbestos and total fibers measured on workers during abatement of NESHAP Building and landfill of debris.

Sample Number		Sample Volume, Liters	Grid Openings Analyzed[1]	Structures Counted		Asbestos (TEM)[2]—s/cm³				Total Fibers (PCM), fibers/cm³
				Chrysotile	Amphibole	Chrysotile	Amphibole	Total	PCME	
WORKER-NESHAP-ABATE-ASB-1		510	14	11	0	0.065	<0.0059	0.065	0.0059	0.022
WORKER-NESHAP-ABATE-ASB-2		1110	10	0	0	<0.0038	<0.0038	<0.0038	<0.0038	<0.0017
WORKER-NESHAP-ABATE-ASB-3		1200	10	10	0	0.035	<0.0035	0.035	<0.0035	0.12
WORKER-NESHAP-ABATE-ASB-4		1200	10	5	0	0.018	<0.0035	0.018	<0.0035	0.083
WORKER-NESHAP-ABATE-ASB-5		60	144	0	0	<0.0049	<0.0049	<0.0049	<0.0049	<0.032
WORKER-NESHAP-ABATE-ASB-6		1140	10	19	0	0.071	<0.0037	0.071	0.0037	0.084
WORKER-NESHAP-ABATE-B3602-ASB-1		820	10	12	0	0.062	<0.0052	0.062	<0.0052	0.024
WORKER-NESHAP-ABATE-B3602-ASB-2		820	10	8	0	0.041	<0.0052	0.041	0.010	0.019
WORKER-NESHAP-ABATE-B3602-ASB-3		820	10	18	0	0.093	<0.0052	0.093	<0.0052	0.0095
WORKER-NESHAP-ABATE-LF-ASB-1C		231	37	0	0	<0.0050	<0.0050	<0.0050	<0.0050	0.013
WORKER-NESHAP-ABATE-LF-ASB-OP		231	37	0	0	<0.0050	<0.0050	<0.0050	<0.0050	0.018
WORKER-NESHAP-ABATE-LF-ASB-OC1		231	Sample overloaded - not analyzed							
WORKER-NESHAP-ABATE-LF-ASB-OC2		231	Sample overloaded - not analyzed							0.028
HEPA-Units Discharge Air	NESHAP-ASB-NE	8778	10	0	0	<0.00048	<0.00048	<0.00048	<0.00048	<0.00022
	NESHAP-ASB-NW	8047	10	0	0	<0.00053	<0.00053	<0.00053	<0.00053	0.0020
	NESHAP-ASB-SE	8047	10	0	0	<0.00053	<0.00053	<0.00053	<0.00053	<0.00024
	NESHAP-ASB-SC	8047	10	0	0	<0.00053	<0.00053	<0.00053	<0.00053	0.00081

[1]Grid opening size = 0.0091 mm²; effective filter area = 385 mm².
[2]Less than values represent the analytical sensitivities; detection limits are 2.99 times higher, per ISO 10312.

Table A-11. Soil – Modified Vertical Elutriator Method.

Sample Number	Sample Mass on Filter, g	Grid Openings Analyzed	Structures Counted		Asbestos Concentration, s/gPM10	
			Total	PCME-ISO	Total	PCME-ISO
NESHAP-PRE-COMP-2	1.55E-4	122	12	11	1.69E+07	1.55E+07
NESHAP-PRE-COMP-5	1.26E-4	120	17	14	3.12E+07	2.57E+07
NESHAP-PRE-COMP-8	1.05E-4	120	6	4	1.27E+07	8.44E+06
NESHAP-POST-COMP-2	1E-4	120	1	0	2.21E+06	<2.21E+06
NESHAP-POST-COMP-5	1.20E-4	90	0	0	<2.47E+06	<2.47E+06
NESHAP-POST-COMP-8	1.25E-4	120	2	1	3.55E+06	1.77E+06
AACM-PRE-COMP-2	1.02E-4	90	13	4	3.76E+07	1.16E+07
AACM-PRE-COMP-5	1.31E-4	90	4	0	9.04E+06	<2.26E+06
AACM-PRE-COMP-8	1.09E-4	85	13	5	3.73E+07	1.43E+07
AACM-POST-DEMO-COMP-2	1.09E-4	120	2	1	4.06E+06	2.03E+06
AACM-POST-DEMO-COMP-5	1.13E-4	90	2	1	5.22E+06	2.61E+06
AACM-POST-DEMO-COMP-8	1.35E-4	90	0	0	<2.19E+06	<2.19E+06
AACM-POST-EXCAV-COMP-2	1.06E-4	90	0	0	<2.78E+06	<2.78E+06
AACM-POST-EXCAV-COMP-5	1.37E-4	90	1	1	2.16E+06	2.16E+06
AACM-POST-EXCAV-COMP-8	2.77E-5	90	3	0	3.20E+07	<1.07E+07

