October 13, 2019

The Honorable Patrick McDonnell
Department of Environmental Protection
Rachel Carson State Office Building
400 Market Street
Harrisburg, PA 17101

Mr. Michael Kutney, P.G. Chief, Permits and Technical Section
Department of Environmental Protection
Pottsville District Mining Office
5 West Laurel Boulevard
Pottsville, PA 17901

Mr. John Stefanko, Deputy Secretary
Active and Abandoned Mine Operations
Department of Environmental Protection
Rachel Carson State Office Building
400 Market Street
Harrisburg, PA 17101

Mr. Gary Latsha, Inspector Supervisor
Department of Environmental Protection
Pottsville District Mining Office
5 West Laurel Boulevard
Pottsville, PA 17901

Re: Response to PADEP September 20, 2019 Letter, Rock Hill Quarry, Hanson Aggregates Pennsylvania LLC, SMP # 7974SM1 East Rockhill Twp., Bucks Co., PA, prepared by the RJ Lee Group

On behalf of Rockhill Environmental Preservation Alliance, Inc. (REPA), enclosed please find an October 13, 2019 report prepared by Erskine Environmental Consulting. The report presents many areas which are of extreme concern to us, especially since it is evident that NONE OF our reports thus far have been taken into consideration based upon the testing and reports we have seen.

The RJ Lee Group letter cites regulatory thresholds and implies that, because the under reported asbestos concentrations are below these thresholds, the presence of asbestos and its associated potential health impacts may be dismissed. **A fact remains: no regulatory or scientific agency has established, nor**

advocates, a safe level of asbestos exposure. It is rather concerning to REPA that the RJ Lee Group appears to be using an internal protocol for both PLM and TEM that **under reports the concentration of asbestos**. **Repeated deviations from test methods, misinterpretation of data, under reporting of asbestos levels and resulting non-compliance with NOA regulations in general, significantly increases the risk of exposure for workers, residents and school children to a known and dangerous carcinogen.**

Among other concerns in our three previous reports, we ask that you consider the following concerns outlined in our report attached:

1. The sampling methodology used by the RJ Lee Group letter is not consistent with standard of care for geologists, and appears to selectively remove most rocks from analysis.

2. The RJ Lee Group letter provides no indication that pre-project air sampling or project perimeter monitoring has been conducted or implemented.

3. The RJ Lee Group used inappropriate methodology to report the asbestos content as required by the acceptable EPA 600/R-93/116 test method for PLM and TEM.

4. The RJ Lee letter argues the appropriateness of using Polarizing Light Microscopy (PLM) for analysis by citing California and Nevada guidance documents. However, it neglected to point out the both California and Nevada utilize TEM, report "non-regulated" amphiboles, and non-amphibole asbestos minerals.

5. RJ Lee Group letter incorrectly argues that crystallization habit is the primary differentiator between asbestos vs. non-asbestos, and by inference, hazardous vs. non-hazardous.

6. The RJ Lee Group letter misrepresented the definitions and use of regulatory thresholds, incorrectly implying that levels below these thresholds are not regulated and considered safe by EPA and OSHA.

We are pleading with the DEP to take our expert's reports into consideration. We understand the Rockhill Quarry is the ONLY quarry that resides in a RESIDENTIAL area (with hundreds of homes/THOUSANDS of students) where there is known asbestos.

Respectfully yours,

Rockhill Environmental Preservation Alliance, Inc.

cc: The Honorable Brian Fitzpatrick, U.S. Representative PA-01
The Honorable Steven Santarsiero, 10th Senatorial District
The Honorable Robert Mensch, 24th Senatorial District
The Honorable Craig Staats, PA's 145th Legislative District
Steven Baluh, P.E
Marianne Morano, East Rockhill Township Manager
Amiee Bollinger PADEP

Virginia Cain, PADEP
Robert Fogel, PADEP
Erika Furlong, PADEP
Craig Lambeth, PADEP
Gary Latsha, PADEP
Shawn Mountain, PADEP
Patrick Patterson, PADEP
James Rebarchak, PADEP
Daniel Sammarco, PADEP
Sachin Shankar, PADEP
Richard Tallman PADEP
Doug White, PADEP

Erskine Environmental Consulting

Geologic Investigations   Hazardous Materials   Naturally Occurring Asbestos

TECHNICAL MEMORANDUM

October 13, 2019 (Revised)

Subject: Comments: Hanson / RJ Lee Letter Dated October 4, 2019
Rockhill Quarry
East Rockhill Township
Bucks County, PA

This memorandum provides comments and recommendations regarding the following document with supporting asbestos analyses:

Response to PADEP September 20, 2019 Letter, Rock Hill Quarry, Hanson Aggregates Pennsylvania LLC, SMP # 7974SM1 East Rockhill Twp., Bucks Co., PA, prepared by the RJ Lee Group.

These comments are supplementary to and augment comments provided in three previous memoranda (attached):

1. Review of Qualitative Geologic Survey Sampling Plan, Rockhill Quarry, East Rockhill Township, Bucks County, PA: Erskine Environmental Consulting (EEC) dated June 6, 2019.

2. Review of Asbestos Test Results, Rockhill Quarry, East Rockhill Township, Bucks County, PA: Erskine Environmental Consulting (EEC) dated September 1, 2019.

3. DEP Comment Regarding Heavy Equipment Loadout and Review of DEP Reanalysis of Asbestos Test Results by TEM Methodology, Rockhill Quarry, East Rockhill Township, Bucks County, PA: Erskine Environmental Consulting (EEC) dated September 23, 2019.

These comments are intended to be a brief summary of findings. The basis for many of the findings and opinions have been discussed in detail within the three previous memoranda submitted by EEC, and the recipients of this memo are referred to those documents where additional explanation is needed.

This memorandum is divided into three components. The first is a summary of the findings. The second is a general comment that provides an opinion of the letter overall.

The third outlines, specific comments regarding key subjects within the letter that support the findings.

All comments and conclusions are the opinion of the author of this memorandum. In most cases, they are based on direct language within the letter under review and reference to applicable test methods and standard of practice. In some cases, certain inferences needed to be made because of vague or imprecise language within the letter, and the absence of EDS spectra and SAD diffraction pattern data.

Summary of Findings

The following is a summary of findings from the review of the RJ Lee Group letter. Detailed support of these findings are provided in the comments that follow.

Sampling

The sampling protocol appears to follow the procedures within the Qualitative Geologic Survey Sampling Plan, whose deficiencies were reviewed in EEC document no. 1, referenced above. None of the site characterization recommendations in the previously reviewed documents appear to have been incorporated, and the sampling relied on the “Qualitative” work plan that was submitted to DEP previously, rather than a quantitative, sampling and analysis plan. In essence, the sampling protocol did not follow standard of practice for a Professional Geologist’s evaluation of an NOA site, utilized subjective inferences, and did not adequately sample or characterize the site for asbestos. In particular, the plan relied on an assumption, rather than proper testing, that asbestos is restricted to the veining. Note that the work plan is a Qualitative, and not a Quantitative, sampling and analysis plan. The result is a severe under characterization of the asbestos content. In addition, because a proper characterization of the site has not been conducted, the test results derived from improper sampling cannot be validated.

Testing

The letter claims to follow the protocol established in EPA Method 600/R-93/116 for Transmission Electron Microscopy (TEM). However, the testing protocol deviates significantly from the test method by relying on descriptive criteria for commercial asbestos and modifications that are contrary to the method’s protocol and EPA’s stated position. These modifications have not been publicly distributed for review or comment, and remain in-house proprietary procedures that are neither employed nor accepted by the overwhelming majority of experienced NOA testing laboratories. Note that the RJ Lee Group letter criticized EMSL Laboratories for not producing their own proprietary supplementary procedures, and dismissed its results accordingly. A fact remains: there is no standard or publicly distributed method that allows differentiation between fibers that were derived from minerals that originally crystallized in the asbestiform vs. the non-asbestiform habit, and the human lung cannot differentiate between the two. An actinolite fiber of equal dimensions should carry the same toxicity regardless of how the fibers were produced. The results, therefore, provide a severe under reporting of asbestos at the site. These repeated deviations from test methods, misinterpretation of data, under reporting of asbestos levels, and resulting non-compliance with requirements for NOA regulations in general, significantly increases the risk of exposure for workers, residents and school children to a known and dangerous carcinogen.

Regulatory Asbestos Thresholds

The RJ Lee Group letter cites regulatory thresholds and implies that, because the under reported asbestos concentrations are below these thresholds, the presence of asbestos and its associated potential health impacts may be dismissed. The thresholds that are cited have no relationship to potential exposure, and are applied for very specific purposes. The citation of these thresholds to support the arguments in the letter belie their intent. A fact remains: no regulatory or scientific agency has established, nor advocates, a safe level of asbestos exposure.

Bias and the Purpose of an NOA Investigation

An NOA investigation needs to be unbiased and unencumbered. It needs to be conducted by those who have no conflicts of interest and designed to produce data that is revealing so that informed decisions by those who are charged with public protection may be made. An unbiased analytical consulting laboratory with extensive experience on EPA research and construction projects can be forwarded to DEP, upon request.

