Asbestos Air Monitoring Plan

Richard E. Pierson Materials Corporation
Hanson Quarry
2055 North Rockhill Road
Sellersville, PA 18960

December 2018
Project 0272.1218.16

Prepared By:
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East Rockhill Quarry Site

December 2018

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1.0 INTRODUCTION

Compliance Plus Services, Inc. ("CPS") has prepared this Asbestos Air Monitoring Plan ("Plan"), on behalf of the Richard E. Pierson Materials Corporation ("R.E. Pierson"), to sample and test ambient air quality conditions for potential airborne asbestos fibers related to the operation of a non-metallic mineral processing plant (including crushers, screens and related equipment) at the existing Hansen Quarry site located at 2055 North Rockhill Road, East Rockhill Township, Bucks County.

R.E. Pierson is currently operating portable crusher equipment at the site pursuant to General Air Quality Permits previously issued for the site. On December 5, 2018, the Pennsylvania Department of Environmental Protection ("PADEP" or the "Department") issued a new Plan Approval to install and operate a permanent crusher plant and related equipment (Plan Approval No. 09-0241). This Plan is intended to meet, and be conducted in accordance with, the air monitoring program requirements specified in Condition 32, Section C, of the December 5, 2018 Plan Approval issued to R.E. Pierson. This Plan also includes and Fugitive and Asbestos Dust Mitigation Plan (see Exhibit 1) which is incorporated by reference and is intended to meet the provisions specified in Condition 33, Section C, of the Plan Approval.

1.1 Background

The site in question is the Hanson Rockhill Quarry located at 2055 North Rockhill Road, Sellersville, PA 18960, East Rockhill Township, Bucks County, PA. The property is owned by Hanson Aggregates Pennsylvania, LLC ("Hanson"). The site is an existing permitted mine with the southern portion of the mine being prepared for additional mining and processing of the diabase bedrock by R.E. Pierson through the use of both portable and stationary (permanent) crushing and screening equipment. R.E. Pierson has applied for and obtained air quality permits which will allow the processing of the mined stone to produce aggregate products.

1.2 Site Mining Permit and Asbestos Monitoring Plan

Under the current mining permit, Hanson is required to perform ongoing geological evaluations, under the supervision of a Pennsylvania Licensed Professional Geologist ("PG"), through public review, on site mapping and sampling and analysis of the rock in planned active mining areas to determine the potential presence of naturally occurring asbestos ("NOA"). The current NOA Monitoring Plan for new exposed high-walls consists of the following, but is subject to change based on ongoing condition at the site:

- One (1) time per calendar quarter, a qualified Professional Geologist visually inspects exposed high-walls in the direct area of production blasting to assess the presence of potential NOA mineral veining and/or geologic contacts with host sedimentary rocks;

- If potential NOA mineral veining is observed, sampling is be conducted. The number of samples will be determined by the Professional Geologist conducting the visual inspection;

- In addition to the quarterly visual high-wall inspection, one (1) composite drill-cuttings sample per active face is collected each calendar quarter from two (2) drill holes per active bench. The drill holes are field located approximately 50 feet back from the active face;

- If laboratory analysis detects NOA to be present above 0.25%, mining in that area is delayed until such time that protective measures are enacted to limit air concentrations below the permissible exposure limit;

- If active mining does not occur for an entire quarter, site monitoring is postponed to the next calendar quarter that mining occurs; and

- Documentation of the high-wall inspections and/or laboratory analysis is maintained at the site.

1.3 Air Quality Permits and Air Monitoring Plan for Asbestos

R.E. Pierson has applied for an obtained the following air quality permits:

- General Permits (Permit Nos. GP3-09-0157 and GP9-09-0083), issued on March 14, 2018, for the operation of the following portable crushing and screening equipment and their associated diesel engines:

  - One (1) Sandvik UJ440i jaw crusher;
  - One (1) Mellotts MC300HPCC closed-circuit crusher/screener;
  - One (1) Sandvik QS331 cone crusher; and
  - One (1) Sandvik scalper screen.

- Plan Approval (Permit No. 09-0241), issued on December 5, 2018, for the construction and operation of a 1,000 ton per hour stone crushing and screening plant equipped with a wet suppression system used to control particulate matter emissions. The plant consists of the following equipment:

  - Phase I – One (1) primary jaw crusher, one (1) screen and eight (8) conveyors; and
  - Phase II – Four (4) crushers, five (5) screens and thirty (30) conveyors.

Under the Section C, Condition #32 of the Plan Approval, R.E. Pierson is required to establish an asbestos air monitoring plan prior to the operation of the 1,000 ton per hour crushing and screening plant in order to detect monitor ambient air quality condition at the site to detect potential airborne asbestos fibers around the perimeter of the quarry. Condition 33 of the Plan Approval also requires that a Fugitive and Asbestos Dust Mitigation Plan be designed, approved by the Department and implemented by R.E. Pierson when naturally-occurring asbestos is detected in the rock which will

be mined and processed at the site. The Fugitive and Asbestos Dust Mitigation Plan is provided in Exhibit 1 of this Plan.

1.4 Data Quality Objectives

The purpose of the asbestos fiber air monitoring plan is to produce data that demonstrates that the site operations and mitigation/control procedures employed by R.E. Pierson achieve the asbestos clearance limits/criteria specified in the Plan Approval of ensuring airborne asbestos fibers so not exceed 0.01 fibers/cc at the site property lines. Details of the required asbestos air monitoring plan can be found in Sections 3.0 to 6.0 below.

2.0 DESCRIPTION OF FACILITY

The site is an existing permitted surface mine located on the western side of Rockhill owned by Hanson Aggregates Pennsylvania, LLC. With respect to the Bucks County Tax Map, Parcel No. 12-9-102 – approximately 123 acres are zoned E- Extraction and the balance of 96 acres is zoned RP-Resource Protection. The area of mining activity is toward the southern end of the property (see **Attachment 1 - Maps and Drawings**). The permitted non-metallic mineral processing plant is being used to process rock from the existing quarry to be used as construction material for a large PennDOT project. The Quarry entrance is from N. Rockhill Road.

2.1 Location

The site is bordered on the West and South West by N. Rockhill Road and bordered on the North, East and South by wooded areas (see **Attachment 1– Maps and Drawings**). Site address is 2205 North Rockhill Road, Sellersville PA 18960 in East Rockhill Township, Bucks County. Latitude and Longitude of the property is approximately 40◦24’15”, 75◦17’56” West.

The approximate proximity to nearby residences, schools, landmarks from nearest property line (see Receptor Location Map in **Attachment 1 – Maps and Drawings**) to the site’s property line, as well as to the actual crushing and screening (C & S) operations is provided below:

		Property Line	C & S Operations
1.	Residence North of Site	740 Feet	900 Feet
2.	Residence East of Site	360 Feet	0.47 Miles
3.	Residence South West of Site	520 Feet	800 Feet
4.	Residence West of Site	65 Feet	0.19 Miles
5.	Upper Bucks Christian School and Bethel Baptist Church	0.45 Miles	0.66 Miles
6.	Pennridge Airport	0.78 Miles	0.85 Miles
7.	WM. H Markey Centennial Park	0.77 Miles	0.87 Miles
8.	Pennridge Middle School	1.30 Miles	1.42 Miles
9.	Deibler Elementary School	0.80 Miles	1.14 Miles

In all cases, the distances between the Quarry's property line and the nearby residences, schools, landmarks are separated by tree lined areas. These forested or wooded areas will serve as natural air quality buffers by helping to reduce migration of airborne particles and /or fibers beyond the tree lines and wooded areas.

2.2 Quarry Operations

The crusher plant is projected to operate approximately 8 to 16 hours during each operating day, however, the actual schedule will vary depending upon demand for aggregates. Rock and crushed stone products are generally loosened by drilling and blasting and then loaded by power shovel or frontend loaders into large haul trucks that transport the material to the processing operations. Processing operation may include crushing, screening, size classification, material handling and storage operations.

Although daily hours of operation may vary, the plant is expected to operate each week Monday through Friday and occasionally on a Saturday. The maximum projected hours of operation during any 12- month rolling period will not exceed 2800 hours.

2.3 Temporary Crusher Area Activities

The location of the temporary crusher operation is depicted in **Attachment 1** - Maps and Drawings/Site Layout Plan.

The operation consists of the following pieces of equipment for crushing and screening:

- Portable Sandvik UJ440i Jaw Crusher with a Volvo D13 Tier 4, 422 HP Diesel engine;
- Portable Sandvik QS331 Hydrocone Crusher with a Caterpillar C-9 Tier 4, 350 HP Diesel engine;
- Portable Sandvik QE441 Scalper Screen with a Caterpillar C4.4 Tier 4 , 129 HP diesel engine;
- Portable Sandvik QH331 Hydrocone Crusher with a Caterpillar C-9 Tier 4, 350 HP Diesel engine;
- Portable Sandvik QA450 Screen with a Deutz BF4M2012 Tier 3, 100 HP diesel engine; and
- Six (6) Stacking Conveyors.

Once the permanent crushing and screening equipment is fully operational, the temporary portable crushers, screeners, stacking conveyors and their associated diesel engines will cease operation and will be removed from the property.

2.4 Permanent Crusher Plant Area Activities

The Permanent Crusher Plan Area Activities include the operation of a 1000 ton per hour crushing and screening plant. The plant will be powered by electricity with no emissions other than particulate matter (PM). A wet suppression system (water sprays) will be used on the plant at several dozen locations throughout the plant to control the PM emissions. At times, some of the

equipment following the surge pile in the process will be used to produce washed aggregates which will eliminate any PM emissions.

3.0 ASBESTOS AIR SAMPLING LOCATIONS

The asbestos air sampling is to be done in four (4) sequenced phases based on transitioning operations as follows: pre-operation, temporary crusher operations, combined crusher operations (temporary & permanent), and permanent crusher operations. During the pre-operation/background, temporary crusher, and permanent crusher phases, there will be a minimum of four (4) samples collected during each sampling event including: one (1) upwind and three (3) downwind sampling locations. Typically, there will be a maximum of seven (7) samples collected per sampling event, particularly during the combined crusher operations, which would routinely include one (1) upwind and three (3) downwind locations relative to the operating locations of the temporary crusher equipment and the permanent crusher plant (for a total of six (6) downwind samples. Crusher operating locations are shown in **Attachment 1 - Maps and Drawings**.

General asbestos air monitoring locations have been relocated and selected based primarily on proposed equipment operating locations, historic prevailing winds at the Quarry, site specific activities connected with quarrying and processing of aggregate products, and locations of potential offsite receptors. Based on the historic Wind Rose plots from Station #14737 Allentown-Bethlehem (see **Attachment 2 - Wind Rose Plots from Station #14737**), winds from December to May generally blow from the Westerly direction with concentration from the Northwest or Southwest based on the month. The proposed sample areas can be seen in **Attachment 1 - Maps and Drawings**. The site was divided into four (4) sampling sector locations based on the above referenced criteria; East, West, South, and Mid. The sample sector locations will be the general area where sample collections will occur, however, the actual sampling locations inside the sector area will be chosen based on wind direction and site-specific weather conditions at the time the samples are being collected.

Wind direction and wind speed will be monitored during each sampling event (see Section 4.5 below). If wind direction changes during a sampling event in any one sampling phase, the time and change in direction will be documented to reflect the change and provide data for analysis and comparison. If wind direction change is considered extreme during any sampling event, the sampling location could be adjusted to reflect the change based on judgment of the field sampling technician. Any change in location will be properly documented to reflect the location, time, and change in wind direction.

In all cases, based on professional judgment and knowledge of offsite concerns, sampling areas may be adjusted to provide a more representative data and consideration of spacial conditions. All adjustment will be documented properly to show the change and the reason for the change.

3.1 Pre-Operation Monitoring

The pre-operation sampling event will be performed prior to startup of the temporary crusher operations. Sampling will be done in accordance with the analytical methods discussed in Section 4.0 of this document. During the pre-operation sampling, each section of the site referenced above will be sampled at least once to provide baseline data for the site and edges of the accessible property. All daily sampling locations and meteorological data will be documented.

3.2 Temporary Crusher Operations Monitoring

The temporary crusher operations sampling will be performed upon the commencement of operations. Sample locations will be chosen based on daily site conditions, location of the temporary crushing operation, and other site activities with at least one (1) upwind location and three (3) downwind locations in relation to the temporary crusher operation. All sampling locations, site activities and wind directions will be documented.

3.3 Combined Crusher Operations (Temporary & Permanent) Monitoring

The combined crusher operations sampling event will take place during the transition between phasing out the temporary crusher and commencement of the permanent crusher operations. Sample locations will be chosen based on site conditions daily. Based on the phase of the

temporary crusher sampling event, site conditions and judgment of site personnel, there could be a maximum of seven sample locations chosen in one day with one (1) upwind location and three (3) downwind locations in relation to each crusher operation. All daily sampling locations and wind directions will be documented.

3.4 Permanent Crusher Operations Monitoring

When site operations proceed to the permanent crusher operations, sampling locations will be chosen in the same manner as discussed above. Based on prevailing winds in relation to the permanent crusher location and daily site conditions a minimum of four (4) samples will be taken, one (1) upwind and three (3) downwind.

4.0 FIELD SAMPLE COLLECTION METHODOLOGY

The air samples will be collected as indicated in Section 3 above, as such samples will be collected in remote areas where power for high volume sampling pumps is not available. Based on these requirements air samples will be collected from fixed sampling locations with low flow pumps or on occasion high flow sampling pumps. Each pump is equipped with cassettes (and cowl) that contain a 25-millimeter (mm) diameter Mixed Cellulose Ester (MCE) filter with a pore size of 0.8 or 0.45 micrometers (µm). All samples will be collected in what is typically referred to as the breathing zone. This is an area approximately 5 ft. above the ground surface and is designed to approximate the breathing area of a worker to assess exposure.

Site personnel working near dust-generating equipment such as crushers and screeners will also be fitted with personal sample pumps and cassettes similar to the fixed sampling locations. These samples are intended to monitor worker exposure to ACM during material handling and processing.

Sampling will be in accordance with the National Institute for Occupational Safety and Health (NIOSH) Manual for Analytical Methods (NMAM), Method 7400 for Asbestos and other Fibers by Phase Contrast Microscopy (PCM). NMAM Method 7402 will be employed when analysis of

the sample by Transitional Electron Microscope (TEM) is required. The field sample procedures are the same for each method. A copy of each of the methods is provided in **Attachment 3 - Sample Methods**. In accordance with the methods, one field blank will be obtained for every five samples or at a minimum one for each sampling event.

Each personal sample pump will be operated at approximately 3 to 4 liters per minute (lpm). If high volume sampling is required, the sample flow rates will be in the range of 5 to 15 lpm. Sampling times will vary however, all sample durations will be established to assure an adequate sample volume to achieve the desired laboratory reporting limits. Samples will be collected during the routine crushing and screening operations to provide a representative sample of any asbestos emissions from the operations. Pumps will be calibrated, prior to and following use each day using a cassette reserved for calibration (from the same lot of the sample cassettes to be used in the field).

The sample collector will record the pump serial number, sample number, initial flow rate, sample start/end times, sample locations, and final flow rate on the Field Data Sheets **(**see **Attachment 4 - Field Sampling Documents)**

4.1 Data Sheets and Field Notes

Sampling Field Data Sheets will be used to record all sampling information. Information in the datasheets will include, at a minimum, the following:

- Location of the sample, crushing and other site activities being conducted during sample collection;
- Date and time of collection;
- Description of temperature, wind direction, wind speed and general weather conditions;
- The unique sample identification number for each air sample;

Field notes will also be maintained daily. The notes will include general information, weather conditions, wind direction, etc. (see **Attachment 4 - Field Sampling Documents** for examples of both the Field Data Sheets and the Field Notes).

Field notes will include drawings, and references to photographs as needed to document site sampling activities.

Data sheets and field notes will be completed, signed, and dated by the field technician.

4.2 Photographs of Air Sampling Activities

Photographs will be taken during selected air sampling activities. The photographs will be used to provide backup documentation of sampling activities. A log of the photographs will be recorded and will include the sampling activity and approximate location for each photograph.

4.3 Chain of Custody Records

Chain of custody procedures will be used to maintain and document sample collection and possession. During the sampling process, a laboratory Asbestos Chain-of-Custody form provided by the Laboratory will be completed (see **Attachment 4 – Field Sampling Documents**). The completed Chain-of-Custody Record will accompany all samples and be signed as required as each sample package recipient receives and relinquishes possession of the sample package.

4.4 Sample Packaging and Shipment

The air sample filter cassettes will be carefully packaged and delivered to the analytical laboratory using standard methodology. Plastic bags and other acceptable packaging containers will be used for sample shipment and convenience.

4.5 Weather and Wind Direction Data

Under Condition #31 of the Air Quality Program Plan Approval (Permit No. 09-0241), R.E. Pierson will be installing an automated weather station to track wind speed and wind direction during each operating day of the permanent crusher operations. Prior to installation of the automated weather station, site personnel will utilize an EXTECH Instruments Mini Thermo-

Anemometer to record and document temperature, wind speed, and wind direction during each sampling event.

5.0 SAMPLING FREQUENCY

Sampling frequency will be performed according to condition #32 of the Air Quality Program Plan Approval (Permit No. 09-0241), issued on December 5, 2018. Condition #32 states:

- The permittee shall conduct daily air samples for the week prior to the commencement of operation of the crusher and during the first week of the operation.
- After two (2) weeks of daily monitoring with airborne fiber levels less than the action level, and upon the permittee's request, DEP will determine the feasibility of decreasing the monitoring frequency to weekly on operating days.
- After one (1) month of weekly monitoring with airborne fiber levels less than the action level, and upon the permittee's request, DEP will determine the feasibility of decreasing the monitoring frequency to monthly on operating days.
- After six (6) months of monthly monitoring with airborne asbestos fiber levels less than the action level, upon the permittee's request, DEP will determine if the monitoring may cease.

The air sampling plan will begin in the pre-operations phase discussed in **Section 3.1** and will resume upon the commencement of the combined (temporary & permanent) crusher operations discussed in **Section 3.2**. When the permanent crusher begins operations daily air sampling will begin again as required by the Air Quality Program Condition #32 for permanent crusher operations. The daily permanent crusher sampling will run simultaneously with the weekly or monthly sampling associated with the temporary crusher operations.

6.0 ANALYTICAL METHODS

The analytical methods and laboratory analysis for asbestos in air analysis to be utilized as part of this plan will include both PCM and TEM methodology, as referenced above in Section 4.0. Both methods can achieve the required detection limits to ensure the action level criteria or ensuring the

airborne asbestos fibers at the property line do not exceed 0.01 fibers/cc at the property line as specified in the Plan Approval. Methods 7400 and 7402 have sample volumes and flow rates that are specified and consistent with the field sampling procedures described in Section 4.0 above.