[1]Grid opening size = 0.01449 mm^2; effective filter area = 385 mm^2.

[2]Less than values represent the analytical sensitivities; detection limits are 2.99 times higher, per ISO 10312.

Table A-12. Asbestos in Soil (PLM and TEM) by Fraction.

Sample Number	Fraction 01 (Soil)						Fraction 02 (Rocks and Organics)		Fraction 03 (Building Debris)	
	% of Sample by Wt	PLM Point Count, % Asbestos	TEM (Asbestos)				% of Sample by Wt	PLM Visual Estimate, % asbestos	% of Sample by Wt	PLM Visual Estimate, % asbestos
			Sample mass on Filter, g	Grid Openings Analyzed[1]	Str/gm	Structure Count				
SOIL-NESHAP-PRE-COMP-1	99.3	<0.1	7.8E-4	10	<2.15E+07	0	0.72	<1	0	-
SOIL-NESHAP-PRE-COMP-2	100	<0.1	5.0E-5	10	6.59E+07	2	0	-	0	-
SOIL-NESHAP-PRE-COMP-3	99.7	<0.1	1.7E-4	10	<9.62E+06	0	0.35	<1	0	-
SOIL-NESHAP-PRE-COMP-4	99.6	<0.1	2.1E-4	10	<7.87E+06	0	0.44	<1	0	-
SOIL-NESHAP-PRE-COMP-5	98.5	<0.1	1.2E-4	10	3.29E+08	22	1.47	<1	0	-
SOIL-NESHAP-PRE-COMP-6	98.2	<0.1	2.2E-4	10	2.54E+07	3	1.81	<1	0.01	8.33
SOIL-NESHAP-PRE-COMP-7	99.2	<0.1	3.0E-4	10	5.73E+06	1	0.82	<1	0	-
SOIL-NESHAP-PRE-COMP-8	100	<0.1	2.2E-4	10	<7.59E+06	0	0	-	0	-
SOIL-NESHAP-PRE-COMP-9	98.6	<0.1	2.2E-4	10	7.75E+06	1	1.35	<1	0.09	3.5
SOIL-NESHAP-PRE-COMP-10	97.9	<0.1	5.6E-5	10	5.84E+07	2	2.12	<1	0.02	<1
SOIL-NESHAP-POST-COMP-1	91.5	<0.1	1.9E-4	10	8.96E+06	1	8.14	<1	0.33	3.6
SOIL-NESHAP-POST-COMP-2	97.5	<0.1	8.1E-4	10	1.56E+08	71	2.35	<1	0.2	0.93
SOIL-NESHAP-POST-COMP-3	95.8	<0.1	2.6E-4	10	<6.57E+06	0	4.06	<1	0.12	4.7
SOIL-NESHAP-POST-COMP-4	96.2	<0.1	2.2E-4	10	<7.97E+06	0	3.68	<1	0.14	0.54
SOIL-NESHAP-POST-COMP-5	97.4	<0.1	3.0E-4	10	5.79E+06	1	2.01	<1	0.57	5.03
SOIL-NESHAP-POST-COMP-6	96.3	<0.1	4.3E-4	10	4.06E+06	1	3.45	<1	0.26	1.52
SOIL-NESHAP-POST-COMP-7	96.6	0.34	1.3E-4	10	1.60E+09	119	3.28	<1	0.11	4.01
SOIL-NESHAP-POST-COMP-8	95.3	<0.1	2.3E-4	10	1.52E+07	2	4.48	<1	0.25	0.16
SOIL-NESHAP-POST-COMP-9	95.3	<0.1	1.9E-4	10	9.17E+06	1	4.35	<1	0.38	2.2
SOIL-NESHAP-POST-COMP-10	96.1	<0.1	1.5E-4	10	2.37E+07	2	3.48	<1	0.39	2.2
SOIL-AACM-PRE-COMP-1	98.7	<0.1	2.7E-4	10	<7.03E+06	0	1.3	<1	0.04	<1
SOIL-AACM-PRE-COMP-2	98.7	<0.1	2.7E-4	10	1.90E+07	3	1.34	<1	0.01	0.62
SOIL-AACM-PRE-COMP-3	98.6	<0.1	3.8E-4	10	<4.64E+06	0	1.44	<1	0.01	<1
SOIL-AACM-PRE-COMP-4	96.5	<0.1	1.6E-4	10	1.09E+07	1	3.45	<1	0.02	<1
SOIL-AACM-PRE-COMP-5	97.8	<0.1	4.5E-4	10	<3.94E+06	0	2.23	<1	0	-
SOIL-AACM-PRE-COMP-6	95.8	<0.1	1.7E-4	10	1.02E+07	1	4.04	<1	0.12	<1
SOIL-AACM-PRE-COMP-7	98.7	<0.1	1.1E-4	10	<1.62E+07	0	1.28	<1	0.06	<1
SOIL-AACM-PRE-COMP-8	96.7	<0.1	1.6E-4	10	4.25E+07	4	3.26	<1	0	-
SOIL-AACM-PRE-COMP-9	98.7	0.11	2.3E-4	10	1.51E+07	2	1.24	<1	0.04	<1
SOIL-AACM-PRE- COMP-10	99.1	0.33	1.1E-4	10	1.15E+10	136	0.83	<1	0.11	<1