It is not clear that this goal was the impetus of the sampling and analysis protocol. The final sentence of the RJ Lee Group letter states:

> "*Certainly, restricting the use of aggregate at such low levels of asbestos may have major impacts on any activity in Pennsylvania that involves the movement/disturbance of rock or soil*".

This concern is grossly over stated. California has the most developed NOA regulations in the nation, and there is, outside of a construction cost associated with hazard mitigation, no evidence of substantial significant impacts due to asbestos in aggregate material. The decision to use the Rockhill quarry material for the Turnpike project should be based on local potential health risk, and not unsubstantiated perceived future financial impacts to an industry.

For example, the City and County of San Francisco is underlain by two large asbestos belts, and construction projects, including residential developments, schools, and routine utility repairs within the urban environment, are conducted every day. Asbestos is considered a geologic hazard that requires mitigation alongside of other geologic hazards such as chemical releases, rock stability, seismic shaking and liquefaction, and subsurface landslides. Precautions for asbestos are expanded when human receptors are located in close proximity to the site. They are further expanded when projects pose an extraordinary potential health risk, such as the hard rock mining of hydrophobic amphibole-bearing rock. Perimeter air monitoring is commonly conducted even when not required by regulatory agencies.

Environmental protection agencies do not dismiss geologic hazards simply because appropriate investigation and mitigation would increase the cost of a construction project.

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Health impacts are often mitigated in the planning phase by identifying alternatives that would reduce or eliminate the potential risk. A preferred alternative for asbestos, whether it be in buildings or soils, is avoidance of the hazard. For the Turnpike project, avoidance can be achieved by selecting one of several quarries located near the project site. Not only will this remove the potential exposure to the residents and children of the Rockhill Township, it is likely that existing test data shows that these quarries are asbestos free, and likely do not have human receptors adjacent to the sites. The Pennsylvania DEP should consider these quarries, listed in Table 1 of EEC document no 2 cited above, as an alternative to the Rockhill quarry.

General Comment

Overall, the RJ Lee Group appears to be using an internal protocol for both PLM and TEM that under reports the concentration of asbestos. As discussed below, the protocol involves applying subjective criteria that is not directly specified in the EPA 600/ R-93/116 method. The arguments set forth in the letter is a re-litigation of a debate that has been resolved years ago. In a response to a letter by RJ Lee Group, the EPA firmly established that the procedures were incorrect and not appropriate. Please refer to memorandum no. 1, referenced above, and the attached response by EPA, attached to this memorandum.

Subject-Specific Comments

1. **The sampling methodology used by the RJ Lee Group letter is not consistent with standard of care for geologists, and appears to selectively remove most rocks from analysis.**

The RJ Lee Group letter states that the samples were collected in accordance with the "approved work plan". If the "approved work plan" is the Qualitative Geologic Survey Sampling Plan, then the sampling was not conducted in accordance with any acceptable standard of practice for Professional Geologists. Please refer to the previous review of the plan for details (document no. 1, referenced above).

The letter states that the sampling selectively focused on the veins because "*These samples were chosen to purposefully isolate potential veins of minerals that could contain asbestos*". The letter also states: "*The data developed to date indicates that the amphibole mineral actinolite can be found in distinct veins occurring infrequently throughout the rock to be quarried, and that actinolite asbestos is present at low concentrations (below 0.25 % by weight)".* Note that the "Qualitative" sampling plan eliminates from sampling rocks where asbestos is not visually present or does not appear to be fibrous through the use of a fine steel pick. Because a comprehensive investigation following standard of practice for a Professional Geologist has not been conducted, as previously recommended, the sampling of the site is, at best, incomplete.

The limitations of the sampling plan may be inferred simply through its title: Qualitative Geologic Survey Sampling Plan. The use of the term "qualitative", "limited", and "preliminary" usually are used to denote incompleteness, and companies require their use when an investigation is not comprehensive and therefore not conducted in accordance with the standard of care of a Professional Geologist. It is a loss-prevention tool to reduce

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liability, typically when budgetary constraints do not allow a thorough and quantitative survey.

2. **The RJ Lee Group letter provides no indication that pre-project air sampling or project perimeter monitoring has been conducted or implemented.**

The letter dismisses the potential health risk to nearby residents and school children through references that asbestos is present in “low amounts”. Studies have shown, and both EPA and OSHA concur, that adverse asbestos exposures can occur from materials with trace amounts of asbestos, as low as 0.01% or less. Potential risk is never associated with asbestos percentage; rather, it is mostly associated with disturbance activity. Because mining and processing hard rock is a high and energetic disturbance activity, and hard rock cannot be wetted, the potential for exposure is much greater than routine grading of soil that accepts water readily. The only way to assess whether disturbance may cause unacceptable exposures is through activity-based sampling before a project commences, and the only way to assure that offsite residents and children are not adversely exposed is through the implementation of a perimeter and targeted off site air monitoring program. Recommendations for these types of sampling have been provided in the previous memoranda.

3. **The RJ Lee Group used inappropriate methodology to report the asbestos content as required by the acceptable EPA 600/R-93/116 test method for PLM and TEM.**

The RJ Lee letter describes several properties of asbestos that was mined commercially, and applies them as a definition to amphiboles that are present in the natural state. It selectively uses these properties to eliminate fibers that apparently do not meet these criteria. The result is a subjective and severe under reporting of asbestos as required by strict conformance with the test method.

One method referenced in the letter that was used to remove fibers from the asbestos count is the application of subjective criteria, which eliminates fibers that crystallized originally in the non-asbestiform habit. The letter states that the method requires the separation of asbestos fibers from non-asbestos fibers, but misconstrues this requirement to mean separation of asbestiform from non-asbestiform as originally crystallized. The reference actually means that the analyst must record, but separate out, non-asbestos fibers that are common to building materials such as fibrous gypsum (from sheet rock), fibrous glass (from insulation) and fibrous cellulose. There is no directive to eliminate fibers that originated in the non-asbestiform habit but were created by cleaving. There is no protocol that provides direction to make this distinction. There is no EPA, NIOSH or OSHA test method that provides a protocol for this distinction.

Another technique reported in the letter used in the analysis is to use the optical extinction angle (inclined extinction) to report a fiber as non-asbestos. The letter criticizes EMSL for using this criterion, and states that it’s application over estimates the concentration of asbestos. On the contrary, the EPA method requires to use this criterion. Table 2.2 of EPA Method 600/R-93/116 indicates that the optical characteristic of actinolite-tremolite is possessing an extinction angle of “*parallel and oblique (up to 21 degrees); Composite* *fibers show parallel extinction*." The elimination of fibers without parallel extinction under reports the concentration of asbestos. This procedure was likely used for the RJ Lee Group PLM testing that was previously submitted, and as a result, under reported the asbestos percentages in the rocks (please refer to document no. 2, referenced above). It should be noted that the bench sheets provided by EMSL (document no. 3, referenced above) indicates that it also used a criterion similar to the RJ Lee Group (parallel vs. inclined extinction), and severely under reported asbestos as a result.

A third method to selectively remove fibers from reporting appears to be the elimination of fibers with compositional aluminum (this possibility is inferred by reviewing the TEM count sheets). Note that within the TEM count sheets at the end of the RJ Lee Group letter, fibers that contain aluminum are reported as non-asbestos, and there is no indication that these fibers are not amphiboles. Without seeing the EDXA spectrographic analysis, which the RJ Lee Group criticized EMSL for not providing, it may be interpreted that actinolite that does not conform to the ideal solid solution actinolite-tremolite end members is reported automatically as non-asbestos. This application, if used, is clearly incorrect. Actinolite and tremolite commonly contain aluminum. Thus, using this criterion, actinolite, as defined by the International Mineralogical Association (IMA), may have been reported as non-actinolite for the purposes of the NOA investigation.

A fourth method that the RJ Lee Group letter reports as utilizing is the elimination of an entire population of fibers based on average aspect ratio (the length divided by width). It seems to argue that if the average aspect ratio of a population is less than the general aspect ratio of commercial asbestos (described in the method as "generally 20:1"), the population may be reported as non-asbestos. This application is not valid for NOA because most fibrous amphiboles do not conform to the properties of commercial asbestos, and often do not have average populations with a 20:1 aspect ratio. The use of this criterion is not allowed by the EPA method, and there is no indication outside of a description of the general properties of commercial asbestos that supports it.

4. **The RJ Lee letter argues the appropriateness of using Polarizing Light Microscopy (PLM) for analysis by citing California and Nevada guidance documents. However, it neglected to point out the both California and Nevada utilize TEM, report "non-regulated" amphiboles, and non-amphibole asbestos minerals.**

Nevada Department of Transportation (NDOT)

The NDOT guidance document cited by RJ Lee specifies PLM for the testing of <u>import aggregate</u> for determination of an asbestos content at the 0.25% threshold. This is consistent with California criteria for surfacing applications. The NDOT protocol for import is logical: if imported material is <0.25% asbestos, then the resulting embankment will automatically meet the 0.25% surfacing standard at the end of the project. However, the requirements for excavation and grading are different. NDOT is currently requiring on a road construction project (undisclosed pending completion) a separate analytical protocol[1]. The protocol requires analysis by both PLM and TEM. It also requires reporting of non-regulated amphiboles. It also requires the reporting of erionite, a non-amphibole fibrous mineral belonging to the zeolite group of minerals. In this particular case, NDOT waived the use of PLM, and is relying solely on TEM. NDOT required the preparation and implementation of an Asbestos and Erionite Dust Mitigation Plan (AEDMP) during construction.