The PCM method (Method 7400) is used to identify fibers within the air and the results will count all fibers including non-asbestos fibers. This test may over predict the actual potential asbestos in the air, consequently, the PCM method will provide a worst-case indication of the number of fibers in the sample areas. TEM analysis (Method 7402) is able to identify and differentiate asbestos fibers from non-asbestos fibers and will be used if any PCM results indicate a potential exceedance of the action level specified in the Plan Approval. A potential exceedance will be considered when a ***total fiber*** result 0.01 exceeds fibers/cc for a sample result using the PCM Method---thus triggering the need of analyze the sample using the TEM Method.

During the pre-operation background sampling, to be completed prior to crushing operations, each sample will be analyzed using TEM methodology with selected samples being tested by both TEM and PCM methods. This will help establish a known background limit for both analytical methods and assure that PCM results unique to the area of the operations are indicative of the same level of fibers in the air as the TEM results. The initial sampling will be undertaken to establish background levels at the site and to fully demonstrate whether PCM results may be used to adequately provide sufficient information to make informed decisions related to the future test results taken during start-up and operation of the crushing equipment.

6.1 Analytical Laboratory

All samples will be analyzed by an analytical laboratory selected from the list of asbestos analytical laboratories that are part of EPA's voluntary asbestos laboratory program, which ensure that the testing facility has been audited and has successfully met EPA's performance criteria. The primary laboratory that is expected to be used for this project is EMSL laboratory. EMSL's corporate offices are located in Cinnaminson, New Jersey and the Company has a laboratory location in Plymouth Meeting, Pennsylvania. It is anticipated that during the extent of the project both locations may be utilized to provide sample results with each being a backup for

the other in the event either laboratory cannot accommodate the required analysis or meet the required sample turnaround times.

6.2 Quality Control

A field quality control (QC) program will be implemented to assure conformance with data quality protocols established by the EPA. The field QC program will include the use of field blanks.

6.2.1 Field Blanks

A field blank is a filter cassette that has been taken to the sampling site, opened, and then closed. Such a filter is analyzed to determine the background asbestos structure count for the measurement. As required for NMAM Method 7400 and 7402, one field blank will be sampled for every five samples or on a daily basis whichever is more frequent.

6.2.2 Duplicate Samples

Duplicate samples may be collected when required, to evaluate the reproducibility of sampling and analysis. Duplicate samples will be collected, stored and transported in the same manner as the actual samples. A separate number will be assigned to each duplicate, and all duplicates will be submitted blind to the laboratory. For this monitoring program, duplicate samples will generally be collected if a sample result exceeds the targeted action level or exceeding 0.01 fibers/cc of airborne asbestos. In general, duplicate samples will be co-located near an actual sample collection location to replicate sampling conditions as closely as possible.

6.3 Field Equipment

Field equipment and supplies will include, but are not limited to, the following:

- Air sampling pumps (personal or low volume pumps and area or high volume pumps).
- Asbestos sample filter cassettes with filters.

- Air pump calibration equipment.
- Quart and gallon size resealable bags.
- Sample transport containers and packing material.
- Additional supplies as needed including health and safety equipment

7.0 RECORDKEEPING AND REPORTING

7.1 Recordkeeping

All records and documents related to the airborne asbestos monitoring program will be maintained by R.E. Pierson during the duration of the sir permit and will be made readily available to PADEP upon request. Field Data Sheets and Field Notes will be completed, signed, and dated by the recorder. All logs will be written with waterproof ink. Corrections to data entered will be made by crossing out the error with a single horizontal line, initialing the correction, and entering the correct information. Crossed-out information shall be readable.

Photographs will be taken during selected air sampling activities. The photographs will be used to provide documentation of sample locations, site activities, etc. that are pertinent to the asbestos monitoring task. A log of the photographs will be recorded and will include the sampling activity and approximate location for each photograph.

All laboratory reports and associated data sheets, as well as progress reports and other documentation related to this project will be properly maintained in accordance with the applicable Plan Approval requirements. All samples analyzed under Method 7400 (PCM) will be retained by the laboratory for at least 30 days to allow for follow-up testing using Method 7402 (TEM), should the need arise.

7.2 Reporting

7.2.1 Reporting of Exceedances of the Action Level

Any confirmed exceedance in specified action level will be immediately reported to the R. E. Pierson site Operations Manager to ensure that the appropriate investigation and corrective measures are initiated as described in Section 8.0 below in addition, this information must also be reported to PADEP, at 484-250-5900, within 24 hours or the reported result.

7.2.2 Weekly Summary Monitoring Reports

During daily and weekly asbestos monitoring period, weekly summary monitoring reports will be prepared and submitted to the Department within fifteen (15) days following receipt of the sample analysis from the laboratory. Weekly summary monitoring reports will include the analytical results for all samples collected and analyzed during the reporting week; copies of applicable chain of custody sheets and applicable field sampling logs; and a written report detailing any investigative actions or corrective measures that may have been taken during the reporting period in response to an exceedance of action level.

At the completion of the project, a final report will be generated. This final report will summarize all site activities and associated data that was collected. Conclusions and recommendations will be provided.

7.2.3 Monthly Summary Monitoring Reports

When asbestos sampling is reduced to monthly sampling, monthly summary monitoring reports will be prepared and submitted to the Department. Monthly summary reports will include the same information as contained in the weekly reports described in 7.2.2 above. These reports will be submitted within fifteen (15) days following receipt of the relevant sampling data from the laboratory.

8.0 CORRECTIVE ACTIONS

This Asbestos Air Monitoring Plan has been developed to monitor conditions at the site to ensure that routine operations of the site as a stone and rock crushing quarry does not result in offsite conditions that may pose any harm to the general public. A key objective of the monitoring program is that the Plan includes defined action level where an exceedance or airborne asbestos fibers detection above the 0.01 fibers/cc in the outdoor air will trigger a number of corrective measures that will be taken by R.E. Pierson to abate any potential harmful migration of asbestos fibers and return the site to a condition where continued monitoring will show that the air samples collected no longer exceed the site action levels.

Pursuant to the conditions of the R.E. Pierson Plan Approval, in the event that a sample is confirmed with a detection level that exceeds the airborne asbestos fiber concentration of 0.01 fibers/cc, the facility will do the following:

1) Report the results immediately to the site operations manager, as indicated in 7.2.1 above, R.E. Pierson will also notify the PADEP within 24 hours of discovery of a confirmed result by calling 484.250.5900;
2) Investigate the cause of the exceedance;
3) R.E. Pierson will take corrective measures as specified here, including implementation measures specified in the Fugitive Asbestos Dust Mitigation Plan as provided in Exhibit 1 of the Plan; and
4) Record the results and the corrective measures taken at the site in a permanent written log.

Normal operations and a reduction of additional measures employed at the site will remain in effect at the site until three (3) consecutive sampling events demonstrate that the site conditions will no longer exceed the action level.

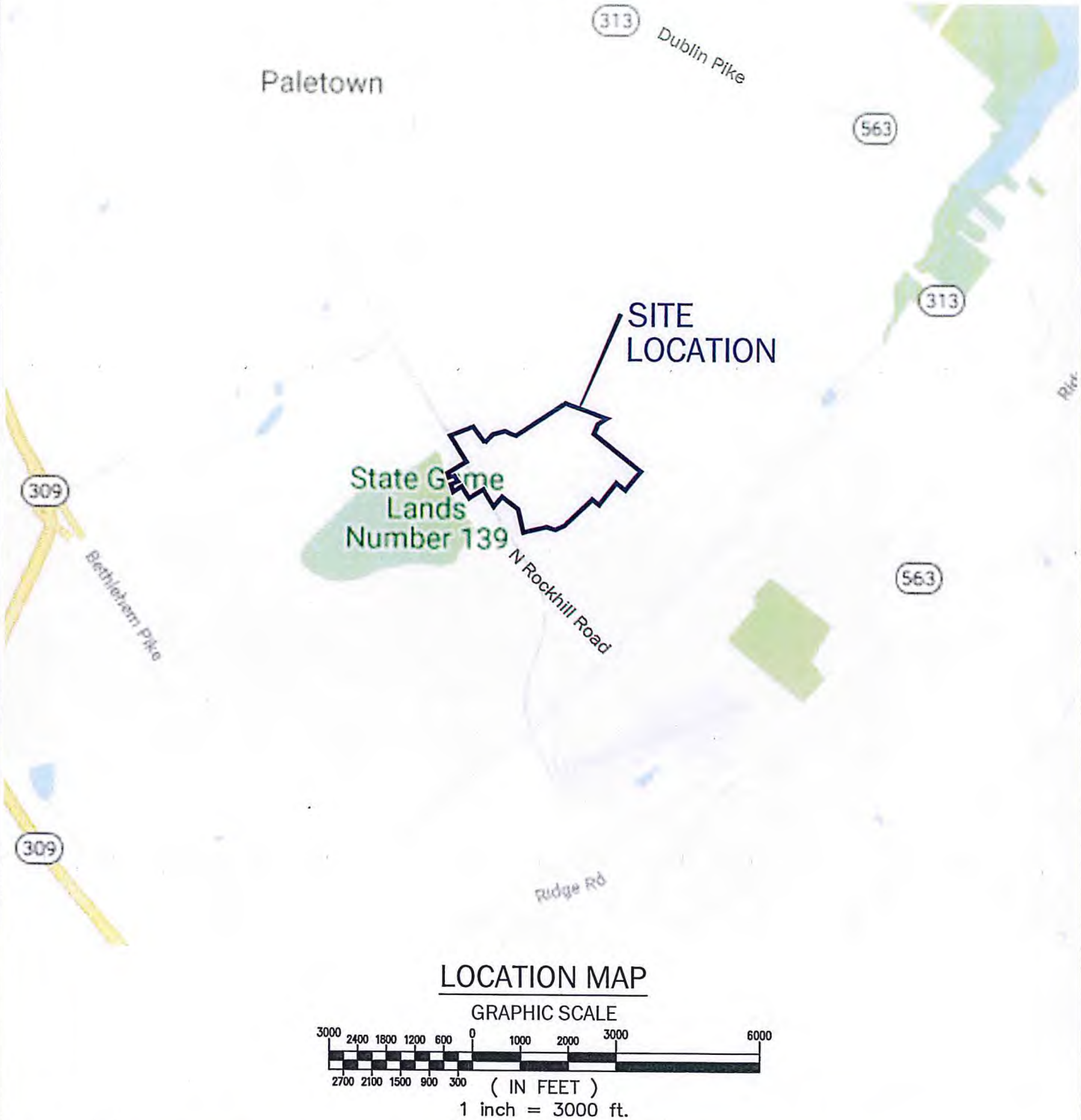
Attachments

Attachment 1

Maps and Drawings

Site Location Map

R.E. PIERSON CONSTRUCTION COMPANY
2055 N Rockhill Road
Sellersville, Pennsylvania 18960



LOCATION MAP

GRAPHIC SCALE

3000 2400 1800 1200 600 0 1000 2000 3000 6000
2700 2100 1500 900 300 (IN FEET)

1 inch = 3000 ft.

Source:  Imagery Dated: 05/16/2018	Scale: As Noted	Approved By: Bradley J. Cunningham, P.E.	Date: 05/16/2018
	Project No: 0272.13	Drawn By: Rick Gradwell	

COMPLIANCE PLUS SERVICES, INC.

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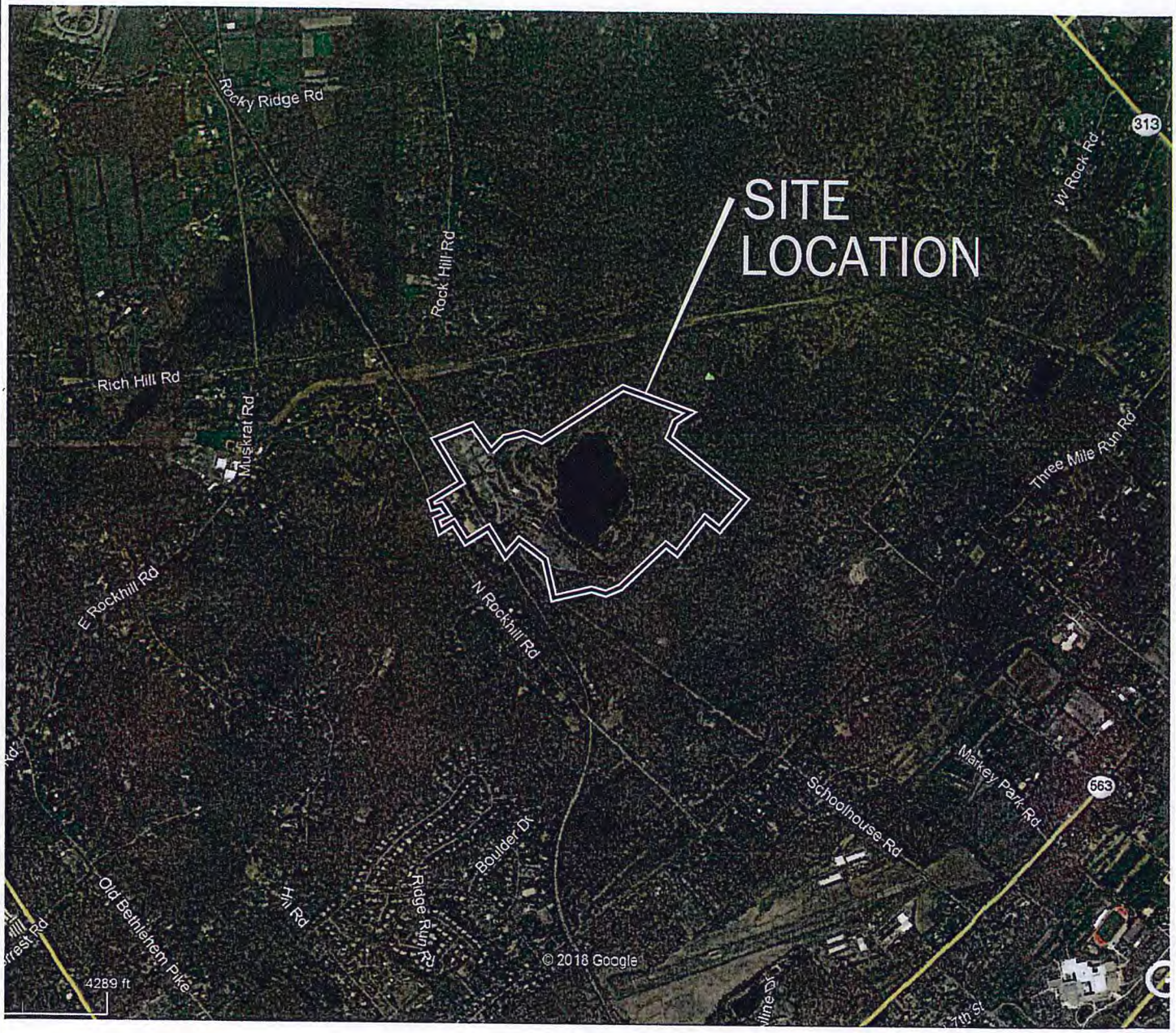
Drawing No: L-01

Site Aerial Map

R.E. PIERSON CONSTRUCTION COMPANY
2055 N Rockhill Road
Sellersville, Pennsylvania 18960



AERIAL MAP

GRAPHIC SCALE

2000 1600 1200 800 400 0 500 1000 2000 4000
1800 1400 1000 600 200 (IN FEET)

1 inch = 2000 ft.

Source: Google earth Imagery Dated: 05/16/2018	Scale: As Noted	Approved By: Bradley J. Cunningham, P.E.	Date: 05/16/2018
	Project No: 0272.13	Drawn By: Rick Gradwell	

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Drawing No: A-01

N:\#0272 - ...rson Construction Company\Drawings\CPS Drawings\A-01 2055 N Rockhill Rd Aerial Map.dwg, 12/21/... 12:35:09 PM