Table A-12. Asbestos in Soil (PLM and TEM) by Fraction. (Continued)

Sample Number	Fraction 01 (Soil)						Fraction 02 (Rocks and Organics)		Fraction 03 (Building Debris)	
	% of Sample by Wt	PLM Point Count, % Asbestos	TEM (Asbestos)				% of Sample by Wt	PLM Visual Estimate, % asbestos	% of Sample by Wt	PLM Visual Estimate, % asbestos
			Sample mass on Filter, g	Grid Openings Analyzed[1]	Str/gm	Structure Count				
SOIL-AACM-POST-COMP-1	90.9	<0.1	6.8E-5	10	<5.48E+06	0	7.96	<1	1.12	2.13
SOIL-AACM-POST-COMP-2	85.3	0.33	2.4E-4	10	4.34E+07	6	13.5	<1	1.18	2.46
SOIL-AACM-POST-COMP-3	93.0	<0.1	1.3E-4	10	1.76E+08	13	5.67	<1	1.3	0.36
SOIL-AACM-POST-COMP-4	90.1	<0.1	2.0E-4	10	2.11E+08	24	8.92	<1	0.01	0.04
SOIL-AACM-POST-COMP-5	92.0	<0.1	1.8E-4	10	9.67E+06	1	7.16	<1	0.82	1.19
SOIL-AACM-POST-COMP-6	95.0	<0.1	2.2E-4	10	<7.89E+06	0	4.75	<1	0.22	<1
SOIL-AACM-POST-COMP-7	96.1	<0.1	2.3E-4	10	2.97E+07	4	3.41	<1	0.51	0.06
SOIL-AACM-POST-COMP-8	96.4	<0.1	2.5E-4	10	2.68E+07	4	2.69	<1	0.9	0.27
SOIL-AACM-POST-COMP-9	96.2	<0.1	2.2E-4	10	<8.23E+06	0	1.91	<1	1.91	0.22
SOIL-AACM-POST- COMP -10	94.3	<0.1	1.7E-4	10	1.02E+07	1	4.99	<1	0.7	1.98
SOIL-AACM- POST - EXCAV -1	94.5	<0.1	1.9E-4	10	8.07E+06	1	4.53	<1	0.97	0.23
SOIL-AACM- POST - EXCAV -2	92.6	<0.1	2.0E-4	10	<1.02E+07	0	6.91	<1	0.46	0.11
SOIL-AACM- POST - EXCAV -3	94.9	<0.1	1.6E-4	10	<1.13E+07	0	4.78	<1	0.36	<1
SOIL-AACM- POST - EXCAV -4	96.2	<0.1	2.2E-4	10	7.99E+06	1	3.67	<1	0.18	<1
SOIL-AACM- POST - EXCAV -5	95.2	<0.1	1.3E-4	10	1.51E+08	11	4.52	<1	0.3	0.6
SOIL-AACM- POST - EXCAV -6	93.8	<0.1	2.4E-4	10	<7.31E+06	0	5.05	<1	1.14	0.03
SOIL-AACM- POST- EXCAV -7	93.7	<0.1	4.4E-4	10	<3.98E+06	0	3.97	<1	2.33	<1
SOIL-AACM- POST - EXCAV -8	95.3	<0.1	3.0E-4	10	<5.99E+06	0	4.42	<1	0.3	0.42
SOIL-AACM- POST - EXCAV -9	95.9	<0.1	2.2E-4	10	<8.01E+06	0	3.59	<1	0.49	0.24
SOIL-AACM- POST - EXCAV -10	93.4	<0.1	1.4E-4	10	<1.32E+07	0	6.36	<1	0.28	0.44