California

The document cited in the RJ Lee Group letter requires the use of PLM for surfacing applications. The RJ Lee Group letter did not disclose that the same document discusses the use of TEM as a supplementary method, discusses the advantage of TEM for detecting fine particles, and cites other California regulatory agencies that require both methods, in this case, the Department of Toxic Substances Control (DTSC). On school sites, DTSC has the same requirements that NDOT has for construction: PLM and TEM, non-regulated amphiboles, and erionite. DTSC's threshold for response actions are lower, being 0.01% asbestos by weight on average or where 25% of the samples are above 0.01%. In effect, the threshold for an entire site is on the order of 0.001%.

5. **RJ Lee Group letter incorrectly argues that crystallization habit is the primary differentiator between asbestos vs. non-asbestos, and by inference, hazardous vs. non-hazardous.**

The photographs within the RJ Lee Group letter show hand samples and PLM photomicrographs of actinolite that initially crystallized in the massive, acicular and asbestiform habit, and attempts to make a case that the non-asbestiform habit can be differentiated and eliminated from reporting. An erroneous argument would follow that fibers produced from the crushing of these materials are not harmful, even when the fibers have identical lengths and widths. This is not true: the human lung responds to fibers of certain lengths and widths, and does not differentiate based on the mechanism by which a particle became a fiber.

To illustrate that there should be no distinction, please refer to Figure 5 of the RJ Lee Group letter that shows a PLM micrograph of a crushed non-asbestiform habit actinolite. The photograph is biased toward showing large and wide cleavage fragments that are generally considered to be of low risk. However, if one takes a careful look, particularly in the lower right corner, numerous thin fibers are present that the human lung would respond to. One can clearly see the striations, parallel to the length on the large fragments, that represent the planes of weakness (cleavages) that fracture preferentially and create thin fibers. High energy disturbance activity such as drilling, blasting, and crushing would create numerous fibers from each large fragment that is represented. Note also that numerous fine fibers that cannot be detected using PLM are invisible on the photomicrograph, numbering perhaps in many million fibers per gram of material. TEM would detect these important fine fibers, and air monitoring would document their

[1] Alternative Laboratory Methods, Solid State Sample Preparation and Analysis for NOA and Erionite, dated December 7, 2018)

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concentration. Risk is the result of the dimension of the fibers and their concentration in air, and not related to crystal habit of the parent mineral in a rock.

The RJ Lee Group letter did not provide an analysis of the rocks that were shown in the photograph, and it can be inferred that the actinolite was deemed to be non-asbestos based on the crystal habit argument. However, an analysis of five similar samples by the author of this memorandum collected in northern and southern California was tested in strict conformance with the EPA protocol by Asbestos TEM Laboratories in Berkeley, California. The results ranged from 3% to 34%. Clearly, the crystal habit of actinolite is not an indicator of asbestos as defined by, and tested by, the EPA method for asbestos by TEM.

6. **The RJ Lee Group letter misrepresented the definitions and use of regulatory thresholds, incorrectly implying that levels below these thresholds are not regulated and considered safe by EPA and OSHA.**

EPA and the 1% threshold

EPA requires the removal of Asbestos Containing Material (ACM) in buildings prior to demolition or renovation. EPA regulations apply to building materials where asbestos was applied (assumed to be in concentrations >1%), and do not require removal where asbestos was not applied. However, EPA recognizes that asbestos concentrations in natural materials range within in a continuum between 0% and 100%, and therefore, does not recognize these thresholds for NOA. Rather, EPA relies nearly entirely on air concentration data. Within the EPA Libby Montana Superfund site toxicological study, for example, the term Asbestos Containing Material is not mentioned or defined. Within other studies, such as the investigation in the El Dorado Hills, California, EPA has repeatedly stated that "*studies have shown that air concentrations of suspended asbestos fibers can reach levels of concern when the soil contains trace levels (<1%) of asbestos*".

OSHA and the 1% threshold

OSHA does not recognize a safe lower limit for asbestos, and regulates asbestos in any amount. The 1% threshold, defined as ACM, is used to require increased worker protection by specifying mandatory, prescriptive and highly restrictive work practices, including mandatory use of respirators. In recognition that adverse worker exposures are possible when disturbing materials with an asbestos content of less than or equal to 1% ("acm"), OSHA requires advanced worker protection methods such as wet methods, oversight by a Competent Person, containment, training, signage, medical surveillance, hazard communication, site control, initial exposure assessments, and personal air monitoring. Respirators are required unless a material and task-specific exposure assessment, using air monitoring data, proves that workers will not likely be exposed above the Permissible Exposure Limit (PEL). Periodic air monitoring must be conducted to prove that this likelihood remains over the project duration. OSHA does not allow composite analysis. If a single sample of a material contains asbestos, then the requirements for ACM or acm apply to the entire material. Therefore, since asbestos was detected within the rocks to be disturbed, all OSHA requirements must be implemented.

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California Air Resource Board (CARB) and the 0.25% threshold

The 0.25% threshold as referred to in the RJ Lee Group letter applies only to surfacing applications as specified in the CARB Asbestos Airborne Toxic Control Measure (ATCM) for Surfacing Applications. For excavation and quarrying, asbestos is regulated in any amount. The intent of the 0.25% threshold for surfacing applications may be found in the companion ATCM for Construction, Grading, Quarrying and Surface Mining, where one of four methods for post-project capping of NOA is "*Any other measure deemed sufficient to prevent wind speeds of ten (10) miles per hour or greater from causing visible dust emissions*". Thus, the intent is to reduce emissions from wind-stripping of surfacing material.

The 1% and 0.25% thresholds are based on detection or quantitation limits of test methods, and not based on potential risk

The 1% threshold originally used by EPA and OSHA in building materials is based on two factors. First, the test method employed by the RJ Lee Group uses visual estimation to quantify asbestos content. The 1% level was, and still is, the level considered to be the limit of accurate quantitation. Reproducibility is not possible at levels below 1%. In addition, because asbestos was applied to building materials, it is logical that the 1% level is a valid concentration to differentiate between ACM (where asbestos was applied) and acm (where asbestos was not applied). EPA requires point counting only to prove that materials with reported trace concentrations are, in fact, <1%. As noted above, OSHA regulates NOA in any amount, and EPA focuses on potential risk by airborne asbestos, not concentrations in soil or rock.

The 0.25% California threshold for surfacing material is also based on the limit of detection or quantitation. The threshold is derived from the CARB 435 method, which includes a 400-point count procedure. The limit of accurate quantitation, called the limit of detection in the method, is one fiber per 400 points, which equals 0.25%. Thus, the 0.25% threshold for surfacing material was based on the level that is achievable by the method, and not related to potential exposure.

Contrary to the direct or implied claim by the RJ Lee Group, neither EPA, OSHA, Cal-EPA nor Cal-OSHA recognizes a safe level in rocks and soil, and regulate asbestos in any amount. The 1% and 0.25% thresholds were set at the quantitation limits of the methods, and not based on the potential for asbestos exposure. Both EPA and OSHA recognize that adverse exposures may occur when asbestos is present in trace amounts.

Conclusions and Recommendations

Review of the RJ Lee letter and test results indicate that the test methodology deviated from the EPA test method standard, and severely under reported asbestos at the site.

Regardless, one fact emerges from both the EMSL and RJ Lee analyses: Regulated actinolite and subordinate tremolite asbestos is present in the rocks underlying the Rockhill quarry site, and the concentrations are sufficiently high to produce a potential adverse health impact to workers at the site, residents near the site, and particularly

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children attending schools near the site. The site is considered an NOA site, and all relevant asbestos regulations and standards of practice apply when disturbing these materials.

The results support the recommendations that were documented in the previous EEC's reviews. These include, but are not limited to the following (see the referenced documents for details):

- A work plan for the geologic investigation of the site needs to be prepared, reviewed and implemented to characterize the asbestos concentrations in each rock unit. The testing should be conducted by an experienced laboratory that follows strict protocols as required by EPA test methods, and not deviate by using arbitrary differential counting methods.

- Following the asbestos investigation, soil or rock disturbance should not occur until an ADMP is prepared, reviewed, and approved by the DEP.

- Consider Activity-Based Sampling (ABS) prior to construction to measure asbestos emissions that may be anticipated during construction.

- Worker protection procedures should be implemented in compliance with the appropriate lead agencies regulations, presumably the Mine Safety and Health Administration (MSHA) and the Occupational Safety and Health Administration (OSHA).

- An air monitoring program that includes perimeter monitoring and monitoring of roads that are used by haul trucks through the Rockhill Township should be developed and implemented. Consider predictive air modeling that may assist in the design of the air monitoring program, and set risk-based thresholds to document exposures to residents and children at nearby schools.

- Consider using an alternative quarry located near the project site. This would eliminate the potential health risk caused by activities at the Rockhill Quarry.

- Samples should be analyzed by a laboratory that does not include arbitrary modifications, and does not have a conflict of interest resulting by a close association with the mining industry.