Site Plan and Equipment Layout

Receptor Location Map

Attachment 2

Wind Rose Plots from Station #14737

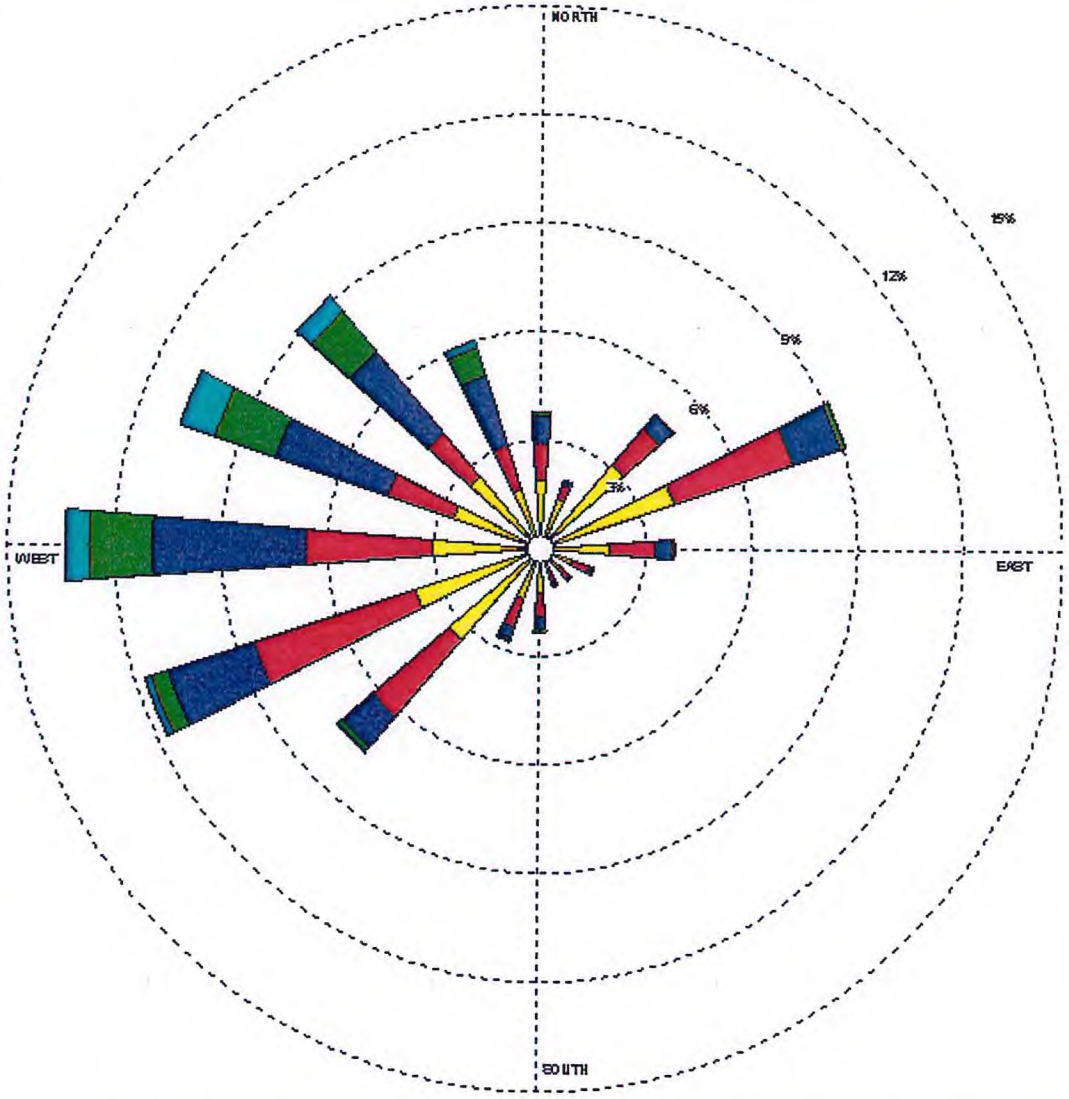
Exhibits

Exhibit 1

Fugitive and Asbestos Dust Mitigation Plan

WIND ROSE PLOT

Station #14737 - ALLENTOWN/BETLEHEM-EASTON ARP, PA



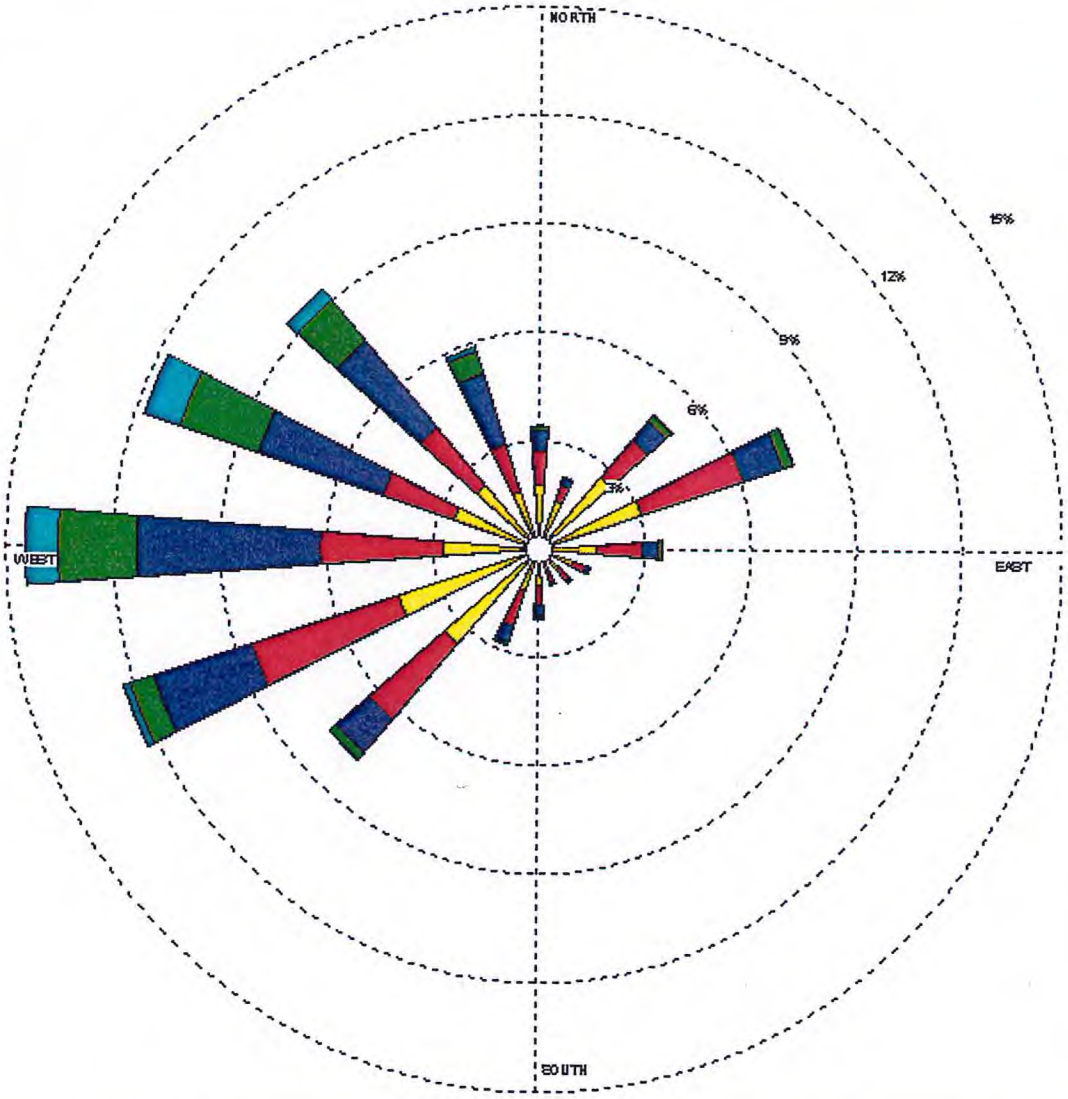
Wind Speed (m/s)

- > 11.06
- 8.49 - 11.06
- 5.40 - 8.49
- 3.34 - 5.40
- 1.80 - 3.34
- 0.51 - 1.80

MODELER	DATE 11/1/2002	COMPANY NAME	
DISPLAY Wind Speed	UNIT m/s	COMMENTS	
AVG. WIND SPEED 4.81 m/s	CALM WINDS 8.81%		
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 1961 Dec 1 - Dec 31 Midnight - 11 PM	PROJECT/PLOT NO.	

WIND ROSE PLOT

Station #14737 - ALLENTOWN/BETLEHEM-EASTON ARP, PA



Wind Speed (m/s)

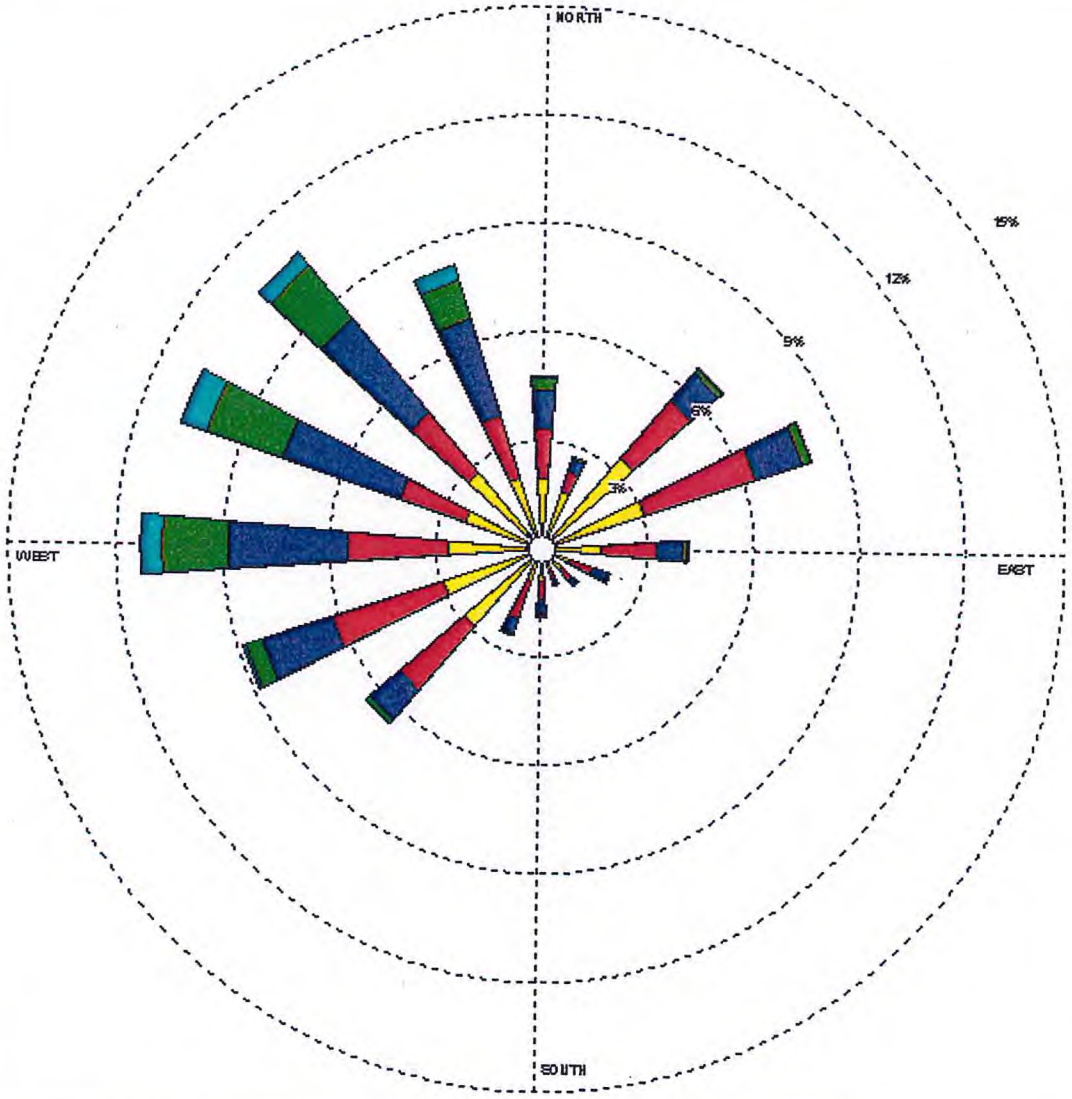
- > 11.06
- 8.49 - 11.06
- 5.40 - 8.49
- 3.34 - 5.40
- 1.80 - 3.34
- 0.51 - 1.80

MODELER	DATE 11/1/2002	COMPANY NAME
DISPLAY Wind Speed	UNIT m/s	COMMENTS
AVG. WIND SPEED 5.00 m/s	CALM WINDS 8.24%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 1961 Jan 1 - Jan 31 Midnight - 11 PM	PROJECT/PLOT NO.

WRPLOT View 3.3 by Lakes Environmental Software - www.lakes-environmental.com

WIND ROSE PLOT

Station #14737 - ALLENTOWN/BETLEHEM-EASTON ARP, PA



Wind Speed (m/s)

- > 11.06
- 8.49 - 11.06
- 5.40 - 8.49
- 3.34 - 5.40
- 1.80 - 3.34
- 0.51 - 1.80

MODELER		DATE 11/1/2002	COMPANY NAME
DISPLAY Wind Speed		UNIT m/s	COMMENTS
AVG. WIND SPEED 5.02 m/s		CALM WINDS 8.35%	
ORIENTATION Direction (blowing from)		PLOT YEAR-DATE-TIME 1961 Feb 1 - Feb 29 Midnight - 11 PM	PROJECT/PLOT NO.

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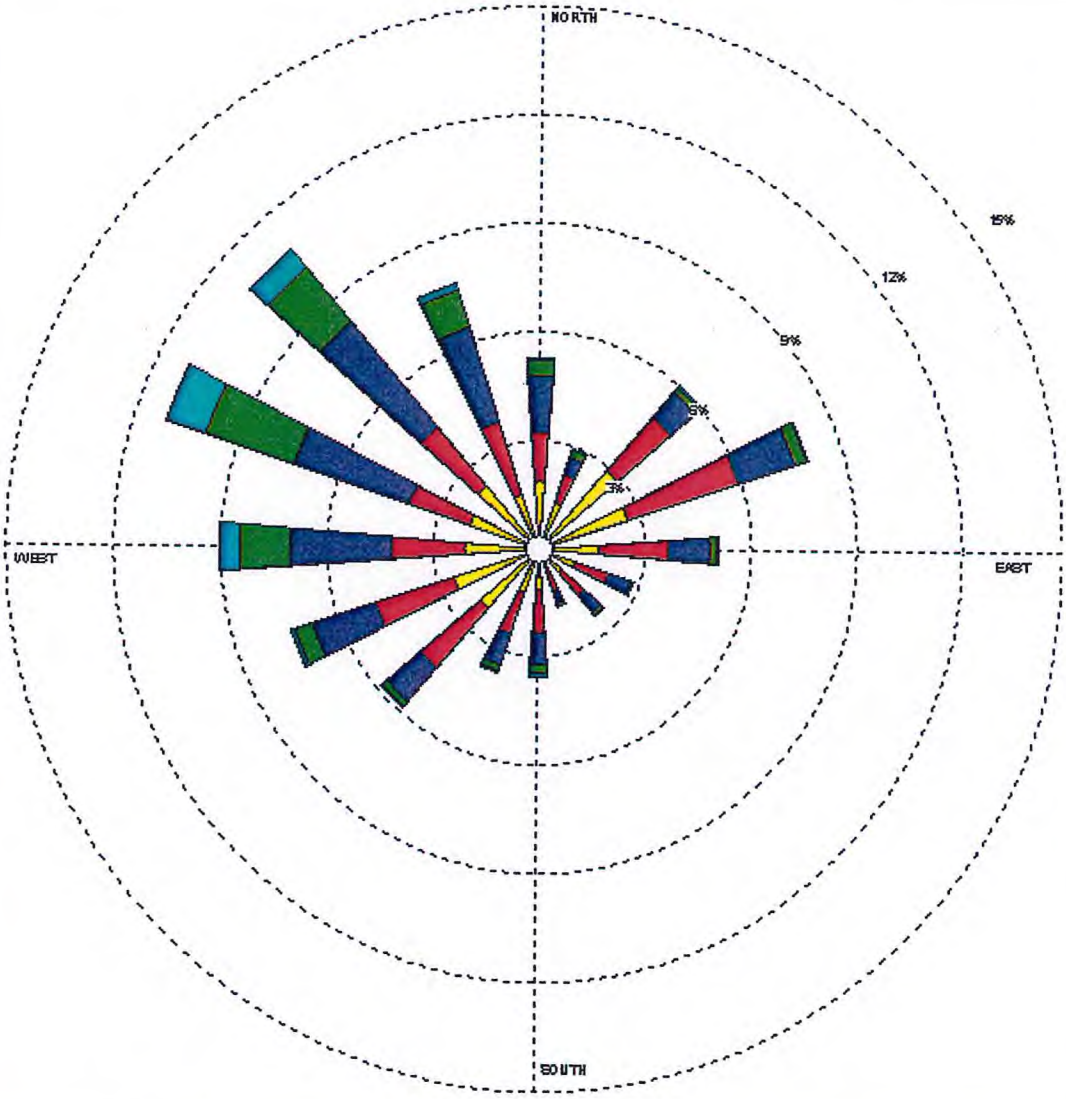
WIND ROSE PLOT

Station #14737 - ALLENTOWN/BETLEHEM-EASTON ARP, PA



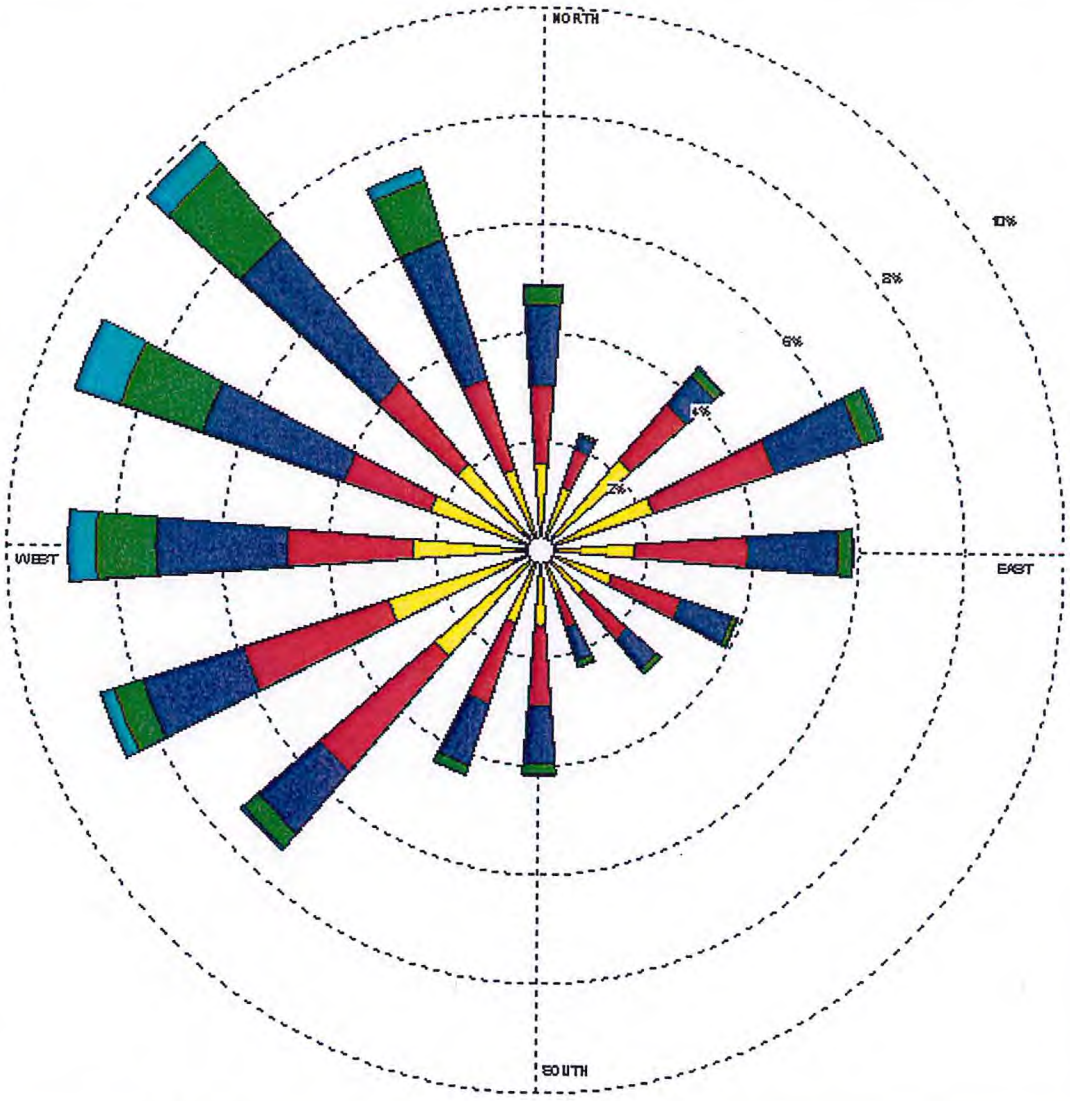
Wind Speed (m/s)

- > 11.09
- 8.49 - 11.09
- 5.40 - 8.49
- 3.34 - 5.40
- 1.80 - 3.34
- 0.51 - 1.80

MODELER		DATE 11/1/2002	COMPANY NAME
DISPLAY Wind Speed		UNIT m/s	COMMENTS
AVG. WIND SPEED 5.27 m/s		CALM WINDS 6.66%	
ORIENTATION Direction (blowing from)		PLOT YEAR-DATE-TIME 1961 Mar 1 - Mar 31 Midnight - 11 PM	PROJECT/PLOT NO.