[1]Grid opening size = 0.01007 mm^2; effective filter area = 193 mm^2.

Table A-13. Weight of Vinyl Asbestos Tile Fragments and other ACM in Soil Samples.

Sample Composite Number	Wt of original sample, g	Wt of VAT, g	Wt of other ACM, g	VAT, wt %	Non-VAT ACM , wt %
NESHAP PRE-DEMOLITION					
1	10946.3	0	0	0	0
2	10491.9	0	0	0	0
3	10854.8	0	0	0	0
4	10582.7	0	0	0	0
5	10582.5	0	0	0	0
6	11126.5	0	0.5	0	0.0005
7	10945.5	0	0	0	0
8	11580.5	0	0	0	0
9	10719.1	3.45	0	0.03	0
10	11552.9	0	0	0	0
NESHAP POST-DEMOLITION					
1	11021.2	17.0	0	0.15	0
2	9870.9	4.16	0	0.04	0
3	10053.7	6.35	0	0.06	0
4	11144.2	1.26	0	0.01	0
5	9483.5	5.93	3.56	0.06	0.04
6	8381.3	4.28	4.22	0.05	0.05
7	9464.9	5.39	0	0.06	0
8	11047.1	1.97	0	0.02	0
9	10730.3	9.79	0	0.09	0
10	9764.9	12.1	0	0.12	0
AACM PRE-DEMOLITION					
1	10452.3	0	0	0	0
2	9156.5	0	0.02	0	0.0002
3	9679.1	0	0	0	0
4	10381.3	0	0	0	0
5	10584.7	0	0	0	0
6	10211.1	0	0	0	0
7	9592.7	0	0	0	0
8	10285.1	0	0	0	0
9	10082.3	0	0	0	0
10	10278.9	0	0	0	0
AACM POST-DEMOLITION					
1	14473.2	17.7	3.25	0.12	0.02
2	14333.6	36.7	0	0.26	0
3	13895.2	8.46	0	0.06	0
4	13609	0.71	0	0.01	0
5	14511	19.3	0	0.13	0
6	9868.9	0	0	0	0
7	13816.8	0.6	0	0.004	0
8	12954.2	3.1	0	0.02	0
9	12556.6	5.8	0	0.05	0
10	12008.2	16.4	0	0.14	0

Table A-13. Weight of Vinyl Asbestos Tile Fragments and other ACM in Soil Samples. (Continued)

Sample Composite Number	Wt of original sample, g	Wt of VAT, g	Wt of other ACM, g	VAT, wt %	Non-VAT ACM , wt %
AACM POST-EXCAVATION					
1	13398.4	3.98		0.03	0
2	12255.2	0.78		0.01	0
3	13163.8	0		0	0
4	12979.2	0		0	0
5	13201.8	2.35		0.02	0
6	8691.8	0.76		0.01	0
7	9558.6	0		0	0
8	12265.8	1.41		0.01	0
9	12086.6	2.23		0.02	0
10	13163.6	2.16		0.02	0