Bradley G. Erskine

Bradley G. Erskine, Ph.D., CEG
Erskine Environmental Consulting

APPENDICIES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX

Response to the November 2005 National Stone, Sand & Gravel Association Report Prepared by the R.J. Lee Group, Inc "Evaluation of EPA's Analytical Data from the El Dorado Hills Asbestos Evaluation Project"

April 20, 2006

United States Environmental Protection Agency Region 9
Response to the November 2005 National Stone, Sand & Gravel Association report prepared by the R.J. Lee Group, Inc:
"Evaluation of EPA's Analytical Data from the El Dorado Hills Asbestos Evaluation Project"

This document constitutes the United States Environmental Protection Agency Region 9 (EPA Region 9) response to the major findings and conclusions of the National Stone, Sand & Gravel Association report "Evaluation of EPA's Analytical Data from the El Dorado Hills Asbestos Evaluation Project" prepared by the R. J. Lee Group (R. J. Lee Report). A more detailed analysis will be completed after additional information is received from the R. J. Lee Group and the National Stone, Sand & Gravel Association,[1] and the United States Geological Survey (USGS).

The R. J. Lee Report draws conclusions that are contradicted by the El Dorado Hills data and by generally accepted scientific principles for measuring asbestos exposure.

Overview

The R. J. Lee Group review of the EPA data was contracted by the National Stone, Sand & Gravel Association. The El Dorado County Office of Education funded the three reviewers who wrote letters in support of the R. J. Lee Report and whose reviews are included in this response.

The EPA Region 9 El Dorado Hills Naturally Occurring Asbestos Exposure Assessment was designed to measure the exposures to asbestos fibers, if any, that resulted from sports and play activities that disturbed dust and soil. EPA Region 9 adhered to accepted EPA standards for sampling and analysis, including rigorous quality assurance/quality control, and to the standard methodologies of EPA exposure and risk assessment.

The R. J. Lee Report Criticizes EPA Region 9 for Using Established Scientific and Public Health Protocols - In assessing naturally occurring asbestos exposures in El Dorado Hills, EPA evaluated asbestos exposures using the PCME (phase contrast microscopy equivalent) asbestos fiber size classification. The PCME classification was used because human epidemiological studies, which form the basis of knowledge of asbestos health effects, measured asbestos fiber concentrations using phase contrast microscopy (PCM) analytical methods. PCME is the standard term for fibers counted by more modern analytical methods that are of equivalent size to those fibers that would be seen by PCM analysis, and includes fibers with a length to width aspect ratio of 3 to 1 or greater. EPA considered PCME fibers in our analysis of the El Dorado data to be consistent with the existing health databases and risk assessment

[1]On March 9, 2006, EPA Region 9 sent a letter to the R.J. Lee Group and the National Stone, Sand, & Gravel Association asking for additional information to support the findings and conclusions of the R.J. Lee Report.

procedures used by EPA, California EPA (Cal/EPA), the World Health Organization, and other federal agencies and international organizations. This approach was rejected by the R.J. Lee Group, which instead advocates use of asbestos fiber definitions which are not health based or supported by the majority of experts in the health community, and which would not allow comparison to the existing epidemiologic data on asbestos related cancers.

The R. J. Lee Report Claims that EPA Region 9 Misapplied Fiber Counting Protocols - The R. J. Lee Report claims that EPA Region 9 inflated the fiber counts in the El Dorado Hills air data by misapplying the International Standards Organization (ISO) method 10312 (the analytical method used by EPA to analyze the El Dorado air samples) and including PCME structures with a 3 to 1 length to width aspect ratio in our analysis. The R. J. Lee Report maintains that EPA should only have counted structures which met the general 5 to 1 aspect ratio fiber size definition described in the body of the ISO 10312 method. However, Annex C and Annex E of the ISO 10312 method specifically authorize the counting of PCME structures with a 3 to 1 aspect ratio. Another example of misleading information is the R.J. Lee Report's statistical evaluation and resulting conclusions regarding the concentrations of asbestos structures detected in the EPA air samples. All of the established EPA, National Institute of Occupational Safety and Health (NIOSH), and ISO analytical methods require the counting of asbestos bundles, recognizing the significance of bundles to proper characterization of asbestos fiber levels. The R.J. Lee Report did not include asbestos bundles in its analysis of the data, thereby undercounting the number of structures.

The R. J. Lee Report Claims that EPA Region 9 Misidentified Amphibole Minerals - The R. J. Lee Report concludes that EPA misidentified actinolite asbestos fibers in the El Dorado soil samples by using inappropriate extinction angle criteria. The R. J. Lee Group conclusion is contradicted by the National Institute of Standards and Technology (NIST) and the major analytical methods used for analysis of asbestos in soil and bulk samples. The R. J. Lee Report also cites an unpublished 1980 draft report to support its contention that structures found in the EPA air samples are not asbestos, and ignores a subsequent 1981 published report by the same author that actually supports the EPA approach.

The R. J. Lee Report Applies a Geologic Definition rather than a Public Health Definition to Characterize Microscopic Structures - The R. J. Lee Report relies heavily on the geologic distinction between asbestos fibers and cleavage fragments of the same dimensions, with the implication that exposure to cleavage fragments is benign and of little or no health significance. For the purposes of public health assessment and protection, EPA makes no distinction between fibers and cleavage fragments of comparable chemical composition, size, and shape. The EPA Region 9 approach, which is supported by most public health agencies and scientists, as well as the American Thoracic Society, is based on the following: (1) The epidemiologic and health studies underlying EPA and Cal/EPA cancer risk assessment methods were based on exposures to both cleavage fragments and fibers, and were unable to distinguish between the two, (2) The most recent panel of experts to review asbestos risk assessment methods, the 2003 Peer Consultation Panel convened by EPA, concluded that "it is prudent at this time to conclude equivalent potency [of cleavage fragments and fibers] for cancer,"[2] (3) No well-designed animal or epidemiological studies have adequately tested the hypothesis that cleavage fragments with the same dimensions as a fiber are benign or that the human body makes any distinction, (4) Studies that purport to show that cleavage fragments are benign are questioned by many asbestos health experts, (5) There are no routine asbestos air analytical methods, including those used by EPA, NIOSH, the Mine Safety and Health Administration (MSHA), the American Society for Testing and Materials (ASTM), and ISO which differentiate between cleavage fragments and crystalline fibers on an individual fiber basis.

The R. J. Lee Report's "Virtual" Review of EPA Region 9's Air Samples is Inconsistent with Established Laboratory Practices - The R.J. Lee Group did not have access to EPA's actual air samples, nor did it collect any air samples of its own. Rather it reviewed limited pictures and spectra data of a small number of EPA's air samples and drew conclusions based on those representations. Such a virtual review is not consistent with the National Voluntary Laboratory Assurance Program (NVLAP) quality assurance procedures nor the verification methods of the National Institutes of Standards and Technology.

Federal Courts Have Supported EPA - Many of the assertions of the R. J. Lee Report are consistent with positions that the R.J. Lee Group took as an expert witness for W.R. Grace in the Libby, Montana litigation. In this litigation, the written opinions of the District and Appeals courts, while not specifically addressing the opinions of the R.J. Lee Group, rule in favor of EPA and expressly hold that EPA's experts and science are credible.[3]

Background

In October 2004, the EPA Region 9 Superfund site assessment program conducted an assessment of exposures to naturally occurring asbestos (NOA) in El Dorado Hills, California. Specifically, EPA Region 9 simulated the sports activities of children and adults at three schools and a community park and, using personal air monitors, measured asbestos levels in the breathing zones of participants. EPA Region 9 also collected samples of ambient air in the area of the sampling at the same time the simulations were conducted to serve as reference samples. The personal activity-based samples were then compared to the reference samples. The Asbestos Hazard Emergency Response Act (AHERA)[4] regulation Z-test for statistical

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[2]USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page viii.

[3] See U.S. v. W.R. Grace, 280 F Supp 2d 1149 (2003): U.S. v. W.R. Grace, 429 F. 3d 1224, 1245 (9th Cir. 2005) (Although debate regarding testing methodology and data analysis is "exceedingly complex", EPA did not ignore accepted scientific principles)

[4]The Asbestos Hazard Emergency Response Act (AHERA) was passed by Congress in 1986 to provide for the inspection and mitigation of asbestos in school buildings. Regulations implementing the Act were promulgated by EPA in 1987.

significance was applied to determine whether there were any statistically significant differences between the personal exposure samples and the ambient reference samples. EPA Region 9 collected over 400 air samples and generated over 7000 data points. All of EPA Region 9's's analyses were conducted by accredited laboratories using recognized methods and procedures with strict quality assurance control, including blind performance samples to check analytical accuracy.

Amphibole asbestos, which many health scientists consider to be even more toxic than chrysotile asbestos, was found in almost all the reference and activity-based samples. Of the 29 different sets of activity-based scenario measurements, application of the Z-test determined that personal exposures from 24 scenarios were significantly elevated over the reference samples. Most importantly, the data showed that children and adults participating in sports activities in areas where asbestos occurs naturally in the surface soils, as it does in El Dorado Hills, can be exposed to asbestos fibers of health concern at up to 62 times the corresponding reference levels.