WIND ROSE PLOT

Station #14737 - ALLENTOWN/BETLEHEM-EASTON ARP, PA



Wind Speed (m/s)

- > 11.09
- 8.49 - 11.09
- 5.40 - 8.49
- 3.34 - 5.40
- 1.80 - 3.34
- 0.51 - 1.80

MODELER	DATE	COMPANY NAME
	11/1/2002	
DISPLAY: Wind Speed	UNIT: m/s	COMMENTS
AVG. WIND SPEED: 5.14 m/s	CALM WINDS: 6.46%	
ORIENTATION: Direction (blowing from)	PLOT YEAR-DATE-TIME: 1961 Apr 1 - Apr 30 Midnight - 11 PM	PROJECT/PLOT NO.

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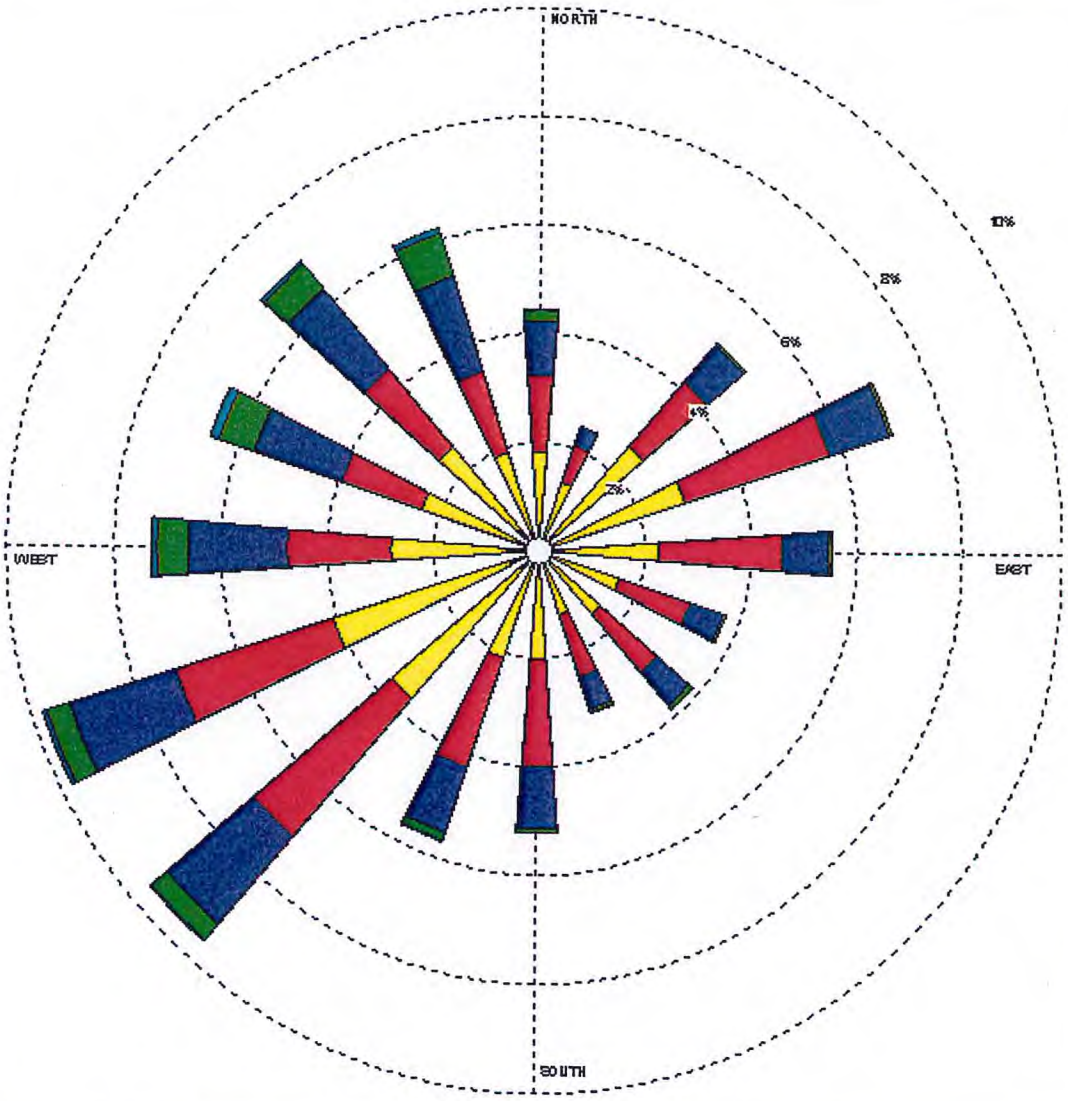
WIND ROSE PLOT

Station #14737 - ALLENTOWN/BETLEHEM-EASTON ARP, PA



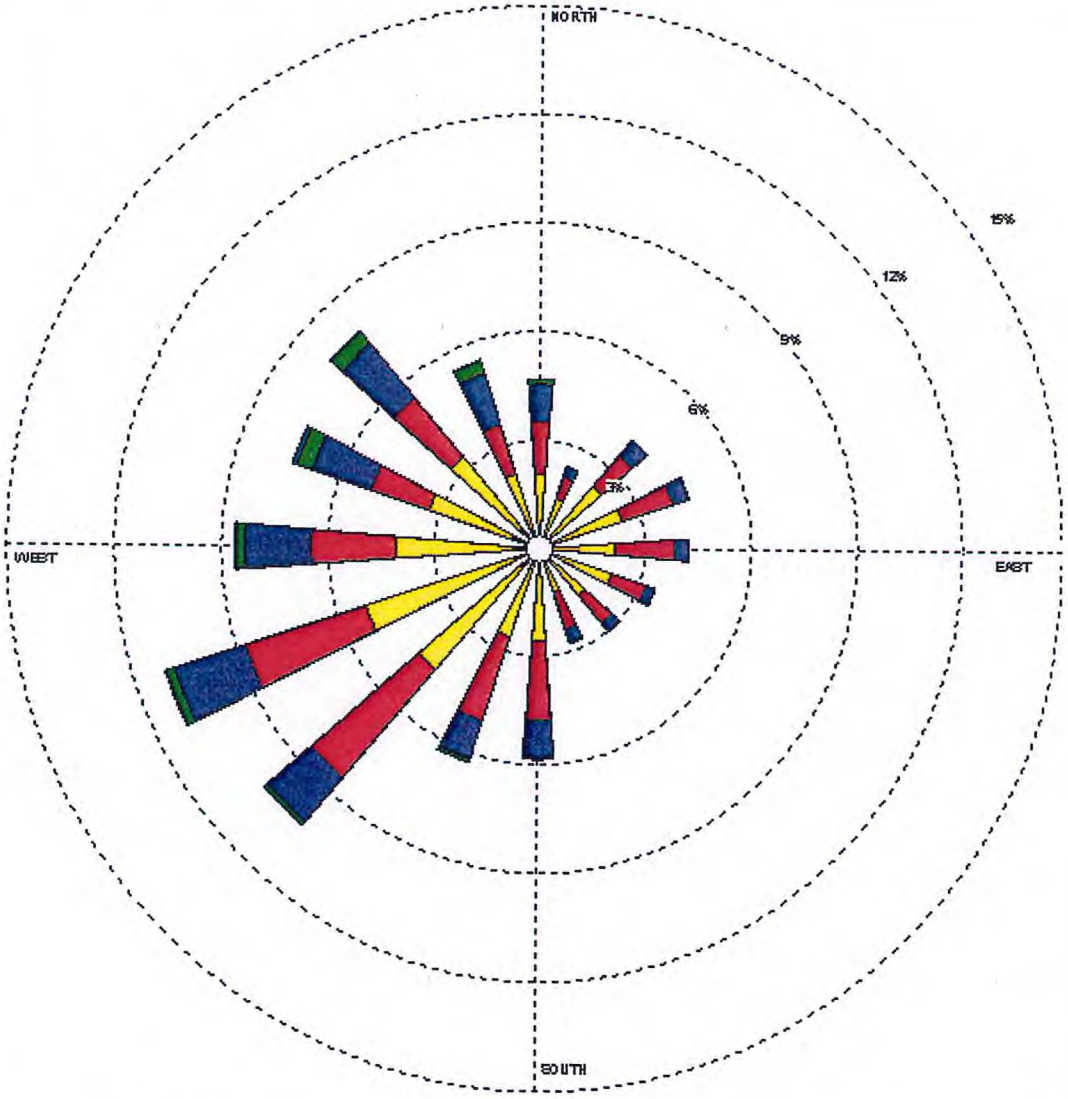
Wind Speed (m/s)

- > 11.05
- 8.49 - 11.05
- 5.40 - 8.49
- 3.34 - 5.40
- 1.80 - 3.34
- 0.51 - 1.80

MODELER		DATE 11/1/2002	COMPANY NAME
DISPLAY Wind Speed		UNIT m/s	COMMENTS
AVG. WIND SPEED 4.38 m/s		CALM WINDS 7.39%	
ORIENTATION Direction (blowing from)		PLOT YEAR-DATE-TIME 1961 May 1 - May 31 Midnight - 11 PM	PROJECT/PLOT NO.

WIND ROSE PLOT

Station #14737 - ALLENTOWN/BETLEHEM-EASTON ARP, PA



Wind Speed (m/s)

- > 11.06
- 8.49 - 11.06
- 5.40 - 8.49
- 3.34 - 5.40
- 1.80 - 3.34
- 0.51 - 1.80

MODELER		DATE 11/1/2002	COMPANY NAME
DISPLAY Wind Speed		UNIT m/s	COMMENTS
AVG. WIND SPEED 3.97 m/s		CALM WINDS 8.11%	
ORIENTATION Direction (blowing from)		PLOT YEAR-DATE-TIME 1961 Jun 1 - Jun 30 Midnight - 11 PM	PROJECT/PLOT NO.

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Attachment 3

Sample Methods

Method 7400

ASBESTOS and OTHER FIBERS by PCM 7400

FORMULA: Various MW: Various CAS: see Synonyms RTECS: Various

METHOD: 7400, Issue 2 EVALUATION: FULL Issue 1: Rev. 3 on 15 May 1989
Issue 2: 15 August 1994

OSHA: 0.1 asbestos fiber (> 5 µm long)/cc; 1 f/cc, 30 min excursion; carcinogen
MSHA: 2 asbestos fibers/cc
NIOSH: 0.1 f/cc (fibers > 5 µm long), 400 L; carcinogen
ACGIH: 0.2 f/cc crocidolite; 0.5 f/cc amosite; 2 f/cc chrysotile and other asbestos; carcinogen

PROPERTIES: solid, fibrous, crystalline, anisotropic

SYNONYMS [CAS #]: actinolite [77536-66-4] or ferroactinolite [15669-07-5]; amosite [12172-73-5]; anthophyllite [77536-67-5]; chrysotile [12001-29-5]; serpentine [18786-24-8]; crocidolite [12001-28-4]; tremolite [77536-68-6]; amphibole asbestos [1332-21-4]; refractory ceramic fibers [142844-00-6]; fibrous glass

SAMPLING

SAMPLER: FILTER (0.45- to 1.2-µm cellulose ester membrane, 25-mm; conductive cowl on cassette)

FLOW RATE*: 0.5 to 16 L/min

VOL-MIN*: 400 L @ 0.1 fiber/cc
-MAX*: (step 4, sampling)

*Adjust to give 100 to 1300 fiber/mm^2

SHIPMENT: routine (pack to reduce shock)

SAMPLE STABILITY: stable

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: 80 to 100 fibers counted

BIAS: see EVALUATION OF METHOD

OVERALL PRECISION ($\hat{S}_{rt}$): 0.115 to 0.13 [1]

ACCURACY: see EVALUATION OF METHOD

MEASUREMENT

TECHNIQUE: LIGHT MICROSCOPY, PHASE CONTRAST

ANALYTE: fibers (manual count)

SAMPLE PREPARATION: acetone - collapse/triacetin - immersion method [2]

COUNTING RULES: described in previous version of this method as "A" rules [1,3]

EQUIPMENT:
1. positive phase-contrast microscope
2. Walton-Beckett graticule (100-µm field of view) Type G-22
3. phase-shift test slide (HSE/NPL)

CALIBRATION: HSE/NPL test slide

RANGE: 100 to 1300 fibers/mm^2 filter area

ESTIMATED LOD: 7 fibers/mm^2 filter area

PRECISION ($\bar{S}_r$): 0.10 to 0.12 [1]; see EVALUATION OF METHOD

APPLICABILITY: The quantitative working range is 0.04 to 0.5 fiber/cc for a 1000-L air sample. The LOD depends on sample volume and quantity of interfering dust, and is <0.01 fiber/cc for atmospheres free of interferences. The method gives an index of airborne fibers. It is primarily used for estimating asbestos concentrations, though PCM does not differentiate between asbestos and other fibers. Use this method in conjunction with electron microscopy (e.g., Method 7402) for assistance in identification of fibers. Fibers < ca. 0.25 µm diameter will not be detected by this method [4]. This method may be used for other materials such as fibrous glass by using alternate counting rules (see Appendix C).

INTERFERENCES: If the method is used to detect a specific type of fiber, any other airborne fiber may interfere since all particles meeting the counting criteria are counted. Chain-like particles may appear fibrous. High levels of non-fibrous dust particles may obscure fibers in the field of view and increase the detection limit.

OTHER METHODS: This revision replaces Method 7400, Revision #3 (dated 5/15/89).

REAGENTS:

1. Acetone,* reagent grade.
2. Triacetin (glycerol triacetate), reagent grade.

*See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: field monitor, 25-mm, three-piece cassette with ca. 50-mm electrically conductive extension cowl and cellulose ester filter, 0.45- to 1.2-µm pore size, and backup pad.
   NOTE 1: Analyze representative filters for fiber background before use to check for clarity and background. Discard the filter lot if mean is ≥ 5 fibers per 100 graticule fields. These are defined as laboratory blanks. Manufacturer-provided quality assurance checks on filter blanks are normally adequate as long as field blanks are analyzed as described below.
   NOTE 2: The electrically conductive extension cowl reduces electrostatic effects. Ground the cowl when possible during sampling.
   NOTE 3: Use 0.8-µm pore size filters for personal sampling. The 0.45-µm filters are recommended for sampling when performing TEM analysis on the same samples. However, their higher pressure drop precludes their use with personal sampling pumps.
   NOTE 4: Other cassettes have been proposed that exhibit improved uniformity of fiber deposit on the filter surface, e.g., bellmouthed sampler (Envirometrics, Charleston, SC). These may be used if shown to give measured concentrations equivalent to sampler indicated above for the application.
2. Personal sampling pump, battery or line-powered vacuum, of sufficient capacity to meet flow-rate requirements (see step 4 for flow rate), with flexible connecting tubing.
3. Wire, multi-stranded, 22-gauge; 1" hose clamp to attach wire to cassette.
4. Tape, shrink- or adhesive-.
5. Slides, glass, frosted-end, pre-cleaned, 25- × 75-mm.
6. Cover slips, 22- × 22-mm, No. 1½, unless otherwise specified by microscope manufacturer.
7. Lacquer or nail polish.
8. Knife, #10 surgical steel, curved blade.
9. Tweezers.

EQUIPMENT (continued):

10. Acetone flash vaporization system for clearing filters on glass slides (see ref. [5] for specifications or see manufacturer's instructions for equivalent devices).
11. Micropipets or syringes, 5-µL and 100- to 500-µL.
12. Microscope, positive phase (dark) contrast, with green or blue filter, adjustable field iris, 8 to 10× eyepiece, and 40 to 45× phase objective (total magnification ca. 400×); numerical aperture = 0.65 to 0.75.
13. Graticule, Walton-Beckett type with 100-µm diameter circular field (area = 0.00785 mm^2) at the specimen plane (Type G-22). Available from Optometrics USA, P.O. Box 699, Ayer, MA 01432 [phone (508)-772-1700], and McCrone Accessories and Components, 850 Pasquinelli Drive, Westmont, IL 60559 [phone (312) 887-7100].
    NOTE: The graticule is custom-made for each microscope. (see APPENDIX A for the custom-ordering procedure).
14. HSE/NPL phase contrast test slide, Mark II. Available from Optometrics USA (address above).
15. Telescope, ocular phase-ring centering.
16. Stage micrometer (0.01-mm divisions).

SPECIAL PRECAUTIONS: Acetone is extremely flammable. Take precautions not to ignite it. Heating of acetone in volumes greater than 1 mL must be done in a ventilated laboratory fume hood using a flameless, spark-free heat source.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. To reduce contamination and to hold the cassette tightly together, seal the crease between the cassette base and the cowl with a shrink band or light colored adhesive tape. For personal sampling, fasten the (uncapped) open-face cassette to the worker's lapel. The open face should be oriented downward.
    NOTE: The cowl should be electrically grounded during area sampling, especially under conditions of low relative humidity. Use a hose clamp to secure one end of the wire (Equipment, Item 3) to the monitor's cowl. Connect the other end to an earth ground (i.e., cold water pipe).
3. Submit at least two field blanks (or 10% of the total samples, whichever is greater) for each set of samples. Handle field blanks in a manner representative of actual handling of associated samples in the set. Open field blank cassettes at the same time as other cassettes just prior to sampling. Store top covers and cassettes in a clean area (e.g., a closed bag or box) with the top covers from the sampling cassettes during the sampling period.
4. Sample at 0.5 L/min or greater [6]. Adjust sampling flow rate, Q (L/min), and time, t (min), to produce a fiber density, E, of 100 to 1300 fibers/mm^2 (3.85×10^4 to 5×10^5 fibers per 25-mm filter with effective

collection area $A_c = 385$ mm^2) for optimum accuracy. These variables are related to the action level (one-half the current standard), L (fibers/cc), of the fibrous aerosol being sampled by:

$$t = \frac{A_c \times E}{Q \times L \times 10^3}.$$

NOTE 1: The purpose of adjusting sampling times is to obtain optimum fiber loading on the filter. The collection efficiency does not appear to be a function of flow rate in the range of 0.5 to 16 L/min for asbestos fibers [7]. Relatively large diameter fibers (>3 µm) may exhibit significant aspiration loss and inlet deposition. A sampling rate of 1 to 4 L/min for 8 h is appropriate in atmospheres containing ca. 0.1 fiber/cc in the absence of significant amounts of non-asbestos dust. Dusty atmospheres require smaller sample volumes (≤400 L) to obtain countable samples. In such cases take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high flow rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres, where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3000 to 10000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust. If ≥50% of the filter surface is covered with particles, the filter may be too overloaded to count and will bias the measured fiber concentration.

NOTE 2: OSHA regulations specify a minimum sampling volume of 48 L for an excursion measurement, and a maximum sampling rate of 2.5 L/min [3].

5. At the end of sampling, replace top cover and end plugs.
6. Ship samples with conductive cowl attached in a rigid container with packing material to prevent jostling or damage.

NOTE: Do not use untreated polystyrene foam in shipping container because electrostatic forces may cause fiber loss from sample filter.