APPENDIX B - KIDDE MSDS

DATA SHEET
#NFC970

NF-3000
Foam & Wetting Agent Concentrate

Description

Environmentally responsible **NF-3000** Wetting Agent concentrate, is a unique new formulation providing unmatched wetting performance, foamability and flexibility. NF-3000 is specially designed for use in industrial and remedial wetting applications. NF-3000 can be used through conventional foam making devices, Class A/B foam systems and is excellent for Compressed Air Foam Systems (CAFS). **This environmentally responsible formulation does not contain reportable components under SARA Title III, Section 313 of 40 CFR-372, or CERCLA.**

NF-3000 improves the penetrating capability of water. It reduces the surface tension of water, which allows it to penetrate surfaces where water might normally run off. Foaming and wetting ingredients give water the ability to adhere to vertical surfaces that allows longer contact with the material to be penetrated. The longer the water is in contact with an absorbent material, the more water is absorbed.

Features

- Environmentally responsible formulation.
- Excellent Wetting and Foaming for dust control and containment.
- Excellent for wetting materials which may contain hazardous dusts and particles such as abestos.
- Premix is stable for more than 30 days (using potable water), which is significantly longer than traditional Class A foam solutions.
- Contains NO alcohols for higher flash point and compatibility with Class A/B Systems.
- Can be used with fresh, brackish and sea water.
- Exhibits good foamability, even in cold water.
- Can be used as a Class A firefighting foam concentrate.

Typical Physical Properties

Appearance .... Pale yellow liquid
Specific Gravity @ 77°F (25°C) 1.05
pH 9.0
Minimum Usable Concentrate Temp. .... 20°F(-7°C)
Maximum Usable ConcentrateTemp. .... 120°F(49°C)
Freezing Point. .... 6°F(-14°C)
Viscosity @ 70°F (21°C) .... 20 csks
Viscosity @ 20°F (-7°C) .... 32 csks
Surface Tension at 0.1% Conc. .... 25.7 Dynes/cm
Surface Tension at 0.5% Conc. .... 24.1 Dynes/cm
Flash Point: Pensky Martens
Closed Cup Method .... >205°F
Freeze/Thaw: ....No Effects on Concentrate Properties

Typical Proportioning Settings

Wetting .... 0.3% - 1.0%
Foaming, Aspirated .... 0.7% - 1.0%
Compressed Air Application .... 0.1% - 0.5%

Standards & Approvals

- NFPA 18

Compatibility

It is recommended that NF-3000 not be mixed with any other type of foam concentrate in long-term storage. Such mixing could lead to chemical changes in the product and a possible reduction in or loss of its capability.

Storage and Handling

The recommended storage temperature range for NF-3000 concentrate is 20°F (-7°C) to 120°F (49°C). NF-3000 foam concentrate is not affected by freeze/thaw cycles, and it has unique premix stability properties. Samples of NF-3000, premixed with potable municipal water supplies, have been shown to be stable and not suffer any significant loss of expansion or drainage properties after 30 days. Actual results may vary based on the water supply.

NF-3000 should be stored in its original shipping container or in tanks or other containers that have been designed for such foam storage. Recommended construction materials are stainless steel (Type 304L or 316), high-density cross-linked polyethylene, or reinforced fiberglass polyester (isophthalic polyester resin) with a vinyl ester resin internal layer coating (50 -100 mils).

Foam concentrates are subject to evaporation which accelerates when the product is exposed to air. Storage tanks should be sealed and fitted with a pressure vacuum vent to prevent free exchange of air.

Shelf Life, Inspection, and Testing

The shelf life of any foam concentrate is maximized by proper storage conditions and maintenance. Factors affecting shelf life are wide temperature changes, extreme high or low temperatures, evaporation, dilution, and contamination by foreign materials. The expected shelf life of NF-3000 foam concentrate is 20 years or more, if stored properly, according to the manufacturer's recommendations. Should the concentrate become contaminated, testing to ensure original foam concentrate physical properties is a service available from National Foam. Annual testing of foam concentrates is recommended to ensure reliability.

Environmental and Toxicological Information

NF-3000 is biodegradable. However, as with any substance, care should be taken to prevent discharge from entering ground water, surface water, or storm drains. With advance notice, NF-3000 foam concentrate or foam solution can be treated by local biological sewage treatment systems. Since facilities vary widely by location, advance notice should be given, and disposal should be made in accordance with federal, state, and local regulations.