EPA Region 9 released the data from the assessment in May 2005 and held a public meeting in El Dorado Hills that was attended by more than 1000 members of the public. From the outset of the assessment, EPA Region 9 made clear to the community that EPA's only intent was to gather data on potential exposures. The community and the State and local regulatory agencies could then use the information to make decisions about the significance of those exposures and determine appropriate control measures. Both EPA Region 9 and the Agency for Toxic Substances and Disease Registry (ATSDR) have informed the community that exposure levels are a main determinant of the risk of developing asbestos-related cancers and non-cancer diseases, and that reducing the exposures reduces the risk. Consistent with its intent, EPA Region 9 has actively engaged the State and local regulatory agencies to improve naturally occurring asbestos mapping, monitoring, dust control, and regulation. El Dorado County has recently adopted more stringent dust control ordinances.

<u>Detailed Comments on the R. J. Lee Report</u>

R.J. Lee Finding #1: "Based on Mineralogy, Sixty-Three Percent (63%) of the Amphibole Particles Identified as Asbestos Fibers can not be Asbestos."

The R. J. Lee Report argues that there is too much aluminum in 63% of EPA Region 9's identified fibers for the fibers to be asbestiform.[5] In addition, the remaining 37% (sometimes the Report uses 35%) are not asbestos fibers based on their particle dimensions.

EPA Response

Aluminum - Analysis of the EPA Region 9 El Dorado air samples was performed using the International Standards Organization (ISO) method 10312, a state-of-the-art

[5]Asbestiform: Having the form or structure of asbestos.

Transmission Electron Microscope (TEM)[6] method with energy dispersive spectroscopy (EDS)[7] that has strict counting rules and characterizes the dimensions and chemistry of every fiber identified by the microscopist. Identification of fiber type was performed according to the general guidelines of the International Mineralogical Association (IMA) (Leake, 1997)[8], the international standard for amphibole nomenclature. This same approach for asbestos classification is recommended in the "Research Method for Sampling and Analysis of Fibrous Amphibole in Vermiculite Attic Insulation", EPA 600/R-04/004, January 2004, and was one of the tools used by Meeker et al (2003)[9] to determine the composition and morphology of amphiboles from Libby, Montana.

The R. J. Lee Report claims that 63% of the amphibole fibers identified by the EPA laboratory[10] as actinolite asbestos have concentrations of total aluminum that are too high to form asbestos fibers. According to page 2 of the R. J. Lee Report, "Particles with more than 0.3 aluminum atoms pfu [per formula unit] or about 1.5 percent Al_2O_3 cannot form in the asbestos habit due to crystal lattice constraints." To support its argument, the R. J. Lee Report cites three references. However, on close examination, two of the three references do not agree with the upper threshold limit that the R.J. Lee Group puts on total aluminum content (Leake et al, 1997) (Deer, Howie and Zussman, 1997)[11]. The third reference (Verkouteren & Wylie, 2000)[12] draws its conclusions on examination of a

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[6]Transmission Electron Microscopy (TEM) produces images of a sample by illuminating the sample with an electron beam in a vacuum, and detecting the electrons that are transmitted through the sample.

[7]Energy Dispersive Spectroscopy (EDS) uses measurement of the energy and intensity of X-rays generated when a selected area of a sample is irradiated with an electron beam to identify the mineralogical composition of a structure.

[8]B.E. Leake et al (1997). Nomenclature of Amphibole: Report of the Subcommittee on Amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral Names. American Mineralogist, Volume 82, pages 1019-1037.

[9]G.P. Meeker et al (2003). The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana. American Mineralogist, Volume 88, pages 1955-1969.

[10]In this document, the terms "EPA laboratory" and "EPA Region 9 laboratory" refer to the private laboratories that conducted the analysis of the EPA soil and air samples under contract to EPA Region 9.

[11]W.A. Deer, R.A. Howie, and J. Zussman (1997). Rock-Forming Minerals: Double Chain Silicates, Vol 2, second edition, p 137 - 145.

[12]J.R. Verkouteren and A.G. Wylie (2000). The Tremolite-Actinolite-Ferro-Actinolite Aeries: Systematic Relationships Among Cell Parameters, Composition, Optical Properties, and

small set of fibrous actinolite asbestos samples which the authors partition into asbestos and fibrous "non-asbestos" byssolite using criteria which the IMA specifically recommends against, and which is inconsistent with all standard asbestos analytical methods. Perhaps most important is the fact that all three references agree that it is the IMA criteria which primarily govern the general classification of amphibole type, not the total aluminum content. These references therefore actually support the classification approach taken by the EPA laboratory.

The R.J. Lee Group did not have access to the EPA air samples to conduct their own analyses. Instead, the R.J. Lee Group looked at a limited number of photographs of the recorded EDS spectra. Interferences by other elements in the sample can affect the aluminum total in the spectra. This is especially important because the EPA samples were of air releases from soil, not processed asbestos material. Soils contain non-asbestos mineral and biological particles that can influence element totals in an EDS spectrum, most notably clay particles, which are high in aluminum. The laboratory used by EPA Region 9 identified aluminum-rich actinolite asbestos, by applying the IMA classification guidelines to its direct analysis of the actual sample.[13]

Particle Dimension - As previously stated, the R. J. Lee Report claims that 37% of the fibers counted by EPA in the El Dorado Hills air samples are not asbestos fibers based on their particle dimensions. The report claims that EPA Region 9 inflated the fiber counts by including asbestos structures which do not meet the definition of a fiber as described in ISO 10312. The general ISO 10312 method requires the counting of every asbestos structure with a length to width aspect ratio of 5:1 or greater. As directed by Region 9, the EPA laboratory counted structures with a 3:1 or greater aspect ratio. The R. J. Lee Report states that EPA erred in counting structures with aspect ratios less than 5:1. **Annex C and Annex E of the ISO method clearly authorize the counting of PCME structures with a 3:1 aspect ratio if the data are to be used for exposure or risk assessment purposes, the stated goal of the El Dorado Hills assessment. In fact, the ISO method contains numerous references to PCME fibers. PCME fibers are defined as fibers greater than 5 microns in length, and 0.25 to 3 microns in width with a 3:1 aspect ratio.[14] PCME fibers form the basis for EPA's IRIS toxicity database and the asbestos risk models of California EPA and other federal and international organizations.[15]**

Habit, and Evidence of Discontinuities. American Mineralogist, 85, p. 1239 - 1254.

[13]Personal communication with John Harris, Lab/Cor, January 2006.

[14]World Health Organization (1986). Environmental Health Criteria 53, International Programme on Chemical Safety, Asbestos and Other Natural Mineral Fibres, section 2.3.2.2.

[15]The IRIS asbestos cancer inhalation unit risk, a measure of asbestos cancer potency, is based on the EPA 1986 Airborne Asbestos Health Assessment Update (EPA/600/8-84/003F; 1986). Cal/EPA used a similar approach and data sets to derive its cancer unit risk. Both the IRIS and the Cal/EPA cancer potency values rely on human epidemiological studies that were conducted using phase contrast microscopy (PCM) analytical methods (some were midget

The R.J. Lee Group also manipulates its statistical analysis of the El Dorado Hills air data by ignoring counts of asbestos fiber bundles in its evaluations. Bundles are two or more attached parallel asbestos fibers which can have a significant health impact when they are inhaled and separate into individual fibers. Bundles were counted in the historical epidemiological studies which form the basis of our knowledge of asbestos-related health effects and EPA's IRIS database. **All of the established EPA, NIOSH, and ISO analytical methods require the counting of asbestos bundles, recognizing the significance of bundles to proper characterization of asbestos fiber levels.**

The R. J. Lee Report further states that EPA's data inflated the asbestos fiber count by ignoring the Agency's own "definition" of asbestos. To support this claim, the R.J. Lee Report cites the glossary of "Method for Determination of Asbestos in Bulk Building Materials", EPA 600/R-93/116, 1993, which states, in part, "With the light microscope, the asbestiform habit is generally recognized by the following characteristics: Mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 microns." The building material analytical method is designed to detect commercially processed asbestos in items like floor tiles, roofing felts, paper insulation, paints, and mastics, not naturally occurring asbestos on air filters or in soil samples. To present the 20:1 aspect ratio for commercial grade asbestos as a universal EPA policy, and to advocate its use as an appropriate standard for analyzing air samples of naturally occurring asbestos is inappropriate and contradictory to use of the PCME dimensional criteria as a tool for assessing exposure risk.

The R. J. Lee Report also states that the diffraction pattern analyses produced by the EPA laboratory for the El Dorado Hills air samples demonstrates that the particles identified by the laboratory are not asbestos.[16] The report cites a 1980 unpublished draft study by S.J. Ring to support its conclusion. The R. J. Lee Report does not mention a 1981 published article by the same author which revises the findings such that they no longer support the conclusion of the R. J. Lee Report and, in fact, support the data produced by

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impinger data converted to PCM counts) that could not distinguish fibers that were 5 microns in length or less. PCM cannot distinguish between fibers and cleavage fragments. PCM is not as powerful as current Transmission Electron Microscope (TEM) methods (400X vs 20,000X) as TEM can see the thinner/shorter fibers. However, since EPA's (and Cal/EPA 's) toxicity database relies on human health studies that used PCM, current EPA risk procedures use the more powerful TEM method but report the PCM equivalent (PCME) fibers and only use the PCME counted fibers in a risk assessment. This is because the IRIS asbestos file specifies that only PCME fiber counts be used with inhalation unit risk for risk calculation. See also the reference cited in footnote 11.