SAMPLE PREPARATION:

NOTE 1: The object is to produce samples with a smooth (non-grainy) background in a medium with refractive index ≤ 1.46. This method collapses the filter for easier focusing and produces permanent (1–10 years) mounts which are useful for quality control and interlaboratory comparison. The aluminum "hot block" or similar flash vaporization techniques may be used outside the laboratory [2]. Other mounting techniques meeting the above criteria may also be used (e.g., the laboratory fume hood procedure for generating acetone vapor as described in Method 7400—revision of 5/15/85, or the non-permanent field mounting technique used in P&CAM 239 [3,7–9]). Unless the effective filtration area is known, determine the area and record the information referenced against the sample ID number [1,9–11].

NOTE 2: Excessive water in the acetone may slow the clearing of the filter, causing material to be washed off the surface of the filter. Also, filters that have been exposed to high humidities prior to clearing may have a grainy background.

7. Ensure that the glass slides and cover slips are free of dust and fibers.
8. Adjust the rheostat to heat the "hot block" to ca. 70 °C [2].

NOTE: If the "hot block" is not used in a fume hood, it must rest on a ceramic plate and be isolated from any surface susceptible to heat damage.

9. Mount a wedge cut from the sample filter on a clean glass slide.
   a. Cut wedges of ca. 25% of the filter area with a curved-blade surgical steel knife using a rocking motion to prevent tearing. Place wedge, dust side up, on slide.
      NOTE: Static electricity will usually keep the wedge on the slide.
   b. Insert slide with wedge into the receiving slot at base of "hot block". Immediately place tip of a micropipet containing ca. 250 µL acetone (use the minimum volume needed to consistently clear the filter sections) into the inlet port of the PTFE cap on top of the "hot block" and inject the

acetone into the vaporization chamber with a slow, steady pressure on the plunger button while holding pipet firmly in place. After waiting 3 to 5 s for the filter to clear, remove pipet and slide from their ports.

CAUTION: Although the volume of acetone used is small, use safety precautions. Work in a well-ventilated area (e.g., laboratory fume hood). Take care not to ignite the acetone. Continuous use of this device in an unventilated space may produce explosive acetone vapor concentrations.

c. Using the 5-µL micropipet, immediately place 3.0 to 3.5 µL triacetin on the wedge. Gently lower a clean cover slip onto the wedge at a slight angle to reduce bubble formation. Avoid excess pressure and movement of the cover glass.

NOTE: If too many bubbles form or the amount of triacetin is insufficient, the cover slip may become detached within a few hours. If excessive triacetin remains at the edge of the filter under the cover slip, fiber migration may occur.

d. Mark the outline of the filter segment with a glass marking pen to aid in microscopic evaluation.

e. Glue the edges of the cover slip to the slide using lacquer or nail polish [12]. Counting may proceed immediately after clearing and mounting are completed.

NOTE: If clearing is slow, warm the slide on a hotplate (surface temperature 50 °C) for up to 15 min to hasten clearing. Heat carefully to prevent gas bubble formation.

CALIBRATION AND QUALITY CONTROL:

10. Microscope adjustments. Follow the manufacturer's instructions. At least once daily use the telescope ocular (or Bertrand lens, for some microscopes) supplied by the manufacturer to ensure that the phase rings (annular diaphragm and phase-shifting elements) are concentric. With each microscope, keep a logbook in which to record the dates of microscope cleanings and major servicing.

    a. Each time a sample is examined, do the following:

        (1) Adjust the light source for even illumination across the field of view at the condenser iris. Use Kohler illumination, if available. With some microscopes, the illumination may have to be set up with bright field optics rather than phase contract optics.

        (2) Focus on the particulate material to be examined.

        (3) Make sure that the field iris is in focus, centered on the sample, and open only enough to fully illuminate the field of view.

    b. Check the phase-shift detection limit of the microscope periodically for each analyst/microscope combination:

        (1) Center the HSE/NPL phase-contrast test slide under the phase objective.

        (2) Bring the blocks of grooved lines into focus in the graticule area.

        NOTE: The slide contains seven blocks of grooves (ca. 20 grooves per block) in descending order of visibility. For asbestos counting, the microscope optics must completely resolve the grooved lines in block 3 although they may appear somewhat faint, and the grooved lines in blocks 6 and 7 must be invisible when centered in the graticule area. Blocks 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope which fails to meet these requirements has resolution either too low or too high for fiber counting.

        (3) If image quality deteriorates, clean the microscope optics. If the problem persists, consult the microscope manufacturer.

11. Document the laboratory's precision for each counter for replicate fiber counts.

    a. Maintain as part of the laboratory quality assurance program a set of reference slides to be used on a daily basis [13]. These slides should consist of filter preparations including a range of loadings and background dust levels from a variety of sources including both field and reference samples (e.g., PAT, AAR, commercial samples). The Quality Assurance Officer should maintain custody of the reference slides and should supply each counter with a minimum of one reference

slide per workday. Change the labels on the reference slides periodically so that the counter does not become familiar with the samples.

b. From blind repeat counts on reference slides, estimate the laboratory intra- and intercounter precision. Obtain separate values of relative standard deviation (S_r) for each sample matrix analyzed in each of the following ranges: 5 to 20 fibers in 100 graticule fields, >20 to 50 fibers in 100 graticule fields, and >50 to 100 fibers in 100 graticule fields. Maintain control charts for each of these data files.

NOTE: Certain sample matrices (e.g., asbestos cement) have been shown to give poor precision [9].

12. Prepare and count field blanks along with the field samples. Report counts on each field blank.

NOTE 1: The identity of blank filters should be unknown to the counter until all counts have been completed.

NOTE 2: If a field blank yields greater than 7 fibers per 100 graticule fields, report possible contamination of the samples.

13. Perform blind recounts by the same counter on 10% of filters counted (slides relabeled by a person other than the counter). Use the following test to determine whether a pair of counts by the same counter on the same filter should be rejected because of possible bias: Discard the sample if the absolute value of the difference between the square roots of the two counts (in fiber/mm^2) exceeds $2.77XS_r'$ where X = average of the square roots of the two fiber counts (in fiber/mm^2) and $S_r' = S_r / 2$ where S_r is the intracounter relative standard deviation for the appropriate count range (in fibers) determined in step 11. For more complete discussions see reference [13].

NOTE 1: Since fiber counting is the measurement of randomly placed fibers which may be described by a Poisson distribution, a square root transformation of the fiber count data will result in approximately normally distributed data [13].

NOTE 2: If a pair of counts is rejected by this test, recount the remaining samples in the set and test the new counts against the first counts. Discard all rejected paired counts. It is not necessary to use this statistic on blank counts.

14. The analyst is a critical part of this analytical procedure. Care must be taken to provide a non-stressful and comfortable environment for fiber counting. An ergonomically designed chair should be used, with the microscope eyepiece situated at a comfortable height for viewing. External lighting should be set at a level similar to the illumination level in the microscope to reduce eye fatigue. In addition, counters should take 10- to 20-minute breaks from the microscope every one or two hours to limit fatigue [14]. During these breaks, both eye and upper back/neck exercises should be performed to relieve strain.

15. All laboratories engaged in asbestos counting should participate in a proficiency testing program such as the AIHA-NIOSH Proficiency Analytical Testing (PAT) Program for asbestos and routinely exchange field samples with other laboratories to compare performance of counters.

MEASUREMENT:

16. Center the slide on the stage of the calibrated microscope under the objective lens. Focus the microscope on the plane of the filter.

17. Adjust the microscope (Step 10).

NOTE: Calibration with the HSE/NPL test slide determines the minimum detectable fiber diameter (ca. 0.25 µm) [4].

18. Counting rules: (same as P&CAM 239 rules [1,10,11]: see examples in APPENDIX B).

a. Count any fiber longer than 5 µm which lies entirely within the graticule area.
   (1) Count only fibers longer than 5 µm. Measure length of curved fibers along the curve.
   (2) Count only fibers with a length-to-width ratio equal to or greater than 3:1.

b. For fibers which cross the boundary of the graticule field:
   (1) Count as ½ fiber any fiber with only one end lying within the graticule area, provided that the fiber meets the criteria of rule a above.

(2) Do not count any fiber which crosses the graticule boundary more than once.
(3) Reject and do not count all other fibers.

c. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of a fiber.
d. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields. Stop at 100 graticule fields regardless of count.

19. Start counting from the tip of the filter wedge and progress along a radial line to the outer edge. Shift up or down on the filter, and continue in the reverse direction. Select graticule fields randomly by looking away from the eyepiece briefly while advancing the mechanical stage. Ensure that, as a minimum, each analysis covers one radial line from the filter center to the outer edge of the filter. When an agglomerate or bubble covers ca. 1/6 or more of the graticule field, reject the graticule field and select another. Do not report rejected graticule fields in the total number counted.

NOTE 1: When counting a graticule field, continuously scan a range of focal planes by moving the fine focus knob to detect very fine fibers which have become embedded in the filter. The small-diameter fibers will be very faint but are an important contribution to the total count. A minimum counting time of 15 s per field is appropriate for accurate counting.

NOTE 2: This method does not allow for differentiation of fibers based on morphology. Although some experienced counters are capable of selectively counting only fibers which appear to be asbestiform, there is presently no accepted method for ensuring uniformity of judgment between laboratories. It is, therefore, incumbent upon all laboratories using this method to report total fiber counts. If serious contamination from non-asbestos fibers occurs in samples, other techniques such as transmission electron microscopy must be used to identify the asbestos fiber fraction present in the sample (see NIOSH Method 7402). In some cases (i.e., for fibers with diameters >1 µm), polarized light microscopy (as in NIOSH Method 7403) may be used to identify and eliminate interfering non-crystalline fibers [15].

NOTE 3: Do not count at edges where filter was cut. Move in at least 1 mm from the edge.

NOTE 4: Under certain conditions, electrostatic charge may affect the sampling of fibers. These electrostatic effects are most likely to occur when the relative humidity is low (below 20%), and when sampling is performed near the source of aerosol. The result is that deposition of fibers on the filter is reduced, especially near the edge of the filter. If such a pattern is noted during fiber counting, choose fields as close to the center of the filter as possible [5].

NOTE 5: Counts are to be recorded on a data sheet that provides, as a minimum, spaces on which to record the counts for each field, filter identification number, analyst's name, date, total fibers counted, total fields counted, average count, fiber density, and commentary. Average count is calculated by dividing the total fiber count by the number of fields observed. Fiber density (fibers/mm^2) is defined as the average count (fibers/field) divided by the field (graticule) area (mm^2/field).

CALCULATIONS AND REPORTING OF RESULTS

20. Calculate and report fiber density on the filter, E (fibers/mm^2), by dividing the average fiber count per graticule field, F / n_f, minus the mean field blank count per graticule field, B / n_b, by the graticule field area, A_f (approx. 0.00785 mm^2):

$$E = \frac{(F/n_f - B/n_b)}{A_f}, \text{ fibers/mm}^2.$$

NOTE: Fiber counts above 1300 fibers/mm^2 and fiber counts from samples with >50% of filter area covered with particulate should be reported as "uncountable" or "probably biased." Other fiber counts outside the 100–1300 fiber/mm^2 range should be reported as having "greater than optimal variability" and as being "probably biased."

21. Calculate and report the concentration, C (fibers/cc), of fibers in the air volume sampled, V (L), using the effective collection area of the filter, A_c (approx. 385 mm^2 for a 25-mm filter):

$$C = \frac{EA_c}{V \times 10^3}.$$

NOTE: Periodically check and adjust the value of A_c, if necessary.

22. Report intralaboratory and interlaboratory relative standard deviations (from Step 11) with each set of results.

NOTE: Precision depends on the total number of fibers counted [1,16]. Relative standard deviation is documented in references [1,15–17] for fiber counts up to 100 fibers in 100 graticule fields. Comparability of interlaboratory results is discussed below. As a first approximation, use 213% above and 49% below the count as the upper and lower confidence limits for fiber counts greater than 20 (Figure 1).

EVALUATION OF METHOD:

Method Revisions:

This method is a revision of P&CAM 239 [10]. A summary of the revisions is as follows:

1. Sampling:
   The change from a 37-mm to a 25-mm filter improves sensitivity for similar air volumes. The change in flow rates allows for 2-m^3 full-shift samples to be taken, providing that the filter is not overloaded with non-fibrous particulates. The collection efficiency of the sampler is not a function of flow rate in the range 0.5 to 16 L/min [10].
2. Sample preparation technique:
   The acetone vapor-triacetin preparation technique is a faster, more permanent mounting technique than the dimethyl phthalate/diethyl oxalate method of P&CAM 239 [2,4,10]. The aluminum "hot block" technique minimizes the amount of acetone needed to prepare each sample.
3. Measurement:
   a. The Walton-Beckett graticule standardizes the area observed [14,18,19].
   b. The HSE/NPL test slide standardizes microscope optics for sensitivity to fiber diameter [4,14].
   c. Because of past inaccuracies associated with low fiber counts, the minimum recommended loading has been increased to 100 fibers/mm^2 filter area (a total of 78.5 fibers counted in 100 fields, each with field area = 0.00785 mm^2.) Lower levels generally result in an overestimate of the fiber count when compared to results in the recommended analytical range [20]. The recommended loadings should yield intracounter S_r in the range of 0.10 to 0.17 [21–23].

Interlaboratory Comparability:

An international collaborative study involved 16 laboratories using prepared slides from the asbestos cement, milling, mining, textile, and friction material industries [9]. The relative standard deviations (S_r) varied with sample type and laboratory. The ranges were:

Rules	Intralaboratory S_r	Interlaboratory S_r	Overall S_r
AIA (NIOSH A Rules)*	0.12 to 0.40	0.27 to 0.85	0.46
Modified CRS (NIOSH B Rules)†	0.11 to 0.29	0.20 to 0.35	0.25

*Under AIA rules, only fibers having a diameter less than 3 µm are counted and fibers attached to particles larger than 3 µm are not counted. NIOSH A Rules are otherwise similar to the AIA rules.

†See Appendix C.

A NIOSH study conducted using field samples of asbestos gave intralaboratory S_r in the range 0.17 to 0.25 and an interlaboratory S_r of 0.45 [21]. This agrees well with other recent studies [9,14,16].

At this time, there is no independent means for assessing the overall accuracy of this method. One measure of reliability is to estimate how well the count for a single sample agrees with the mean count from a large number of laboratories. The following discussion indicates how this estimation can be carried out based on measurements of the interlaboratory variability, as well as showing how the results of this method relate to the theoretically attainable counting precision and to measured intra- and interlaboratory S_r. (NOTE: The following discussion does not include bias estimates and should not be taken to indicate that lightly loaded samples are as accurate as properly loaded ones).

Theoretically, the process of counting randomly (Poisson) distributed fibers on a filter surface will give an S_r that depends on the number, N, of fibers counted:

$$S_r = 1/N^{1/2}.$$

Thus S_r is 0.1 for 100 fibers and 0.32 for 10 fibers counted. The actual S_r found in a number of studies is greater than these theoretical numbers [17,19–21].

An additional component of variability comes primarily from subjective interlaboratory differences. In a study of ten counters in a continuing sample exchange program, Ogden [15] found this subjective component of intralaboratory S_r to be approximately 0.2 and estimated the overall S_r by the term:

$$\frac{[N+(0.2\times N)^2]^{1/2}}{N}.$$

Ogden found that the 90% confidence interval of the individual intralaboratory counts in relation to the means were $+2\ S_r$ and $-1.5\ S_r$. In this program, one sample out of ten was a quality control sample. For laboratories not engaged in an intensive quality assurance program, the subjective component of variability can be higher.

In a study of field sample results in 46 laboratories, the Asbestos Information Association also found that the variability had both a constant component and one that depended on the fiber count [14]. These results gave a subjective interlaboratory component of S_r (on the same basis as Ogden's) for field samples of ca. 0.45. A similar value was obtained for 12 laboratories analyzing a set of 24 field samples [21]. This value falls slightly above the range of S_r (0.25 to 0.42 for 1984–85) found for 80 reference laboratories in the NIOSH PAT program for laboratory-generated samples [17].

A number of factors influence S_r for a given laboratory, such as that laboratory's actual counting performance and the type of samples being analyzed. In the absence of other information, such as from an interlaboratory quality assurance program using field samples, the value for the subjective component of variability is chosen as 0.45. It is hoped that the laboratories will carry out the recommended interlaboratory quality assurance programs to improve their performance and thus reduce the S_r.

The above relative standard deviations apply when the population mean has been determined. It is more useful, however, for laboratories to estimate the 90% confidence interval on the mean count from a single sample fiber count (Figure 1). These curves assume similar shapes of the count distribution for interlaboratory and intralaboratory results [16].

For example, if a sample yields a count of 24 fibers, Figure 1 indicates that the mean interlaboratory count will fall within the range of 227% above and 52% below that value 90% of the time. We can apply these percentages directly to the air concentrations as well. If, for instance, this sample (24 fibers counted) represented a 500-L volume, then the measured concentration is 0.02 fibers/mL (assuming 100 fields counted, 25-mm filter, 0.00785 mm^2 counting field area). If this same sample were counted by

a group of laboratories, there is a 90% probability that the mean would fall between 0.01 and 0.08 fiber/mL. These limits should be reported in any comparison of results between laboratories.

Note that the S_r of 0.45 used to derive Figure 1 is used as an estimate for a random group of laboratories. If several laboratories belonging to a quality assurance group can show that their interlaboratory S_r is smaller, then it is more correct to use that smaller S_r. However, the estimated S_r of 0.45 is to be used in the absence of such information. Note also that it has been found that S_r can be higher for certain types of samples, such as asbestos cement [9].

Quite often the estimated airborne concentration from an asbestos analysis is used to compare to a regulatory standard. For instance, if one is trying to show compliance with an 0.5 fiber/mL standard using a single sample on which 100 fibers have been counted, then Figure 1 indicates that the 0.5 fiber/mL standard must be 213% higher than the measured air concentration. This indicates that if one measures a fiber concentration of 0.16 fiber/mL (100 fibers counted), then the mean fiber count by a group of laboratories (of which the compliance laboratory might be one) has a 95% chance of being less than 0.5 fibers/mL; i.e., $0.16 + 2.13 \times 0.16 = 0.5$.

It can be seen from Figure 1 that the Poisson component of the variability is not very important unless the number of fibers counted is small. Therefore, a further approximation is to simply use +213% and −49% as the upper and lower confidence values of the mean for a 100-fiber count.