The biological oxygen demand (BOD) and chemical oxygen demand (COD) of NF-3000 are as follows:

	Concentrate	0.5% Sol.	1% Sol.
BOD_5	389,000 mg/kg	2,140 mg/kg	4,220 mg/kg
COD	782,000 mg/kg	3,900 mg/kg	7,960 mg/kg

Tests for acute oral toxicity have proved negative. NF-3000 concentrate is a primary skin irritant. Repeated skin contact will remove oils from the skin and cause dryness. NF-3000 is classified as a primary eye irritant, and contact with the eyes should be avoided. Users are advised to wear protective eyewear. If the foam concentrate enters the eyes, flush them well with water and seek immediate medical attention. For further details see the NF-3000 Material Safety Data Sheet.

This product does NOT contain reportable components under SARA Title III, Section 313 of 40 CFR-372 or CERCLA

Ordering Information

Capacity	Description	Part Number	Shipping Weight lbs.	(kg)	Approximate Shipping Cube Ft ³	(m³)
5-Gallon (19 litres)	Pails (Round)	2170-9340-6	46	(20.9)	1.13	(0.029)
55-Gallon (208 litres)	Drums	2170-9481-6	503	(228.0)	11.10	(0.326)
275-Gallon (1041 litres)	IBC Reusable Tote Tank	2170-9725-6	2549	(1156.0)	48.20	(1.061)
Per Gallon	Bulk Delivery	2170-9001-6	8.75	(4.0)		

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NATIONAL FOAM, INC.
P.O. Box 695 • Exton, PA 19341-0695 • (610) 363-1400 • Fax: (610) 524-9073
www.Kidde-Fire.com

National Foam

MATERIAL SAFETY DATA SHEET #NMS970

NF-3000

Synthetic Foam

Section 1. CHEMICAL PRODUCT/COMPANY IDENTIFICATION

Material Identification

Product: NF-3000
Synonyms: Synthetic Detergent, Wetting Agent
CAS No: Mixture - No single CAS # applicable

Company Identification
Manufacturer:
National Foam, Inc.
150 Gordon Drive
P.O. Box 695
Exton, PA 19341-0695
Emergency Phone Number (Red Alert): (610) 363-1400 (U.S.A.)
Fax (610) 524-9073
http://www.kidde-fire.com/nf1.shtml

Section 2. COMPOSITION / INFORMATION ON INGREDIENTS

Components	CAS Number
Water	7732-18-5
Proprietary mixture of synthetic detergents	No single CAS # applicable
1, 2 Propanediol	57-55-6
(2-Methoxymethylethoxy) Propanol	34590-94-8
Proprietary mixture of corrosion inhibitors	No single CAS # applicable

Section 3. HAZARDS IDENTIFICATION

Potential Health Effects

Inhalation
Vapors are minimal at room temperature. If product is heated or sprayed as an aerosol, airborne material may cause respiratory irritation.

Skin Contact
Contact with liquid may cause moderate irritation or dermatitis due to removal of oils from the skin.

Eye Contact
Product is an eye irritant.

Ingestion
Not a hazard in normal industrial use. Small amounts swallowed during normal handling operations are not likely to cause injury; swallowing large amounts may cause injury or irritation.

Additional Health Effects
Existing eye or skin sensitivity may be aggravated by exposure.

Carcinogenicity Information
No data available.

Section 4. FIRST AID MEASURES

Inhalation
No specific treatment is necessary since this material is not likely to be hazardous by inhalation. If exposed to excessive levels of airborne aerosol mists, remove to fresh air. Seek medical attention if effects occur.

Skin Contact
In case of skin contact, wash off in flowing water or shower. Launder clothing before reuse.

Eye Contact
In case of eye contact, flush eyes promptly with water for 15 minutes. Retract eyelids often to ensure thorough rinsing. Consult a physician if irritation persists.

Ingestion
Swallowing less than an ounce is not expected to cause significant harm. For larger amounts, do not induce vomiting. Give milk or water. Never give anything by mouth to an unconscious person. Seek medical attention.