[16]Diffraction pattern analyses irradiates a sample with x-rays and then takes an x-ray photograph.

EPA.[17]

R.J. Lee Finding #2: "The Laboratory Procedures did not Comply With the NVLAP Quality Assurance Standard."

The R. J. Lee Report says that the false positive rate in our air samples was 35% when the acceptable limit in the National Voluntary Laboratory Accreditation Program (NVLAP) is 10%.

EPA Response

The laboratories used by EPA Region 9 for analysis of the El Dorado Hills air and soil samples are accredited through the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP is administered by the National Institute of Standards and Technology, a non-regulatory agency within the U.S. Commerce Department. A large part of the accreditation process involves on-site audits performed by NVLAP-certified inspectors who review laboratory operational and quality assurance compliance parameters, including documentation proving compliance with NVLAP requirements for verification analyses. A laboratory must demonstrate that all analysts reporting data meet the false negative and false positive requirements set forth by NVLAP before an accreditation certificate is issued. To make a determination that a laboratory did not comply with NVLAP verification standards would require a very detailed examination of all laboratory generated raw data, project specific information, such as a site-specific EPA issued Quality Assurance Project Plan, laboratory instrument log books, and other data and information not supplied in an analytical report. Interviews with the laboratory manager, quality assurance manager, and involved analysts are also mandatory to make judgement on a laboratory's possible non-compliance. The R.J. Lee Report's conclusion that the EPA laboratory was not in compliance with NVLAP, based on a cursory review of count sheet and other limited data without the in-depth examination detailed above, is therefore invalid and cannot be used to question EPA's analytical results.

EPA chose NVLAP-accredited laboratories for the El Dorado Hills assessment as a minimum quality requirement. For supplemental quality assurance, the laboratories were subjected to on-site audits performed by EPA's Quality Assurance Technical Support group, and both laboratories were sent performance evaluation samples prior to analysis of the El Dorado samples. In addition, the laboratory conducting the air sample analysis was sent double blind performance evaluation samples during the sampling event. In all cases, the laboratories successfully identified the amounts and types of asbestos present on the blind samples within acceptable limits. Further, the El Dorado Hills air and soil data were validated by a third party in accordance with standard EPA quality assurance

[17]S.J. Ring (1981). Identification of Amphibole Fibers, Including Asbestos, Using Common Electron Diffraction Patterns. In Russell P.A. and Hutchings A.E. (Eds), Electron Microscopy and X-ray Applications to Environmental and Occupational Health Analysis, Vol. 2:175-198, Ann Arbor Science Publ., Inc.

procedures and were found to be acceptable for all uses.

R. J. Lee Finding #3: "The Soil Samples do not Demonstrate the Presence of Amphibole Asbestiform Minerals."

The R. J. Lee Report states that the actinolite asbestos fibers identified in the El Dorado Hills soil samples contain too much aluminum to be asbestiform and that the extinction angles of the fibers indicate that they are non-fibrous cleavage fragments. The R.J. Lee Group's analysis of 23 split soil samples from EPA's October 2004 sampling event found no asbestos in the samples.

EPA Response

Aluminum - The R. J. Lee Report states that the aluminum content of the fibers in the soil samples was too high to be asbestiform actinolite and that it was indicative of non-asbestiform actinolite and another amphibole, hornblende, which contains approximately 10-20% by weight Al_2O_3 (5.3-10.6% by weight aluminum). Both the laboratory performing EPA's El Dorado soil sample analysis and the laboratory which analyzed the EPA air samples noted significant quantities of hornblende in the samples, but did not count or report those particles as asbestos. Please see the EPA response to Finding #1 for a further discussion of the aluminum issue.

Extinction Angles - The extinction angle of a fiber evaluated by polarized light microscopy is one of many criteria used to identify mineralogical composition. The extinction angle for amphibole asbestos fibers is the difference in degrees between the long axis of the fiber and the angle at which the fiber optically disappears (the polarization direction where the light passing through it becomes "extinct") when the fiber is rotated under a polarized light microscope. The R.J. Lee Report states that amphibole asbestos fibers have a zero-degree extinction angle and that non-asbestos cleavage fragments have non-zero extinction angles. Therefore, because the EPA soil sample analysis reported extinction angles which, according to the R.J. Lee Group, averaged 12^o, the report alleges EPA incorrectly identified cleavage fragments as asbestos fibers.

The R.J. Lee Report's conclusion regarding extinction angles is contradicted by the National Institute of Standards and Technology (NIST) and the major analytical methods used for analysis of asbestos in soil and bulk samples. NIST certifies and provides Standard Reference Materials (SRM) for laboratory instrument calibration and laboratory accuracy measurement. The NIST Tremolite/Actinolite SRM 1867A is a special set of three samples certified by NIST to be of ultra-high purity tremolite, actinolite, and anthophyllite asbestos and is considered the "gold standard" for asbestos analytical laboratories. The material is rigorously characterized and is accompanied by a six-page document that describes the properties of each sample. It is required that all analytical laboratories accredited by NIST/NVLAP have the material in their possession and that they use it to calibrate their operations and to test their analysts. The NIST SRM

1867A certificate which accompanies the samples of tremolite and actinolite states that the reference tremolite can have an extinction angle of up to 16.6 ± 0.3° and that the actinolite can have an extinction angle of up to 15.9±0.2°. When the EPA laboratory processed the NIST actinolite standard in the manner of the El Dorado Hills soil samples, the extinction angles of the fibers in the processed standard sample were consistent with allowed maximum extinction angles for tremolite/actinolite asbestos (~ 10° to 20°) and the extinction angles of the fibers seen in the EPA soil samples.[18]

Further, the laboratory methods of EPA, NIOSH, and other agencies for analysis of asbestos in bulk material all state that tremolite-actinolite asbestos fibers may have zero (parallel) or *non-zero* (inclined or oblique) extinction angles. EPA Method 600/R-93/116[19], the standard method used by all NIST/NVLAP accredited laboratories to test building materials for the presence of asbestos, states in Table 2-2, Optical Properties of Asbestos Fibers, that tremolite-actinolite asbestos has extinction "parallel and oblique (up to 21°)." NIOSH Method 9002[20], the method used for analysis of the El Dorado Hills soil samples, states directly that actinolite and tremolite fibers exhibiting inclined extinction are to be considered asbestos. The method further states that "If anisotropic fibers are found (during PLM analysis), rotate the stage to determine the angle of extinction. Except for tremolite-actinolite asbestos which has oblique extinction at 10-20°, the other forms of asbestos exhibit parallel extinction... Tremolite may show both parallel and oblique extinction."[21]

R.J. Lee Finding #4: "The ISO 10312 Analytical Method can not Distinguish Between Asbestos Fibers and Non-Asbestos Cleavage Fragments."

The R.J. Lee Report states that the ISO 10312 method contains the disclaimer that "The method cannot discriminate between individual fibers of asbestos and non-asbestos analogues of the same amphibole material," and, therefore, EPA inflated the asbestos air concentrations by counting "cleavage fragments."

EPA Response

The ISO 10312 method cannot differentiate between fibers and cleavage fragments with

[18] M. Bailey (2006). Identification of Asbestiform Tremolite/Actinolite. Naturally Occurring Asbestos Workgroup Meeting Presentation.

[19] USEPA (U.S. Environmental Protection Agency) (1993). Method for the Determination of Asbestos if Bulk Building Materials. EPA Method 600/R-93/116.

[20] NIOSH (National Institute for Occupational Safety and Health) (1992). Asbestos (Bulk) by PLM.. Method 9002 (Issue 2).

[21] NIOSH (National Institute for Occupational Safety and Health) (1992). Asbestos (Bulk) by PLM.. Method 9002 (Issue 2). Qualitative Assessment, Item c, page 4.

the same dimensions and chemical composition. No routine analytical method has a protocol for distinguishing fibers from cleavage fragments on an individual particle basis. Additionally, from a health standpoint, there is no evidence that supports making the distinction.

Cleavage fragment is a geologic term which refers to structures that form when non-fibrous forms of asbestos minerals split along crystallographic planes, as opposed to asbestos fibers which form from crystalline growth. The R.J. Lee Report maintains that there is a toxicological difference between asbestos structures which formed as fiber crystals and fibers which formed by cleavage plane separation. Page 3 of the R.J. Lee Report states that cleavage fragments are “not known to produce asbestos-like disease.” **It is the position of EPA, the U.S. Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry (ATSDR) and National Institute for Occupational Safety and Health (NIOSH), and the American Thoracic Society, among others, that microscopic structures of amphibole and serpentine minerals that are asbestiform and meet the size definition of PCM fibers, should be counted as asbestos, regardless of the manner by which they were formed.** There are four reasons why the health agencies have taken this position: (1) The epidemiologic and health studies underlying EPA, and California EPA, cancer risk assessment methods were based on exposures to both cleavage fragments and fibers, but were unable to distinguish between the two, (2) The most recent panel of experts to review asbestos risk assessment methods, the 2003 Peer Consultation Panel convened by EPA, concluded that “it is prudent at this time to conclude equivalent potency [of cleavage fragments and fibers] for cancer,”[22] (3) No well-designed animal or human epidemiological studies have been conducted to date to test the hypothesis that cleavage fragments with the same dimensions of a fiber are benign, or that the human body makes any distinction, and studies that purport to show that cleavage fragments are benign are questioned by many asbestos health experts,[23] (4) There are no routine air analytical methods, including those used by EPA, NIOSH, the Mine Safety and Health Administration (MSHA), the American Society for Testing and Materials (ASTM), and the ISO which differentiate between cleavage fragments and crystalline fibers.