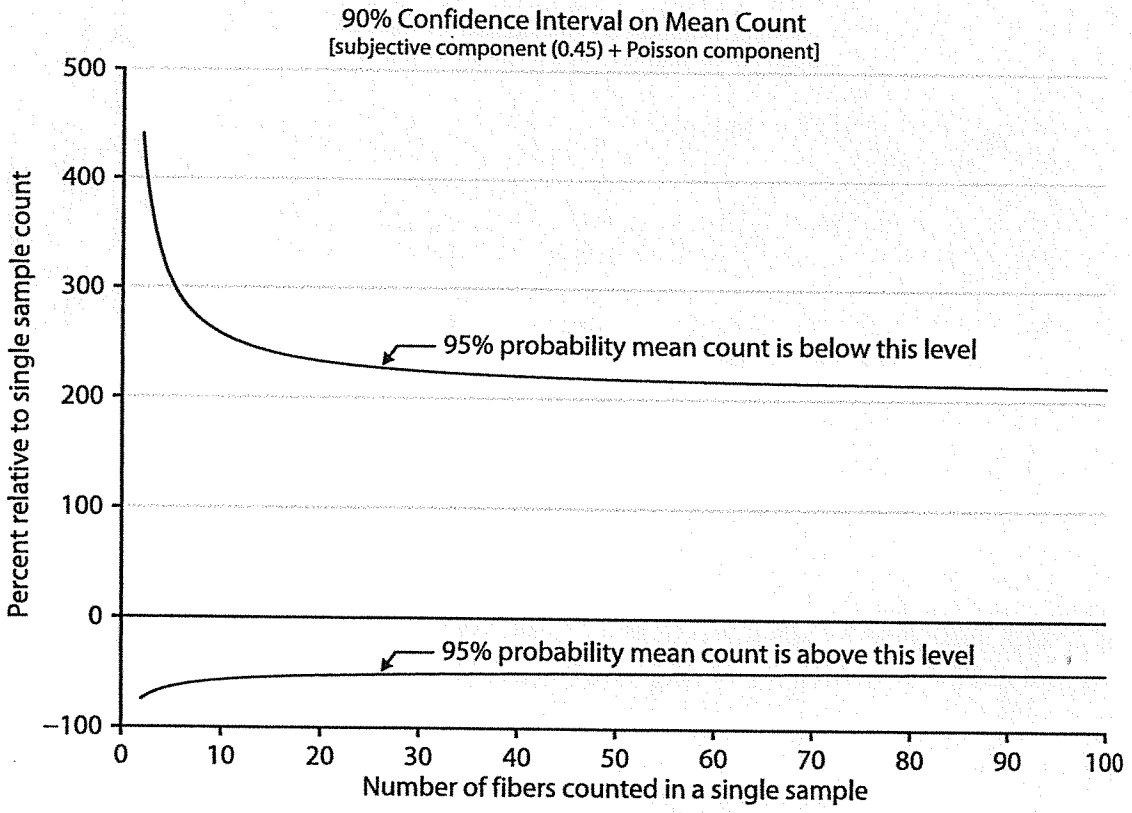

Figure 1. Interlaboratory precision of fiber counts.

The curves in Figure 1 are defined by the following equations:

$$U_{CL} = \frac{2X + 2.25 + [(2.25 + 2X)^2 - 4(1 - 2.25S_r^2)X^2]^{1/2}}{2(1 - 2.25S_r^2)} \text{ and}$$

$$L_{CL} = \frac{2X + 4 - [(4 + 2X)^2 - 4(1 - 4S_r^2)X^2]^{1/2}}{2(1 - 4S_r^2)},$$

where S_r = subjective interlaboratory relative standard deviation, which is close to the total interlaboratory S_r when approximately 100 fibers are counted,
X = total fibers counted on sample,
L_{CL} = lower 95% confidence limit, and
U_{CL} = upper 95% confidence limit.

Note that the range between these two limits represents 90% of the total range.

REFERENCES:

[1] Leidel, N. A., S. G. Bayer, R. D. Zumwalde, and K. A. Busch. USPHS/NIOSH Membrane Filter Method for Evaluating Airborne Asbestos Fibers, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 79-127 (1979).

[2] Baron, P. A. and G. C. Pickford. "An Asbestos Sample Filter Clearing Procedure," *Appl. Ind. Hyg., 1*, 169–171, 199 (1986).

[3] Occupational Safety and Health Administration, U.S. Department of Labor, Occupational Exposure to Asbestos, Tremolite, Anthophyllite, and Actinolite Asbestos; Final Rules, 29 CFR Part 1910.1001 Amended June 20, 1986.

[4] Rooker, S. J., N. P. Vaughn, and J. M. LeGuen. "On the Visibility of Fibers by Phase Contrast Microscopy," *Amer. Ind. Hyg. Assoc. J., 43*, 505–515 (1982).

[5] Baron, P. and G. Deye, "Electrostatic Effects in Asbestos Sampling," Parts I and II, *Amer. Ind. Hyg. Assoc. J., 51*, 51–69 (1990).

[6] Johnston, A. M., A. D. Jones, and J. H. Vincent. "The Influence of External Aerodynamic Factors on the Measurement of the Airborne Concentration of Asbestos Fibers by the Membrane Filter Method," *Ann. Occup. Hyg., 25*, 309–316 (1982).

[7] Beckett, S.T., "The Effects of Sampling Practice on the Measured Concentration of Airborne Asbestos," *Ann. Occup. Hyg., 21*, 259–272 (1980).

[8] Jankovic, J. T., W. Jones, and J. Clere. "Field Techniques for Clearing Cellulose Ester Filters Used in Asbestos Sampling," *Appl. Ind. Hyg., 1*, 145–147 (1986).

[9] Crawford, N. P., H. L. Thorpe, and W. Alexander. "A Comparison of the Effects of Different Counting Rules and Aspect Ratios on the Level and Reproducibility of Asbestos Fiber Counts," Part I: Effects on Level (Report No. TM/82/23), Part II: Effects on Reproducibility (Report No. TM/82/24), Institute of Occupational Medicine, Edinburgh, Scotland (December, 1982).

[10] NIOSH Manual of Analytical Methods, 2nd ed., Vol. 1., P&CAM 239, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-A (1977).

[11] Revised Recommended Asbestos Standard, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-169 (1976); as amended in NIOSH statement at OSHA Public Hearing, June 21, 1984.

[12] Asbestos International Association, AIA Health and Safety Recommended Technical Method #1 (RTMI). "Airborne Asbestos Fiber Concentrations at Workplaces by Light Microscopy" (Membrane Filter Method), London (1979).

[13] Abell, M., S. Shulman and P. Baron. "The Quality of Fiber Count Data," *Appl. Ind. Hyg., 4*, 273–285 (1989).

[14] "A Study of the Empirical Precision of Airborne Asbestos Concentration Measurements in the Workplace by the Membrane Filter Method," Asbestos Information Association, Air Monitoring Committee Report, Arlington, VA (June, 1983).

[15] McCrone, W., L. McCrone and J. Delly, "Polarized Light Microscopy," Ann Arbor Science (1978).
[16] Ogden, T. L. "The Reproducibility of Fiber Counts," Health and Safety Executive Research Paper 18 (1982).
[17] Schlecht, P. C. and S. A. Schulman. "Performance of Asbestos Fiber Counting Laboratories in the NIOSH Proficiency Analytical Testing (PAT) Program," *Am. Ind. Hyg. Assoc. J., 47*, 259–266 (1986).
[18] Chatfield, E. J. Measurement of Asbestos Fiber Concentrations in Workplace Atmospheres, Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario, Study No. 9, 180 Dundas Street West, 22nd Floor, Toronto, Ontario, CANADA M5G 1Z8.
[19] Walton, W. H. "The Nature, Hazards, and Assessment of Occupational Exposure to Airborne Asbestos Dust: A Review," *Ann. Occup. Hyg., 25*, 115–247 (1982).
[20] Cherrie, J., A.D. Jones, and A.M. Johnston. "The Influence of Fiber Density on the Assessment of Fiber Concentration Using the membrane filter Method." *Am. Ind. Hyg. Assoc. J., 47*(8), 465–74 (1986).
[21] Baron, P. A. and S. Shulman. "Evaluation of the Magiscan Image Analyzer for Asbestos Fiber Counting." *Am. Ind. Hyg. Assoc. J.*, (in press).
[22] Taylor, D. G., P. A. Baron, S. A. Shulman and J. W. Carter. "Identification and Counting of Asbestos Fibers," *Am. Ind. Hyg. Assoc. J. 45*(2), 84–88 (1984).
[23] "Potential Health Hazards of Video Display Terminals," NIOSH Research Report, June 1981.
[24] "Reference Methods for Measuring Airborne Man-Made Mineral Fibers (MMMF)," WHO/EURO Technical Committee for Monitoring an Evaluating Airborne MMMF, World Health Organization, Copenhagen (1985).
[25] Criteria for a Recommended Standard...Occupational Exposure to Fibrous Glass, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-152 (1977).

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APPENDIX A. CALIBRATION OF THE WALTON-BECKETT GRATICULE

Before ordering the Walton-Beckett graticule, the following calibration must be done to obtain a counting area (*D*) 100 µm in diameter at the image plane. The diameter, d_c (mm), of the circular counting area and the disc diameter must be specified when ordering the graticule.

1. Insert any available graticule into the eyepiece and focus so that the graticule lines are sharp and clear.
2. Set the appropriate interpupillary distance and, if applicable, reset the binocular head adjustment so that the magnification remains constant.
3. Install the 40 to 45× phase objective.
4. Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.
5. Measure the magnified grid length of the graticule, L_o (µm), using the stage micrometer.
6. Remove the graticule from the microscope and measure its actual grid length, L_a (mm). This can best be accomplished by using a stage fitted with verniers.
7. Calculate the circle diameter, d_c (mm), for the Walton-Beckett graticule:

$$d_c = \frac{L_a}{L_o} \times D.$$

Example: If $L_o = 112$ µm, $L_a = 4.5$ mm, and $D = 100$ µm, then $d_c = 4.02$ mm.

8. Check the field diameter, *D* (acceptable range 100 µm ± 2 µm) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine field area (acceptable range 0.00754 mm^2 to 0.00817 mm^2).

APPENDIX B. COMPARISON OF COUNTING RULES

Figure 2 shows a Walton-Beckett graticule as seen through the microscope. The rules will be discussed as they apply to the labeled objects in the figure.

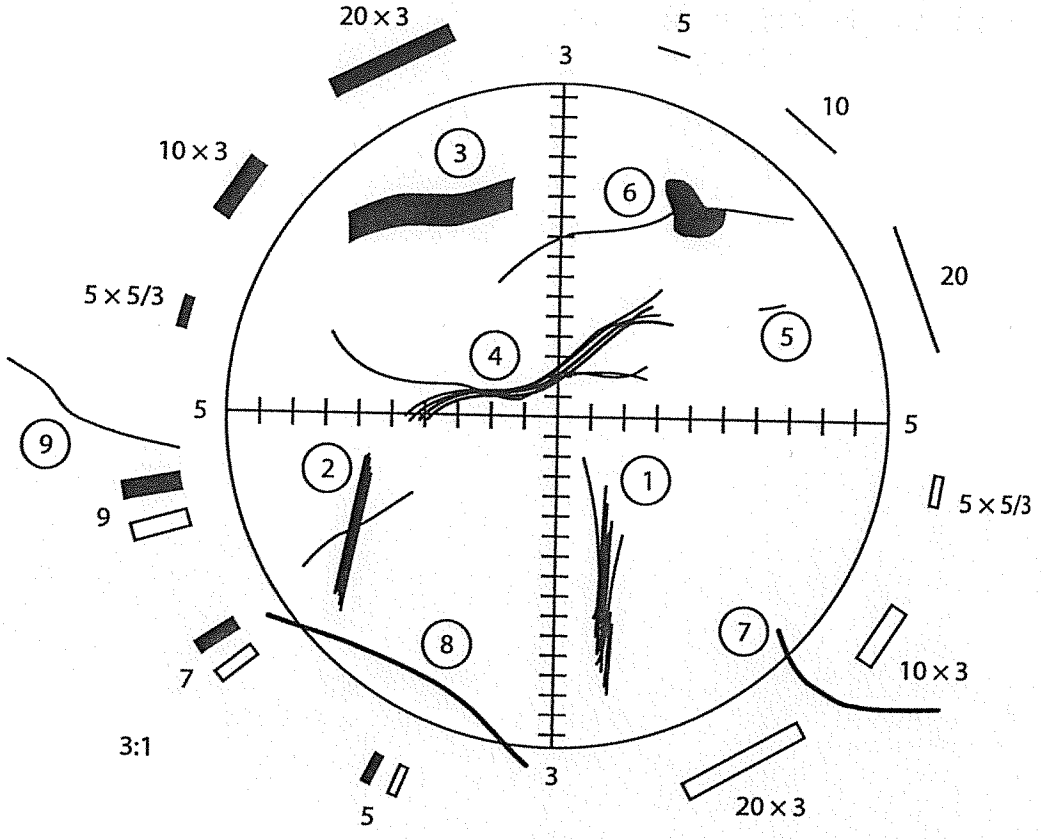

Figure 2. Walton-Beckett graticule with fibers.

These rules are sometimes referred to as the "A" rules:

Object	Count	Discussion
1	1 fiber	Optically observable asbestos fibers are actually bundles of fine fibrils. If the fibrils seem to be from the same bundle, the object is counted as a single fiber. Note, however, that all objects meeting length and aspect ratio criteria are counted whether or not they appear to be asbestos.
2	2 fibers	If fibers meeting the length and aspect ratio criteria (length >5 µm and length-to-width ratio > 3 to 1) overlap, but do not seem to be part of the same bundle, they are counted as separate fibers.
3	1 fiber	Although the object has a relatively large diameter (>3 µm), it is counted as fiber under the rules. There is no upper limit on the fiber diameter in the counting rules. Note that fiber width is measured at the widest compact section of the object.
4	1 fiber	Although long fine fibrils may extend from the body of a fiber, these fibrils are considered part of the fiber if they seem to have originally been part of the bundle.
5	Do not count	If the object is ≤ 5 µm long, it is not counted.
6	1 fiber	A fiber partially obscured by a particle is counted as one fiber. If the fiber ends emanating from a particle do not seem to be from the same fiber and each end meets the length and aspect ratio criteria, they are counted as separate fibers.
7	½ fiber	A fiber which crosses into the graticule area one time is counted as ½ fiber.
8	Do not count	Ignore fibers that cross the graticulate boundary more than once.
9	Do not count	Ignore fibers that lie outside the graticule boundary.

APPENDIX C. ALTERNATE COUNTING RULES FOR NON-ASBESTOS FIBERS

Other counting rules may be more appropriate for measurement of specific non-asbestos fiber types, such as fibrous glass. These include the "B" rules given below (from NIOSH Method 7400, Revision #2, dated 8/15/87), the World Health Organization reference method for man-made mineral fiber [24], and the NIOSH fibrous glass criteria document method [25]. The upper diameter limit in these methods prevents measurements of non-thoracic fibers. It is important to note that the aspect ratio limits included in these methods vary. NIOSH recommends the use of the 3:1 aspect ratio in counting fibers.

It is emphasized that hybridization of different sets of counting rules is not permitted. Report specifically which set of counting rules are used with the analytical results.

"B" Counting Rules

1. Count only *ends* of fibers. Each fiber must be longer than 5 µm and less than 3 µm diameter.
2. Count only ends of fibers with a length-to-width ratio equal to or greater than 5:1.
3. Count each fiber end which falls within the graticule area as one end, provided that the fiber meets rules 1 and 2 above. Add split ends to the count as appropriate if the split fiber segment also meets the criteria of rules 1 and 2 above.
4. Count visibly free ends which meet rules 1 and 2 above when the fiber appears to be attached to another particle, regardless of the size of the other particle. Count the end of a fiber obscured by another particle if the particle covering the fiber end is less than 3 µm in diameter.

5. Count free ends of fibers emanating from large clumps and bundles up to a maximum of 10 ends (5 fibers), provided that each segment meets rules 1 and 2 above.
6. Count enough graticule fields to yield 200 ends. Count a minimum of 20 graticule fields. Stop at 100 graticule fields, regardless of count.
7. Divide total end count by 2 to yield fiber count.

APPENDIX D. EQUIVALENT LIMITS OF DETECTION AND QUANTITATION

	Fiber density on filter*		Fiber concentration in air, f/cc	
	Fibers per 100 fields	Fibers/mm^2	400-L air sample	1000-L air sample
	200	255	0.25	0.10
	100	127	0.125	0.05
LOQ	80.0	102	0.10	0.04
	50	64	0.0625	0.025
	25	32	0.03	0.0125
	20	25	0.025	0.010
	10	12.7	0.0125	0.005
	8	10.2	0.010	0.004
LOD	5.5	7	0.00675	0.0027

*Assumes 385 mm^2 effective filter collection area, and field area = 0.00785 mm^2, for relatively "clean" (little particulate aside from fibers) filters.

Method 7402

ASBESTOS by TEM

7402

FORMULA: Various MW: Various CAS: Various RTECS: Various

METHOD: 7402 EVALUATION: PARTIAL

Issue 1: 15 May 1989
Issue 2: 15 August 1994

OSHA : 0.1 asbestos fibers (>5 µm long)/cc; 1 f/cc/30 min excursion; carcinogen
MSHA: 2 asbestos fibers/cc
NIOSH: 0.1 f/cc (fibers > 5 µm long)/400 L; carcinogen
ACGIH: 0.2 crocidolite; 0.5 amosite; 2 chrysotile and other asbestos, fibers/cc; carcinogen

PROPERTIES: solid, fibrous, crystalline, anistropic

SYNONYMS [CAS#]: actinolite [77536-66-4] or ferroactinolite [15669-07-5]; amosite [12172-73-5]; anthophyllite [77536-67-5]; chrysotile [12001-29-5]; serpentine [18786-24-8]; crocidolite [12001-28-4]; tremolite [77536-68-6]; amphibole asbestos [1332-21-4].

SAMPLING

SAMPLER: FILTER (0.45- to 1.2-µm cellulose ester membrane, 25-mm diameter; conductive cassette)

FLOW RATE: 0.5 to 16 L/min

VOL-MIN*: 400 L @ 0.1 fiber/cc
-MAX*: (step 4, sampling)
*Adjust for 100 to 1300 fibers/mm^2

SHIPMENT: routine (pack to reduce shock)

SAMPLE STABILITY: stable

BLANKS: 2 to 10 field blanks per set

ACCURACY

RANGE STUDIED: 80 to 100 fibers counted

BIAS: not determined

OVERALL PRECISION ($\hat{S}_{rT}$): see EVALUATION OF METHOD

ACCURACY: not determined

MEASUREMENT

TECHNIQUE: MICROSCOPY, TRANSMISSION ELECTRON (TEM)

ANALYTE: asbestos fibers

SAMPLE PREPARATION: modified Jaffe wick

EQUIPMENT: transmission electron microscope; energy dispersive X-ray system (EDX) analyzer

CALIBRATION: qualitative electron diffraction; calibration of TEM magnification and EDX system

RANGE: 100 to 1300 fibers/mm^2 filter area [1]

ESTIMATED LOD: 1 confirmed asbestos fiber above 95% of expected mean blank value

PRECISION ($\hat{S}_r$): 0.28 when 65% of fibers are asbestos; 0.20 when adjusted fiber count is applied to PCM count [2].

APPLICABILITY: The quantitative working range is 0.04 to 0.5 fiber/cc for a 1000-L air sample. The LOD depends on sample volume and quantity of interfering dust, and is <0.01 fiber/cc for atmospheres free of interferences. This method is used to determine asbestos fibers in the optically visible range and is intended to complement the results obtained by phase contrast microscopy (Method 7400).