Section 5. FIRE FIGHTING MEASURES

Flammable Properties
Flash Point – Not applicable

Fire and Explosion Hazards
Avoid contact with water reactive materials, burning metals and electrically energized equipment.

Extinguishing Media
Product is an extinguishing media. Use media appropriate for surrounding materials.

Special Fire Fighting Instructions
This product will produce foam when mixed with water.

Section 6. ACCIDENTAL RELEASE MEASURES

Safeguards (Personnel)
NOTE: Review FIRE FIGHTING MEASURES and HANDLING (Personnel) sections before proceeding with clean-up. Use appropriate Personal Protective Equipment during clean-up.

<u>Accidental Release Measures</u>

Concentrate
Stop flow if possible. Use appropriate protective equipment during clean up. For small volume releases, collect spilled concentrate with absorbent material; place in approved container. For large volume releases, contain and collect for use where possible. Flush area with water until it no longer foams. Exercise caution, surfaces may be slippery. Prevent discharge of concentrate to waterways. Disposal should be made in accordance with federal, state and local regulations.

Foam/Foam Solution
See above. Flush with water. Prevent discharge of foam/foam solution to waterways. Do not discharge into biological sewer treatment systems without prior approval. Disposal should be made in accordance with federal, state and local regulations.

Section 7. HANDLING AND STORAGE

Handling (Personnel)
Avoid contact with eyes, skin or clothing. Avoid ingestion or inhalation. Rinse skin and eyes thoroughly in case of contact. Review HAZARDS and FIRST AID sections.

Storage
Recommended storage environment is between 20°F (-7°C) and 120°F (49°C). Store product in original shipping container or tanks designed for product storage.

Section 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls
Special ventilation is not required.

Personal Protective Equipment

Respiratory
Recommended exposure limits (OSHA-PEL and ACGIH-TLV) have not been determined for this material. A qualified health specialist should evaluate the need for respiratory protection.

Protective Clothing
Rubber or PVC gloves recommended.

Eye Protection
Safety glasses, face shield or chemical splash goggles must be worn when possibility exists for eye contact. Contact lenses should not be worn. Eye wash facilities are recommended.

Other Hygienic Practices
Use good personal hygiene practices. Wash hands before eating, drinking, smoking, or using toilet facilities. Promptly remove soiled clothing and wash thoroughly before re-use.

Exposure Guidelines

Exposure Limits
(2-Methoxymethylethoxy) Propanol (34590-94-8)

PEL (OSHA)
100 ppm, 8 hr. TWA Skin
150 ppm, 15 min. STEL Skin

TLV (ACGIH)
100 ppm, 8 hr. TWA Skin
150 ppm, 15 min. STEL Skin

Section 9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Data

Boiling Point:	Not applicable
Vapor Pressure:	Not applicable
Vapor Density:	Not applicable
Melting Point:	Not applicable
Evaporation Rate:	<1 (Butyl Acetate = 1.0)

Solubility in Water:	100%
pH:	8.0
Specific Gravity:	1.05 @ 25°C
Odor:	Bland
Form:	Liquid
Color:	Pale Yellow

Section 10. STABILITY AND REACTIVITY

Chemical Stability
Stable.

Incompatibility, Materials to Avoid
Avoid use of product on burning metals, electrically-energized equipment and contact with water reactive materials.

Polymerization
Will not occur.

Section 11. TOXICOLOGICAL INFORMATION

Mammalian Toxicity

	Concentrate	**1% Solution**
Acute Oral Toxicity – Sprague-Dawley Rats	LD_{50} > 5000 mg/kg	LD_{50} > 5000 mg/kg
Acute Dermal Toxicity – New Zealand White Rabbits	LD_{50} > 2000 mg/kg	LD_{50} > 2000 mg/kg
Primary Dermal Irritation – New Zealand White Rabbits	Slightly Irritating (Toxicity Category IV)	Non-Irritating (Toxicity Category IV)
Primary Eye Irritation – Unwashed Eyes New Zealand White Rabbits	Moderately Irritating (Toxicity Category I)	Minimally Irritating (Toxicity Category IV)
Primary Eye Irritation – Washed Eyes New Zealand White Rabbits	Mildly Irritating (Toxicity Category III)	Practically Non- Irritating (Toxicity Category IV)

Section 12. ECOLOGICAL INFORMATION

Ecotoxicological Information Aquatic Toxicity
96 hr. LC_{50} for Rainbow Trout (oncorhynchus mykiss) is reported to be 28 mg/liter.