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[22]USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page viii.

[23]Both Addison (Addison J, Davies LST. 1990. Analysis of amphibole asbestos in chrysotile and other minerals. Ann Occ Hyg, Apr;34(2):159-75) and members of the U.S. EPA 2003 Peer Consultation panel raised concerns about interpretation of the Davis study (Davis JM, McIntosh C, Miller BG, Niven K. 1991. Variations in the carcinogenicity of tremolite dust samples of differing morphology. Ann NY Acad Sci, Dec;643:473-90), which attempted to compare the toxicity of asbestos fibers and cleavage fragments. These concerns reflected the lack of peer review, use of intra peritoneal injection instead of inhalation exposure, significance of mesotheliomas caused by structures reported as cleavage fragments, purity of the cleavage fragment samples and issues related to fiber dimensions.

In terms of epidemiological data and health outcomes, the cleavage fragment argument is without merit. For the purposes of public health assessment and protection, EPA makes no distinction between fibers and cleavage fragments of comparable chemical composition, size, and shape.

There are no recognized analytical protocols, including those used by EPA, NIOSH, MSHA, ASTM, and ISO, which include criteria to differentiate between cleavage fragments and crystalline fibers. All these methods require that structures which meet their definition of the specific counting rules for an asbestos fiber be counted. The requirements are based on the fact that, in the words of an expert from the United States Geological Survey, "At a microscopic level, distinguishing between these forms on single [asbestos] particles, can be extremely difficult to impossible."[24] As noted above, R.J. Lee made a very similar claim with regard to cleavage fragments as the expert witness for W.R. Grace in the Libby, Montana, Superfund cost recovery litigation. The EPA analytical experts who reviewed the R.J. Lee Group's testing methodology related to the Libby site found that the R.J. Lee laboratory could not demonstrate any reliable criteria with which to distinguish, at the microscopic level, asbestos cleavage fragments from asbestos fibers of the same size, shape, and composition. The Ninth Circuit Court of Appeals recognized the competing scientific arguments but found that EPA's position was consistent with the record of evidence and accepted scientific principles.[25]

R.J. Lee Finding #5: "Applying the Latest Science and Definitional Techniques, the El Dorado Hills Study Shows no Significant Exposure to the Type of Amphibole Asbestos Fiber Connected To Health Risk."

The R. J. Lee Report claims that the latest science for measuring the risk posed by asbestos is the Berman-Crump Asbestos Risk Assessment Protocol ("Berman-Crump") which proposes that amphibole asbestos fibers which are more than 10 microns long and less than 0.5 microns wide (protocol fibers) are the most toxic. Of the 2,386 fibers which the R. J. Lee Report states the EPA laboratory identified, the R.J. Lee Report concludes that only 7 fibers meet the "Berman-Crump" definition. Therefore, the R.J. Lee Group maintains that EPA has overstated the risk from exposure to asbestos fibers in El Dorado Hills.

EPA Response

The "Berman-Crump" protocol that the R.J. Lee Report references is in fact a draft EPA method. EPA had the method reviewed by a peer consultation panel in 2003. The panel made a number of important recommendations that must be addressed before the method can be used for EPA risk assessments. A number of important revisions have been made

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[24] G.P. Meeker, USGS, (2002). Review of Expert Report of R.J. Lee.

[25] U.S. v. W.R. Grace, 429 F.3d at 1245.

to the draft method since 2003, but at this time the method has not been independently peer reviewed. It will not be adopted by EPA as a risk assessment tool unless and until it passes rigorous internal and external peer review.

The expert peer panel has recommended that the fiber size for the draft EPA risk assessment method be adjusted to include fibers greater than 5 microns in length and up to 1.5 microns in width.[26] The change is designed to account for lung deposition of fibers that results when fibers are inhaled through the mouth, and not filtered by the nasal passages. The broadening of the fiber definition to include inhalation by "mouth breathers" is especially relevant to the El Dorado Hills data. Our investigation measured personal asbestos exposures of individuals participating in sports activities, where physical exertion would likely increase breathing through the mouth. **The PCME fibers counted in the EPA air samples are actually consistent with the latest science of EPA, as reflected in the recommendations of the peer consultation panel.** In addition, the EPA peer consultation expert panel recommended that cleavage fragments be treated as any other asbestos fiber of the same morphology and chemical composition.[27]

EPA Region 9 focused on obtaining an accurate count of PCME structures, consistent with our risk assessment protocols and those of Cal/EPA and other health agencies. The counting rules which EPA set for the laboratory were designed to stop counting when a statistically-significant number of PCME fibers were detected. By concentrating on PCME structures, other fiber size classifications may not have been counted to statistical significance. This may have resulted in under counts of other fiber sizes (e.g. the "Berman Crump" protocol fibers referred to in the R. J. Lee Report). **EPA Region 9's study counted PCME structures so that the data could be directly compared to human health epidemiological studies.** These epidemiological studies form the basis for risk assessment models currently used by EPA, Cal/EPA and other federal agencies and international organizations.

R. J. Lee Report Peer Reviews

The R. J. Lee Report was reviewed by three individuals, although research of one of the individuals was extensively quoted in the report and therefore the independence of the reviewer is debatable. The three reviewers generally agree with the conclusions of the R. J. Lee Report regarding aluminum content, fiber chemistry, cleavage fragments, and extinction angles.

Both the R. J. Lee Report and one of the reviewers support use of the original "Berman-

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[26]USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page 5-5.

[27]Ibid, page 5-1.

Crump" protocol and calculate a "Berman-Crump" fiber air concentration of 0.0002 fibers/cubic centimeter, using the EPA fibers which they assert meet the "Berman-Crump" definition. The peer reviewer then compares that concentration with an ambient concentration of 0.0008 fibers/milliliter measured in New York City, and states that the "Berman-Crump" value in El Dorado Hills is extremely low. This comparison is flawed for at least two reasons. Significantly, the New York City numbers are based on fibers counted against a totally different size classification (essentially comparing apples to oranges), but **the reviewer also fails to recognize that a concentration of 0.0002 f/cc translates in the protocol to an increased cancer risk of 1 in 1,000 exposed individuals.** This number is disturbingly high and is outside the acceptable cancer risk ranges of EPA, Cal/EPA, and most other state and federal health agencies.

<u>Conclusions</u>

EPA Region 9 has carefully reviewed the R. J. Lee Report and believes that it makes largely unsupported and incorrect conclusions about the EPA Region 9 El Dorado Hills Naturally Occurring Asbestos Exposure Assessment. EPA Region 9 has asked the United States Geological Survey (USGS) to conduct an independent study of the El Dorado County area to address several mineralogical questions raised by the R. J. Lee Report. The USGS study will use sophisticated analytical techniques (such as electron probe micro analysis) to more completely characterize the naturally occurring asbestos in terms of mineral identification and particle morphology.

All of the EPA Region 9 work in El Dorado Hills was, and continues to be, consistent with the EPA's standard operating and quality control procedures for asbestos work throughout the country.

Erskine Environmental Consulting

Geologic Investigations   Hazardous Materials   Naturally Occurring Asbestos

June 6, 2019

Subject: Review of Qualitative Geologic Survey Sampling Plan
Rockhill Quarry
East Rockhill Township
Bucks County, PA

This report presents a technical review of the following documents and provides recommendations for improvement:

- Qualitative Geologic Survey Sampling Plan (QGSSP), Rock Hill Quarry, SMP No. 7974SM1, East Rockhill Township, Bucks County submitted to the Pennsylvania Department of Environmental Protection by Earthres, dated April 3, 2019.

- Response to PA DEP and East Rockhill Township Comments, Qualitative Geologic Survey Sampling Plan (QGSSP), Rock Hill Quarry, SMP No. 7974SM1, East Rockhill Township, Bucks County submitted to the Pennsylvania Department of Environmental Protection by Earthres, dated April 25, 2019.

While not a part of the QGSSP, a limited review (air sample collection and test methodology) of the following document is incorporated:

- Asbestos Air Monitoring Plan (AAMP), East Rockhill Quarry Site, submitted to the Pennsylvania Department of Environmental Protection by Richard E. Pierson Materials Corporation, dated April, 2019.

Purpose

The purpose of the review is to provide an independent analysis of the QGSSP to assess whether the Plan is adequate to characterize the site for the presence of Naturally Occurring Asbestos (NOA), and if identified, sufficient to provide data allowing informed decisions regarding dust mitigation during quarrying, potential risk to offsite receptors, and air monitoring requirements to verify that offsite receptors are not adversely exposed to asbestos.