INTERFERENCES: Other amphibole particles that have aspect ratios greater than 3:1 and elemental compositions similar to the asbestos minerals may interfere in the TEM analysis. Some non-amphibole minerals may give electron diffraction patterns similar to amphiboles. High concentrations of background dust interfere with fiber identification. Some non-asbestos amphibole minerals may give electron diffraction patterns similar to asbestos amphiboles.

OTHER METHODS: This method is designed for use with Method 7400 (phase contrast microscopy).

REAGENTS:

1. Acetone. (See SPECIAL PRECAUTIONS.)

EQUIPMENT:

1. Sampler: field monitor, 25-mm, three-piece cassette with ca. 50-mm electrically-conductive extension cowl, cellulose ester membrane filter, 0.45- to 1.2-µm pore size, and backup pad.
   NOTE 1: Analyze representative filters for fiber background before use. Discard the filter lot if mean count is >5 fibers/100 fields. These are defined as laboratory blanks.
   NOTE 2: Use an electrically-conductive extension cowl to reduce electrostatic effects on fiber sampling and during sample shipment. Ground the cowl when possible during sampling.
   NOTE 3: 0.8-µm pore size filters are recommended for personal sampling. 0.45-µm filters are recommended for sampling when performing TEM analysis on the samples because the particles deposit closer to the filter surface. However, the higher pressure drop through these filters normally preclude their use with personal sampling pumps.
2. Personal sampling pump, 0.5 to 16 L/min, with flexible connecting tubing.
3. Microscope, transmission electron, operated at ca. 100 kV, with electron diffraction and energy-dispersive X-ray capabilities, and having a fluorescent screen with inscribed or overlaid calibrated scale (Step 15).
   NOTE: The scale is most efficient if it consists of a series of lines inscribed on the screen or partial circles every 2 cm distant from the center.
4. Diffraction grating replica with known number of lines/mm.
5. Slides, glass, pre-cleaned, 25- x 75-mm.
6. Knife, surgical steel, curved-blade.
7. Tweezers.
8. Grids, 200-mesh TEM copper, (optional: carbon-coated).
9. Petri dishes, 15-mm depth. The top and bottom of the petri dish must fit snugly together. To assure a tight fit, grind the top and bottom pieces together with an abrasive such as carborundum to produce a ground-glass contact surface.
10. Foam, clean polyurethane, spongy, 12-mm thick.
11. Filters, Whatman No. 1 qualitative paper or equivalent, or lens paper.
12. Vacuum evaporator.
13. Cork borer, (about 8-mm).
14. Pen, waterproof, marking.
15. Reinforcement, page, gummed.
16. Asbestos standard bulk materials for reference; e.g. SRM #1866, available from the National Institute of Standards and Technology.
17. Carbon rods, sharpened to 1 mm x 8 mm.
18. Microscope, light, phase contrast (PCM), with Walton-Beckett graticule (see method 7400).
19. Grounding wire, 22-gauge, multi-strand.
20. Tape, shrink- or adhesive-.

SPECIAL PRECAUTIONS: Acetone is extremely flammable (flash point = 0 °F). Take precautions not to ignite it. Heating of acetone must be done in a fume hood using a flameless, spark-free heat source. Asbestos is a confirmed human carcinogen. Handle only in a well-ventilated fume hood.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. For personal sampling, fasten sampler to worker's lapel near worker's mouth. Remove the top cover from cowl extension ("open-face") and orient sampler face down. Wrap joint between extender and monitor body with tape to help hold the cassette together and provide a marking surface to identify the cassette. Where possible, especially at low %RH, attach sampler to electrical ground to reduce electrostatic effects during sampling.
3. Submit at least two field blanks (or 10% of the total samples, whichever is greater) for each set of samples. Remove top covers from the field blank cassettes and store top covers and cassettes in a clean area (e.g., closed bag or box) during sampling. Replace top covers when sampling is completed.
4. Sample at 0.5 to 16 L/min [3]. Adjust sampling rate, Q (L/min), and time, t (min), to produce fiber density, E, of 100 to 1300 fibers/mm ^{2} [$3.85 \cdot 10^4$ to $5 \cdot 10^5$ fibers per 25-mm filter with effective collection area (A_c = 385 mm^2)] for optimum accuracy. Do not exceed ca. 0.5 mg total dust loading on the filter. These variables are related to the action level (one-half the current standard), L (fibers/cc), of the fibrous aerosol being sampled by:

$$t = \frac{A_c \cdot E}{Q \cdot L \cdot 10^3}, \text{ min.}$$

NOTE: The purpose of adjusting sampling times is to obtain optimum fiber loading on the filter. A sampling rate of 1 to 4 L/min for 8 h (700 to 2800 L) is appropriate in atmospheres containing ca. 0.1 fiber/cc in the absence of significant amounts of non-asbestos dust. Dusty atmospheres require smaller sample volumes (≤400 L) to obtain countable samples. In such cases take short, consecutive samples and average the results over the total collection time. For documenting episodic exposures, use high rates (7 to 16 L/min) over shorter sampling times. In relatively clean atmospheres, where targeted fiber concentrations are much less than 0.1 fiber/cc, use larger sample volumes (3000 to 10000 L) to achieve quantifiable loadings. Take care, however, not to overload the filter with background dust [3].

5. At the end of sampling, replace top cover and small end caps.
6. Ship samples upright with conductive cowl attached in a rigid container with packing material to prevent jostling or damage.
   NOTE: Do not use untreated polystyrene foam in the shipping container because electrostatic forces may cause fiber loss from sample filter.

SAMPLE PREPARATION:

7. Remove circular sections from any of three quadrants of each sample and blank filter using a cork borer [4]. The use of three grid preparations reduces the effect of local variations in dust deposit on the filter.
8. Affix the circular filter sections to a clean glass slide with a gummed page reinforcement. Label the slide with a waterproof marking pen.
   NOTE: Up to eight filter sections may be attached to the same slide.
9. Place the slide in a petri dish which contains several paper filters soaked with 2 to 3 mL acetone. Cover the dish. Wait 2 to 4 min for the sample filter(s) to fuse and clear.
   NOTE: The "hot block" clearing technique [5] of Method 7400 or the DMF clearing technique [6] may be used instead of steps 8 and 9.
10. Transfer the slide to a rotating stage inside the bell jar of a vacuum evaporator. Evaporate a 1- by 5-mm section of a graphite rod onto the cleared filter(s). Remove the slide to a clean, dry, covered petri dish [4].
11. Prepare a second petri dish as a Jaffe wick washer with the wicking substrate prepared from filter or lens paper placed on top of a 12-mm thick disk of clean, spongy polyurethane foam [7].

Cut a V-notch on the edge of the foam and filter paper. Use the V-notch as a reservoir for adding solvent.

NOTE: The wicking substrate should be thin enough to fit into the petri dish without touching the lid.

12. Place the TEM grid on the filter or lens paper. Label the grids by marking with a pencil on the filter paper or by putting registration marks on the petri dish halves and marking with a waterproof marker on the dish lid. In a fume hood, fill the dish with acetone until the wicking substrate is saturated.

NOTE: The level of acetone should be just high enough to saturate the filter paper without creating puddles.

13. Remove about a quarter section of the carbon-coated filter from the glass slide using a surgical knife and tweezers. Carefully place the excised filter, carbon side down, on the appropriately-labeled grid in the acetone-saturated petri dish. When all filter sections have been transferred, slowly add more solvent to the wedge-shaped trough to raise the acetone level as high as possible without disturbing the sample preparations. Cover the petri dish. Elevate one side of the petri dish by placing a slide under it (allowing drops of condensed acetone to form near the edge rather than in the center where they would drip onto the grid preparation).

CALIBRATION AND QUALITY CONTROL:

14. Determine the TEM magnification on the fluorescent screen:
    a. Define a field of view on the fluorescent screen either by markings or physical boundaries.
       NOTE: The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric) [7].
    b. Insert a diffraction grating replica into the specimen holder and place into the microscope. Orient the replica so that the grating lines fall perpendicular to the scale on the TEM fluorescent screen. Ensure that goniometer stage tilt is zero.
    c. Adjust microscope magnification to 10,000X. Measure the distance (mm) between the same relative positions (e.g., between left edges) of two widely-separated lines on the grating replica. Count the number of spaces between the lines.
       NOTE: On most microscopes the magnification is substantially constant only within the central 8- to 10-cm diameter region of the fluorescent screen.
    d. Calculate the true magnification (M) on the fluorescent screen:

$$m = \frac{X \cdot G}{Y}$$

       where: X = total distance (mm) between the two grating lines;
              G = calibration constant of the grating replica (lines/mm);
              Y = number of grating replica spaces counted
    e. After calibration, note the apparent sizes of 0.25 and 5.0 µm on the fluorescent screen. (These dimensions are the boundary limits for counting asbestos fibers by phase contrast microscopy.)
15. Measure 20 grid openings at random on a 200-mesh copper grid by placing a grid on a glass slide and examining it under the PCM. Use the Walton-Beckett graticule to measure the grid opening dimensions. Calculate an average graticule field dimension from the data and use this number to calculate the graticule field area for an average grid opening.

NOTE: A grid opening is considered as one graticule field.

16. Obtain reference selected area electron diffraction (SAED) or microdiffraction patterns from standard asbestos materials prepared for TEM analysis.

NOTE: This is a visual reference technique. No quantitative SAED analysis is required [7]. Microdiffraction may produce clearer patterns on very small fibers or fibers partially obscured by other material.

    a. Set the specimen holder at zero tilt.

b. Center a fiber, focus, and center the smallest field-limiting aperture on the fiber. Obtain a diffraction pattern. Photograph each distinctive pattern and keep the photo for comparison to unknowns.

NOTE: Not all fibers will present diffraction patterns. The objective lens current may need adjustment to give optimum pattern visibility. There are many more amphiboles which give diffraction patterns similar to the analytes named on p. 7402-1. Some, but not all, of these can be eliminated by chemical separations. Also, some non-amphiboles (e.g., pyroxenes, some talc fibers) may interfere.

17. Acquire energy-dispersive X-ray (EDX) spectra on approximately 5 fibers having diameters between 0.25 and 0.5 µm of each asbestos variety obtained from standard reference materials [7].

NOTE: The sample may require tilting to obtain adequate signal. Use same tilt angle for all spectra.

a. Prepare TEM grids of all asbestos varieties.
b. Use acquisition times (at least 100 sec) sufficient to show a silicon peak at least 75% of the monitor screen height at a vertical scale of ≥500 counts per channel.
c. Estimate the elemental peak heights visually as follows:
   (1) Normalize all peaks to silicon (assigned an arbitrary value of 10).
   (2) Visually interpret all other peaks present and assign values relative to the silicon peak.
   (3) Determine an elemental profile for the fiber using the elements Na, Mg, Si, Ca, and Fe. Example: 0-4-10-3-<1 [7].
      NOTE: In fibers other than asbestos, determination of Al, K, Ti, S, P, and F may also be required for fiber characterization.
   (4) Determine a typical range of profiles for each asbestos variety and record the profiles for comparison to unknowns.

MEASUREMENT:

18. Perform a diffraction pattern inspection on all sample fibers counted under the TEM, using the procedures given in step 17. Assign the diffraction pattern to one of the following structures:
   a. chrysotile;
   b. amphibole;
   c. ambiguous;
   d. none.

   NOTE: There are some crystalline substances which exhibit diffraction patterns similar to those of asbestos fibers. Many of these, (brucite, halloysite, etc.) can be eliminated from consideration by chemistry. There are, however, several minerals (e.g., pyroxenes, massive amphiboles, and talc fibers) which are chemically similar to asbestos and can be considered interferences. The presence of these substances may warrant the use of more powerful diffraction pattern analysis before positive identification can be made. If interferences are suspected, morphology can play an important role in making positive identification.

19. Obtain EDX spectra in either the TEM or STEM modes from fibers on field samples using the procedure of step 18. Using the diffraction pattern and EDX spectrum, classify the fiber:
   a. For a chrysotile structure, obtain EDX spectra on the first five fibers and one out of ten thereafter. Label the range profiles from 0-5-10-0-0 to 0-10-10-0-0 as "chrysotile."
   b. For an amphibole structure, obtain EDX spectra on the first 10 fibers and one out of ten thereafter. Label profiles ca. 0-2-10-0-7 as "possible amosite"; profiles ca. 1-1-10-0-6 as "possible crocidolite"; profiles ca. 0-4-10-3-<1 as "possible tremolite"; and profiles ca. 0-3-10-0-1 as "possible anthophyllite."
      NOTE: The range of profiles for the amphiboles will vary up to ± 1 unit for each of the elements present according to the relative detector efficiency of the spectrometer.
   c. For an ambiguous structure, obtain EDX spectra on all fibers. Label profiles similar to the chrysotile profile as "possible chrysotile." Label profiles similar to the various amphiboles as "possible amphiboles." Label all others as "unknown" or "non-asbestos."

20. Counting and Sizing:

a. Insert the sample grid into the specimen grid holder and scan the grid at zero tilt at low magnification (ca. 300 to 500X). Ensure that the carbon film is intact and unbroken over ca. 75% of the grid openings.

b. In order to determine how the grids should be sampled, estimate the number of fibers per grid opening during a low-magnification scan (500 to 1000X). This will allow the analyst to cover most of the area of the grids during the fiber count and analysis. Use the following rules when picking grid openings to count [7,8]:

(1) Light loading (<5 fibers per grid opening): count total of 40 grid openings.

(2) Moderate loading (5 to 25 fibers per grid opening): count minimum of 40 grid openings or 100 fibers.

(3) Heavy loading (>25 fibers per opening): count a minimum of 100 fibers and at least 6 grid openings.

Note that these grid openings should be selected approximately equally among the three grid preparations and as randomly as possible from each grid.

c. Count only grid openings that have the carbon film intact. At 500 to 1000X magnification, begin counting at one end of the grid and systematically traverse the grid by rows, reversing direction at row ends. Select the number of fields per traverse based on the loading indicated in the initial scan. Count at least 2 field blanks per sample set to document possible contamination of the samples. Count fibers using the following rules:

(1) Count all particles with diameter greater than 0.25 µm that meet the definition of a fiber (aspect ratio ≥3:1, longer than 5 µm). Use the guideline of counting all fibers that would have been counted under phase contrast light microscopy (Method 7400). Use higher magnification (10000X) to determine fiber dimensions and countability under the acceptance criteria. Analyze a minimum of 10% of the fibers, and at least 3 asbestos fibers, by EDX and SAED to confirm the presence of asbestos. Fibers of similar morphology under high magnification can be identified as asbestos without SAED. Particles which are of questionable morphology should be analyzed by SAED and EDX to aid in identification.

(2) Count fibers which are partially obscured by the grid as half fibers.
NOTE: If a fiber is partially obscured by the grid bar at the edge of the field of view, count it as a half fiber only if more than 2.5 µm of fiber is visible.

(3) Size each fiber as it is counted and record the diameter and length:

(a) Move the fiber to the center of the screen. Read the length of the fiber directly from the scale on the screen.
NOTE 1: Data can be recorded directly off the screen in µm and later converted to µm by computer.
NOTE 2: For fibers which extend beyond the field of view, the fiber must be moved and superimposed upon the scale until its entire length has been measured.

(b) When a fiber has been sized, return to the lower magnification and continue the traverse of the grid area to the next fiber.

d. Record the following fiber counts:

(1) f_s, f_b = number of asbestos fibers in the grid openings analyzed on the sample filter and corresponding field blank, respectively.

(2) F_s, F_b = number of fibers, regardless of identification, in the grid openings analyzed on the sample filter and corresponding field blank, respectively.

CALCULATIONS:

21. Calculate and report the fraction of optically visible asbestos fibers on the filter, $(f_s - f_b)/(F_s - F_b)$. Apply this fraction to fiber counts obtained by PCM on the same filter or on other filters for which the TEM sample is representative. The final result is an asbestos fiber count. The type of asbestos present should also be reported.
22. As an integral part of the report, give the model and manufacturer of the TEM as well as the model and manufacturer of the EDX system.

EVALUATION OF METHOD:

The TEM method, using the direct count of asbestos fibers, has been shown to have a precision of 0.275 (s_r) in an evaluation of mixed amosite and wollastonite fibers. The estimate of the asbestos fraction, however, had a precision of 0.11 (s_r). When this fraction was applied to the PCM count, the overall precision of the combined analysis was 0.20 [2].

REFERENCES:

[1] Walton, W. H. "The Nature, Hazards, and Assessment of Occupational Exposure to Airborne Asbestos Dust: A Review," Ann. Occup. Hyg., 25, 115-247 (1982).
[2] Taylor, D. G., P. A. Baron, S. A. Shulman and J. W. Carter. "Identification and Counting of Asbestos Fibers," Am. Ind. Hyg. Assoc. J. 45(2), 84-88 (1984).
[3] Johnston, A. M., A. D. Jones, and J. H. Vincent. "The Influence of External Aerodynamic Factors on the Measurement of the Airborne Concentration of Asbestos Fibers by the Membrane Filter Method," Ann. Occup. Hyg., 25, 309-316 (1982).
[4] Zumwalde, R. D. and J. M. Dement. Review and Evaluation of Analytical Methods for Environmental Studies of Fibrous Particulate Exposures, NIOSH Technical Information Bulletin #77-204 (1977).
[5] Baron, P. A. and G. C. Pickford. "An Asbestos Sample Filter Clearing Procedure," Appl. Ind. Hyg., 1:169-171,199 (1986).
[6] LeGuen, J. M. and S. Galvin "Clearing and Mounting Techniques for the Evaluation of Asbestos Fibers by the Membrane Filter Method" Ann. Occup. Hyg. 24, 273-280 (1981).
[7] Yamate, G., S. A. Agarwal, and R. D. Gibbons. "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy," EPA Contract No. 68-02-3266 (in press).
[8] Steel, E. B. and J. A. Small. "Accuracy of Transmission Electron Microcopy for the Analysis of Asbestos in Ambient Environments," Anal. Chem., 57, 209-213 (1985).

METHOD REVISED BY:

Paul A. Baron, Ph.D.; NIOSH/DPSE.

Attachment 4

Field Sampling Documents

Project Summary Sheets

COMPLIANCE PLUS SERVICES, INC.