Environmental Fate

	Concentrate	0.5% Solution	1.0% Solution
BOD_5	389,000 mg/kg	2,140 mg/kg	4,220 mg/kg
COD	782,000 mg/kg	3,900 mg/kg	7,960 mg/kg

This product meets the criteria for Readily Biodegradable when tested in accordance to EPA OPPTS 835-3110, Section 0, Ready Biodegradability (greater than 60% biodegradation in 28 days).

Section 13. DISPOSAL CONSIDERATIONS

NF-3000, as sold, is not a RCRA-listed waste or hazardous waste as characterized by 40 CFR 261. However, State and local requirements for waste disposal may be more restrictive or otherwise different from Federal regulations. Therefore, applicable local and state regulatory agencies should be contacted regarding disposal of waste foam concentrate or foam/foam solution.

Concentrate
Do not discharge into biological sewer treatment systems without prior approval. Specific concerns are high BOD load and foaming tendency. Low dosage flow rate or antifoaming agents acceptable to the treatment plant may be helpful. Do not flush to waterways. Disposal should be made in accordance with federal, state and local regulations.

Foam/Foam Solution
NF-3000 solution can be treated by wastewater treatment facilities. Discharge into biological sewer treatment facilities may be done with prior approval. Specific concerns are high BOD load. Dilution will reduce BOD and COD factors proportionately. Low dosage flow rate or antifoaming agents acceptable to the treatment plant may be helpful. Do not flush to waterways. Disposal should be made in accordance with federal, state and local regulations.

NOTE: As a service to our customers, National Foam has approvals in place with disposal facilities throughout the U.S. for waste water treatment and solidification and landfill of our foam liquid concentrates and foam solutions. If required, National Foam, Inc. can also provide information on the disposal of drums used for shipping our concentrates. Please contact National Foam's Risk Management Administrator at (610) 363-1400 for additional information.

Section 14. TRANSPORTATION INFORMATION

Shipping Information
Proper Shipping Name: Fire Extinguisher Charges or Compounds N.O.I., Class 60
National Motor Freight Code: 69160 Sub 0
Hazard Class: None
UN Number: None

Section 15. REGULATORY INFORMATION

U.S. Federal Regulations

Toxic Substances Control Act (TSCA)
All components of this product are listed in the TSCA inventory.

Superfund Amendments and Reauthorization Act of 1986 (SARA), Title III

Section 302/304
There are no components of this material with known CAS numbers which are on the Extremely Hazardous Substances (EHS) list.

Section 311 & 312
Based on available information, this material contains the following components which are classified as the following health and/or physical hazards according to Section 311 & 312:
(2-Methoxymethylethoxy) Propanol 34590-94-8 (Flammability)

Section 313
This material does not contain any chemical components subject to Section 313 reporting requirements.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)
This material does not contain any components subject to the reporting requirements of CERCLA.

OTHER REGULATORY INFORMATION
None.

STATE REGULATIONS

PENNSYLVANIA RIGHT-TO-KNOW HAZARDOUS SUBSTANCES LIST

PA Hazardous Substances present at levels greater than 1%:
1, 2 Propanediol 57-55-6
(2-Methoxymethylethoxy) Propanol 34590-94-8

Section 16. OTHER INFORMATION

NFPA Rating

Health 0
Flammability 0
Reactivity 0

WHMIS Rating

D2B

ADDITIONAL INFORMATION

Revision Summary

3/13/06 New Issue

The information contained herein is furnished without warranty either expressed or implied. This data sheet is not a part of any contract of sale. The information contained herein is believed to be correct or is obtained from sources believed to be generally reliable. However, it is the responsibility of the user of these materials to investigate, understand and comply with federal, state and local guidelines and procedures for safe handling and use of these materials. National Foam, Inc. shall not be liable for any loss or damage arising directly or indirectly from the use of this product and National Foam, Inc. assumes no obligation or liabilities for reliance on the information contained herein or omissions herefrom.

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