Project Summary Sheet

Project Name: _____
Project Location: _____

CPS Project No.: _____
Site Contact: _____
Phone Number: _____

Date/Time: _____
Project Length Est.: _____
Vehicle #: _____
Vehicle Mileage: Start: _____
End: _____
Vehicle Mileage Total: _____

CPS Project Representatives:
Name(s): _____
_____
_____

Visit Preparation:

1) Reviewed PPE requirements for site and prepare all required PPE	Y/N
2) CPS Vehicle Required on site/CPS Magnetic Stickers	Y/N
3) Orientation Requirements	Y/N
4) Documents reviewed (Site Plans, HASP, Remedial Action Reports)?	Y/N
5) Required equipment/safety supplies available, charged and ready for use?	Y/N

Project Manager Review: _____ Date: _____

Special Instructions/Project Notes:

_____
_____
_____
_____
_____

Field Report/Notes: **Weather Conditions:** _____

_____
_____
_____
_____
_____
_____
_____
_____

Field Notes:

CPS Project No.: _____

Date/Time: _____

Field Representative: _____

Page _____ of _____

Field Drawing:

CPS Project No.: _____

Date/Time: _____

Field Representative: _____

Drawing No.: _____

Field Data Sheets

R. E. Pierson Asbtestos Sampling Log

Field Data Sheet and Sampling Log

Sample No.	Pump Number	Sample Area and Description	Time On	Time Off	Sampling Flow Rate[1]	Volume (l)	Analytical Result		
							PCM	TEM	Units
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc
									Fibers/cc

SAMPLED BY: _____ **DATE:** _____ **TIME:**

Field Notes: _____

_____

_____

_____

_____

Note 1 - see pump calibration log

Laboratory Chain of Custody

EMSL ANALYTICAL, INC.
LABORATORY • PRODUCTS • TRAINING

Asbestos Chain of Custody

EMSL Order Number *(Lab Use Only)*:

PHONE:
FAX:

Company Name :		**EMSL Customer ID:**	
Street:		**City:**	**State/Province:**
Zip/Postal Code:	**Country:**	**Telephone #:**	**Fax #:**
Report To (Name):		**Please Provide Results:** ☐ Fax ☐ Email	
Email Address:		**Purchase Order:**	
Project Name/Number:		**EMSL Project ID** *(Internal Use Only)*:	
U.S. State Samples Taken:		**CT Samples:** ☐ Commercial/Taxable ☐ Residential/Tax Exempt	

EMSL-Bill to: ☐ Same ☐ Different - If Bill to is Different note instructions in Comments**
Third Party Billing requires written authorization from third party

Turnaround Time (TAT) Options* – Please Check

☐ 3 Hour ☐ 6 Hour ☐ 24 Hour ☐ 48 Hour ☐ 72 Hour ☐ 96 Hour ☐ 1 Week ☐ 2 Week

**For TEM Air 3 hr through 6 hr, please call ahead to schedule.*There is a premium charge for 3 Hour TEM AHERA or EPA Level II TAT. You will be asked to sign an authorization form for this service. Analysis completed in accordance with EMSL's Terms and Conditions located in the Analytical Price Guide.*

PCM - Air ☐ Check if samples are from NY
- ☐ NIOSH 7400
- ☐ w/ OSHA 8hr. TWA

PLM - Bulk (reporting limit)
- ☐ PLM EPA 600/R-93/116 (<1%)
- ☐ PLM EPA NOB (<1%)

Point Count
- ☐ 400 (<0.25%) ☐ 1000 (<0.1%)

Point Count w/Gravimetric
- ☐ 400 (<0.25%) ☐ 1000 (<0.1%)
- ☐ NYS 198.1 (friable in NY)
- ☐ NYS 198.6 NOB (non-friable-NY)
- ☐ NYS 198.8 SOF-V
- ☐ NIOSH 9002 (<1%)

TEM – Air ☐ 4-4.5hr TAT (AHERA only)
- ☐ AHERA 40 CFR, Part 763
- ☐ NIOSH 7402
- ☐ EPA Level II
- ☐ ISO 10312

TEM - Bulk
- ☐ TEM EPA NOB
- ☐ NYS NOB 198.4 (non-friable-NY)
- ☐ Chatfield SOP
- ☐ TEM Mass Analysis-EPA 600 sec. 2.5

TEM – Water: EPA 100.2
- Fibers >10µm ☐ Waste ☐ Drinking
- All Fiber Sizes ☐ Waste ☐ Drinking

TEM- Dust
- ☐ Microvac - ASTM D 5755
- ☐ Wipe - ASTM D6480
- ☐ Carpet Sonication (EPA 600/J-93/167)

Soil/Rock/Vermiculite
- ☐ PLM EPA 600/R-93/116 with milling prep (<1%)
- ☐ PLM EPA 600/R-93/116 with milling prep (<0.25%)
- ☐ TEM EPA 600/R-93/116 with milling prep (<0.1%)
- ☐ TEM Qualitative via Filtration Prep
- ☐ TEM Qualitative via Drop Mount Prep
- ☐ Cincinnati Method EPA 600/R-04/004 – PLM/TEM (BC only)

Other:
- ☐

☐ **Check For Positive Stop – Clearly Identify Homogenous Group**

Filter Pore Size (Air Samples): ☐ 0.8µm ☐ 0.45µm

Samplers Name:

Samplers Signature:

Sample #	Sample Description	Volume/Area (Air) HA # (Bulk)	Date/Time Sampled

Client Sample # (s): - **Total # of Samples:**

Relinquished (Client): **Date:** **Time:**

Received (Lab): **Date:** **Time:**

Comments/Special Instructions:

EMSL ANALYTICAL, INC.
LABORATORY • PRODUCTS • TRAINING

Asbestos Chain of Custody

EMSL Order Number (*Lab Use Only*):

PHONE:
FAX:

Additional Pages of the Chain of Custody are only necessary if needed for additional sample information

Sample #	Sample Description	Volume/Area (Air) HA # (Bulk)	Date/Time Sampled

***Comments/Special Instructions:**

Exhibits

Exhibit 1

Fugitive and Asbestos Dust Mitigation Plan

FUGITIVE AND ASBESTOS DUST MITIGATION PLAN

Richard E. Pierson Materials Corporation
Hanson Quarry
2055 North Rockhill Road
Sellersville, PA 18960

December 2018

Prepared by:

Compliance Plus Services, Inc.
455 Business Center Drive, Suite 250
Horsham, PA 19044
(215) 734-1414

TABLE OF CONTENTS

ATTACHMENTS

1.0 INTRODUCTION

This Fugitive and Asbestos Dust Mitigation Plan (the "Plan") has been prepared, as required under Section C, Condition #33 and of Richard E. Pierson Materials Corporation's ("R.E. Pierson") Plan Approval (No. 09-0241) for use at R.E. Pierson's stone crushing and screening operation located at the Hanson Quarry, 2055 North Rockhill Road, Sellersville, PA 18960, East Rockhill Township, Bucks County, PA when naturally-occurring asbestos has been discovered in the stone to be mined and processed. The Plan describes the dust management practices that will be implemented to control potential fugitive particulate emissions, as well as any potential asbestos, that may be generated as a result of the facility's operations involving the crushing and screening of stone, as well as, potential fugitive dust emissions from unpaved and paved roads on the plant property.

The R.E. Pierson facility currently has air quality General Permits (Permit Nos. GP3-09-0157 and GP9-09-0083) which allows the operation of portable crushing and screening equipment. The General Permits expire on March 14, 2023. Copies of the permits are in **Attachment 1**.

R.E. Pierson has also obtained a Plan Approval (No. 09-0241) for the installation and temporary operation of a 1,000 ton/hour permanent stone crushing and screening plant. The Plan Approval (see **Attachment 2**) was issued on December 5, 2018. This is a temporary site permit to construct which allows for the crushing and screening of stone obtained from the quarry. Once the permanent plant has been constructed and is able to produce the required amounts and types of stone, the portable crushing and screening equipment will be removed from the site.

The Plan includes the following:

- Dust management procedures that are used to minimize fugitive dust and asbestos emissions;

- Use of a visual inspection program to monitor stone handling areas and process equipment;

- Procedures for the implementation of corrective action measures to be taken in the event of excessive fugitive dust emissions; and

- A list of sources and areas to be monitored for visible emissions and accumulation of stone in open areas

2.0 GENERAL OVERVIEW OF OPERATIONS

A general overview of the R.E. Pierson facility operations and facility features and equipment that are relevant to this plan is provided below.

2.1 Facility Description

R.E. Pierson's stone crushing and screening facility is located at the Hanson Quarry, 2055 North Rockhill Road, Sellersville, PA 18960. A map showing the location of the site and an aerial photo showing the site are included in **Attachment 3**.

The facility is located in a rural area of Bucks County. The portable crushing and screening equipment is located approximately 1,200 feet from North Rockhill Road on the northwest part of the property. The equipment is surrounded by trees to the west and north with the quarry lake to the east. Once constructed, the permanent crushing and screening plant will be located on the south/southwest portion of the property. The nearest crusher associated with the plant will be approximately 1,000 feet from North Rockhill Road. A site plan showing the location of portable equipment and the 1,000 ton/hour plant is included in **Attachment 4**. Areas where the land has been disturbed and that are not used for the crushing and screening equipment are used for internal roadways for truck and equipment movements and for the stockpiling of unprocessed and processed stone.

2.2 Description of Operations

For both the portable and permanent crushing and screening plants, unprocessed stone from the quarry is placed into the hoppers which feed the primary crushers. Other crushers and screens downstream of the primary crushers reduce the size of the aggregates further and produce various sized aggregates which are then stockpiled. The stockpiles aggregate products are then sold for construction jobs throughout the region.

The portable crushing and screening equipment operates 1,850 hours/year while the proposed permanent crushing and screening plant, once operational, will operate up to 2,800 hours/year.

3.0 FUGITIVE DUST EMISSIONS SOURCES/FACTORS

Potential dust emission sources and the factors that can influence dust emissions at the facility are presented in this section. Sources of dust are outdoor emissions only. Outdoor fugitive dust emissions are defined as those emissions occurring outside the buildings and not associated with a stack (point) discharge. The potential dust emission sources/factors that are addressed for this facility include:

1. Paved and Unpaved Roadways
2. Crushing and Screening Operation
3. Stones Handling and Stone Storage Areas
4. Weather Conditions

3.1 Paved and Unpaved Roadways

Paved roadways can generate fugitive dust from vehicle traffic that disturbs fine particulate matter deposited on the paved surface, causing the particles to become airborne. Sources of dust from paved and unpaved surfaces at the facility include:

(1) tracking of mud, dirt, and aggregates from unpaved surfaces; (2) spillage of stone and aggregates on road surfaces; and (3) deposition of dust from other sources, on- and off-site. Sources of dust from paved and unpaved surfaces are mainly due to truck traffic and equipment movements on internal roadways and shared roadway/vehicle routes. Dust can be generated by aggregates that fall off the trucks entering and exiting the facility as well as dirt entrained on tires of equipment used to load trucks or move stones around the facility.

Due to the location of the facility, it is anticipated that the trucks entering the facility will not be tracking mud or dirt onto the site. Additionally, R.E. Pierson's interior traffic management controls are intended to minimize the truck and equipment cross traffic and avoid drag-out from areas where aggregates and stones are stored.

Variables that influence dust emissions from the roads and trucks are weather conditions and vehicular traffic, including the volume of traffic and speed of truck traffic while on-site. Dry, windy conditions will intensify the amount of potential dust emissions from the unpaved roads. The number of trucks entering the facility and the truck travel speed while on-site will influence the amount of dust generated at the site.

3.2 Crushing and Screening Operation

Dust emissions may be generated from the operation of the crushers, screens and associated conveyors which all operate or will operate at least 1,000 feet from North Rockhill Road. As described above, unprocessed stone is transferred from the storage locations into the feed hoppers servicing the primary crushers where they are crushed, screened and conveyed to storage piles. This process has the potential to create fugitive dust emissions.

3.3 Stones Handling and Stone Storage Areas

R.E. Pierson handles and stores unprocessed and processed stone on the property. Stone handling and mobile stone handling equipment employed at the site (e.g., front-end

loaders, etc.) can potentially be sources of fugitive dusts as stones are unloaded from trucks, loaded into trucks, and the transfer of stones are potential sources of fugitive dusts at the facility.

As stones are stored on site in stockpiles, there is a potential for fugitive dusts to be generated as wind blows across the piles especially if there are fines in the stockpiles.

3.4 Blasting of Stone

Prior to processing in the crushing and screening equipment, stone must be obtained from the quarry. The in-situ stone in the quarry wall being worked is obtained by explosive blasts which loosen the stone and fracture it into manageable pieces. The fractured stone pieces can then be either sent directly to stockpiles near the crushing and screening equipment for processing or, for larger sized pieces of stone, can be further broken by physical means.

3.5 Weather Conditions

R.E. Pierson monitors weather conditions and pays particular attention to those conditions which may increase the potential for fugitive dust emissions. The potential for fugitive dust emissions can vary based on humidity, air and ground temperatures and wind direction and speed.

R.E. Pierson will implement the dust control measures, based on weather conditions, as discussed in Section 4.0 below to reduce the potential for fugitive dust emissions exiting the property.

4.0 FUGITIVE DUST AND ASBESTOS MITIGATION MEASURES

R.E. Pierson employs several fugitive dust and asbestos mitigation measures to control the generation and dispersion of fugitive dust, and potentially, asbestos from the facility. On days

when higher speed winds and/or dry condition occur, extra efforts will be made to ensure that all the control measures are implemented and strictly enforced by facility management. The following practices are employed by R.E. Pierson to minimize dust emissions:

4.1 Roadway Emissions

The following measures are employed by R.E. Pierson at the facility to control the fugitive dust from facility roadways:

- The beds of all trucks exiting the facility are tarped to reduce the dispersion of fugitive dust from the loaded trucks and to limit the potential for unintended spillage of stone on facility roads. A sign will be posted at the entrance/exit gate to the facility to remind drivers of RE Pierson's truck tarping requirements.

- Any internal paved roadways are cleaned (as needed), using a water truck and/or street sweeper to control the generation of fugitive dust or to collect accumulated dust and mud, unless weather conditions (e.g., rain/snow) prohibit the use of these control measures.

- As needed, water is applied to unpaved roads at the facility each operating day through the use of a water truck assigned to the facility unless weather conditions (e.g., rain/snow) prohibit the use of this control measure.

- A facility-wide vehicle speed limit of 15 miles/hour is posted and enforced to reduce associated dust emissions. Stone or asphalt paving will be applied to the roadway near the entrance/exit to the facility to help reduce PM emissions.

- Trucks leaving the facility use North Rockhill Road. Any spillage of stone onto the road will be removed and the roadway is cleaned as soon as practical. All materials will be wetted prior to removal.

4.2 Crushing and Screening Operation

Whenever the crushing and screening plants are or will be operating, R.E. Pierson uses or will use a wet suppression system to minimize fugitive dust emissions and to maintain compliance with visible emissions limits specified in the permit. Water for the systems is drawn from the large quarry pond near the middle of the property. The systems will be inspected each operating day to ensure that they are operating properly and that enough water is being applied to the stone to reduce the potential for the generation of fugitive dust. Repairs on the wet suppression systems will be made as needed. Records of the daily inspections and all repairs and maintenance performed on the wet suppression systems will be kept at the facility.

The new permanent crushing and screening plant will employ a sophisticated water spray system to control the emissions of fugitive dust and the potential emissions of asbestos. A water spray system has been shown to be the best available technology to control emissions from crushing and screening plants. For this plant, over 150 gallons of water per minute will be applied to the stone as it is processed in the plant. At 150 gallons per minute, approximately 90,000 gallons per 10-hour operating day will be used to control emissions of particulate matter. No runoff is expected from the application of water to the stone as it is being processed as most of the water will either adhere to the stone or evaporate. Tables and drawings showing the details of the water sprays on the plant and the amount of water applied at each of the 51 separate sprays are shown in **Attachment 5**. If there are any excess emissions after the plant is operational, additional water sprays will be added where needed.

4.3 Stone Handling and Stone Storage Areas

In order to control emissions of particulate matter from stone that has been processed and from stone handling operations, the following methods are used.

- Stone that has accumulated near or under process equipment is cleaned up and removed on a regular basis.

- As needed, hoses on the water truck operating at the facility are used to spray water onto stockpiles and any other area where stone is being handled to wet the stone and, thereby, limiting the potential for fugitive dust. If needed, portable water misters, similar to that pictured in **Attachment 6**, will be used to control emissions from specific areas where excess emissions have been observed.

- The height of each stockpile will be maintained so that the top of each pile is accessible to the water sprays from the water truck.

- The drop heights of stone onto stockpiles or during stones handling operations are kept to a minimum.

- Loaders and hoppers are not overfilled to prevent spillage of stone.

- If any excess PM emissions are coming from unused area(s) on the property, dust suppressant additives (crusting agents) will be applied to the area(s) to reduce the potential for PM emissions.

4.4 Blasting of Stone

Prior to blasting of stone at the quarry, the area is subject to the pre-inspection and sampling procedures specified by the site's Surface Mining Permit and authorization to minimize the potential that any portion of the blast area has naturally occurring asbestos serpentine and/or ultramafic rock. During the actual blasting of stone at the quarry, a plume of dust is expected to be generated.

To minimize the dust and its possible offsite migration, the blast area will be pre-wetted to minimize the release of surface dust and fines. Additionally, following blasting the fugitive dust spray mister may be set up downwind of the blast area to mitigate/reduce dust cloud and minimize the potential offsite impacts.

4.5 Preventative Maintenance Program

All equipment is regularly inspected and maintained in accordance with manufacturer recommended guidelines or specifications.

4.6 Good Housekeeping Practices

Good housekeeping practices are followed as a preventive measure to minimize the potential for the creation of fugitive dust. Good housekeeping is essentially the maintenance of a clean, orderly work environment in order to reduce the possibility of accidents and dust emissions.

Elements of good housekeeping practices include:

- Maintaining neat and orderly work areas both indoors and outdoors;
- Maintaining neat and orderly storage of stones, chemicals, containers and drums;
- Routine and regular cleanup of any spilled unprocessed and processed stone;
- Use of the street sweeper and/or water spray truck, daily or more frequently as necessary to collect dust that accumulates on paved roads; and
- Providing training to employees about good housekeeping practices.

4.7 Employee Training

Employee training is provided to all RE Pierson operations personnel. Training consists of a review of facility procedures and operations, including review of this Plan, evaluation of control measures, and adoption of new control measures as needed. Training is conducted on an annual basis and as needed when facility procedures and

operations are changed. New employees are made aware of the details of the Plan as part of their initial orientation.

The objective of the training is to ensure that the facility is under constant observation by knowledgeable personnel. Employees are trained to inspect and identify fugitive dust emissions from potential sources and to be able to implement corrective procedures as quickly as practical to mitigate fugitive dust emissions.

4.8 Routine Inspection Programs

Daily inspections will be conducted throughout the facility to identify fugitive PM emissions and potential dust generating situations as part of the facility's regular daily inspection program (see **Attachment 7**).

5.0 RECORDKEEPING

A copy of this Plan will be maintained at the facility at all times. Completed copies of the Daily Operations Log (See **Attachment 7**) will be maintained at the facility for a minimum of five years and will be made immediately available to the Department personnel upon request.

6.0 FACILITY CONTACT INFORMATION

The following individual can be contacted in the event that fugitive dust control issues are identified at the R.E. Pierson facility.

Contact Information
Jim Allen **R.E. Pierson Materials, Corp.** **2055 North Rockhill Road** **Sellersville, PA 18960**

Phone: (609) 743-0350

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