This review includes opinions produced solely by the author. This review is based on more than 30 years of experience of the author within asbestos testing laboratories and consulting in the field of NOA. In particular, many of the observations, comments, conclusions and recommendations are shaped by experience with two recent major NOA projects: The Boulder City Bypass Project in Nevada, a three-year construction project and the first large NOA project in Nevada, and the Calaveras Dam Replacement Project, an eight-year project that represents the largest and most technically advanced NOA project in the U.S. Both projects included construction activities similar to the Rock Hill Quarry site (drilling, blasting, sorting and sizing, crushing and screening), and the challenges and potential solutions are similar.

The QGSSP includes procedures, terminology, test methodology and other subjects that are difficult to understand without extensive experience in the field of NOA. An attempt was made in this review to explain some of the more difficult concepts and communicate in language that may be comprehended by those who have limited experience with NOA, particularly the application of standards and regulations to a quarrying project.

This review focuses on the following:

- Does the QGSSP include procedures which will produce a thorough geologic assessment that allows each litho-structural unit to be identified and tested independently?

- Are the proposed procedures for inspection and sample selection for testing adequate to fully characterize the site for NOA?

- Are the proposed test methodologies described in the QGSSP and AAMP appropriate for the intended applications, and will they adequately characterize the concentration of NOA in rock, water and air?

Summary of Conclusions

The following is a summary of findings from the QGSSP review. Details that led to these findings are presented below. Recommendations for improvement of the QGSSP are presented at the end of the report, as well as references cited in the review.

Geologic Assessment

There is little evidence that an appropriate geologic investigation has been conducted to identify each litho-structural unit that requires independent testing. Before sampling is to be conducted, the rocks at the site need to be mapped in detail and broken into independent units that are distinct in lithology and structure.

Questions to be answered include:

- Are there different geologic facies within the diabase, such as a coarse-grained component, fine grained component, xenoliths, and other variations that may include differences in the composition or relative percent of amphiboles?

- Are there ductile or brittle shear zones (outside of the veins under investigation), each of which require sampling?

It appears from the description in the QGSSP that the diabase was considered a single homogeneous unit, and that the sampling program will provide a result that represents a composite (average) of the rock unit. Sampling within each unit should include incremental sampling to assess the average NOA composition within a unit as well as targeted sampling at locations with the highest potential for NOA. The incremental sampling will provide data on the overall disturbance activities, while the targeted sampling will provide data for OSHA compliance. The geologic investigation should be guided by the most comprehensive NOA-specific regulations and guidelines available, notably the CARB 435 and CARB 435 implementation guidance, protocols outlined in the California Department of Toxic Substances Control guidance for NOA investigations at school sites, guidance provided by the California Geological Survey, and the California Air Resources Board Asbestos Airborne Toxic Control Measure for Construction, Grading & Quarrying operations. References are incorporated herein and within the references cited section of this review.

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Procedures for Sample Selection for Testing

The procedures for sample selection are unorthodox, and do not conform to basic principles for geologic investigations. In particular, it appears that the QGSSP prescribes a field test using visual methods in the field to determine if asbestos is present, and screens samples from further testing. The procedure is subjective, and based on a definition of asbestos where no consensus has been arrived at. Most importantly, fine particles, such as asbestos particles of the size of interest, are commonly not visible using a hand lense or even a binocular microscope, and these rocks would be excluded for testing. The proposed field methods should be employed to help differentiate rock units for independent testing, and not as a screening tool.

The QGSSP appears to exclude the diabase from further sampling, and focuses on the veining where asbestos has been identified. A thorough analysis of the diabase is Important because diabasic rocks containing tremolite/actinolite amphibole often exhibit asbestos mineralization through replacement of olivine and pyroxene minerals which is rarely obvious in the field. The sample selection procedure that was employed does not appear to have been sufficient. In addition, the sample preparation procedures are not well described and likely were not in accordance with standard of practice, and therefore, the results may not be reliable. It is recommended that the QGSSP include proper sample selection, preparation and analysis of this unit as well as all litho-structural units at the site.

Test Methodology

The proposed test methodology for rock, water and air sampling are not appropriate for the goals of the investigation (e.g. to make informed decisions regarding potential exposure to offsite receptors), and for water and air testing, the use of the data is not consistent with intended purpose of the test methods.

Rock Sampling

The QGSSP procedure prescribes polarized light microscopy (PLM), which commonly cannot detect fine asbestos particles, and if potential NOA is reported, uses transmission electron microscopy (TEM) only to verify the positive result rather than eliminate the possibility of a false negative. The QGSSP procedure is somewhat reverse of the standard of practice. PLM is used as a pre-screen, and TEM, which can positively identify fibers that are less than 0.001 microns in width, is used to confirm the lack of detection by PLM. The methodology in the QGSSP will not reveal asbestos if it is in relatively low concentrations (<0.25% by point counting) or where present as fine particles, which is common for NOA. It is recommended that both PLM and TEM be employed on all samples to fully characterize the rocks.

Water Sampling

The method chosen (EPA M100.2) counts and reports fibers that are greater than 10 microns only. A sizable fraction of asbestos in water from runoff has lengths less than 10 microns, particularly where rocks have been subjected to highly energetic disturbance such as blasting, drilling, pneumatic hammering, and crushing beneath heavy equipment and during crushing and screening. EPA 100.1, a companion method to EPA 100.2, counts and reports all fibers greater than 0.5 microns. If the water is to be used for dust suppression, the release of respirable fibers through evaporation is possible. It is recommended that previous sample preparations be reanalyzed by EPA 100.1, and this method be employed throughout the project.

Air Testing

The AAMP prescribes sample collection and testing procedures using the NIOSH 7400 and 7402 methods. The NIOSH methods are designed specifically for worker exposure, and use the OSHA

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Permissible Exposure Limit (PEL) standard for workers, which is not a standard for the general public. In addition, the 7400 method uses Phase Contrast Microscopy (PCM), which is not allowed by EPA for purposes related to non-worker exposure. Unlike the EPA TEM test procedures, The NIOSH counting rules selectively remove any fiber that is less than 5 microns in length, and less than 0.25 microns in width. Therefore, the actual concentration of asbestos in air is under represented. This is particularly important with the close proximity of a school within 0.5 mile of the quarry along the proposed truck route, and homes in which families with small children live within 300 ft and adjacent to the quarry. It is recommended that the AAMP prescribe the sample collection and testing following the standard of practice for perimeter monitoring using the TEM method prescribed under the Asbestos Hazard Emergency Response Act (AHERA). This method counts all structures that are greater than 0.5 microns in length, and the result should be compared to a risk-based perimeter threshold that is determined to be protective of offsite receptors. The latter method is the standard for perimeter monitoring at NOA sites.

Other Considerations and Recommendations

<u>Air Modeling</u>

The AAMP presents a series of graphical wind rose charts that provide information on the wind speed and direction. While informative, they have limited value and do not include important data that contribute to asbestos concentrations offsite. For example, asbestos concentrations attenuate through dispersion on warm windy days where turbulent conditions exist. On cold days with low wind speeds, the asbestos concentrations can be exceedingly high, and offsite receptors exposed for longer periods of time.

It is recommended that the perimeter monitoring program be supported by air modeling to provide a predictive capability to airborne dust concentrations at off-site locations. The standard modeling program is EPA's AERMOD, a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence and other inputs. Using standard EPA emission rates for equipment at the site, particle concentrations can be evaluated at any point offsite for the duration of the project. Air modeling is fairly commonplace at sites such as quarries where high emissions are predicted, and the data from the model can be used to calculate a risk-based threshold for the site perimeter program.

<u>Definition and Reporting of "Asbestos"</u>

Some consultants and many laboratories rely on the commercial definition of asbestos and report asbestos only when the composition of an amphibole fiber is equivalent to the very narrow compositions that were mined and applied to building materials. This practice eliminates many amphibole compositions and morphologies that are present in rock and soil, and can produce a deceptive result (in rock, water and air samples). There is consensus among many researchers, particularly mineralogists, that this definition and practice is not appropriate for NOA. It is recommended that a mineralogical definition of asbestos be employed, and all amphibole compositions be determined and reported. This method was successfully employed at the Calaveras Dam site, and its application was instrumental for the protection of workers and offsite receptors. Using a mineralogical definition of minerals will prevent eliminating amphiboles from lab reports that are not precisely the same compositions as those applied in building materials.

It is also recommended that the laboratory refrain from arriving at an opinion whether a particle is asbestiform or a cleavage fragment. There is no approved test method to make this determination, and the opinion is subjective. It is also recommended that the laboratory refrain from classifying a particle as asbestos based on parallel extinction relative to the long axis of the fiber. This may be appropriate for asbestos in building materials or commercially exploitable asbestos, but not appropriate for NOA. NIST, the accrediting agency for asbestos testing labs supplies asbestos testing

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standards with inclined extinction, requires reporting of parallel or inclined extinction, and does not exclude fibers with inclined extinction from being counted as asbestos. EPA is in support of this view.

Activity Based Sampling

One method advocated by EPA to assess whether asbestos present in rock and soil results in adverse air concentrations is to conduct activity-based sampling (ABS). This form of sampling involves the collection of air samples during an activity designed to mirror an activity that will be performed at the site. One simple test is to collect air samples behind moving vehicles and along unpaved roads that are currently present at the site. On a park road near the Calaveras Dam site, sampling inside and outside three vehicles while driving on an unpaved road with asbestos concentrations of <0.25% produced dust plumes with high airborne asbestos concentrations. The purpose was to assess whether park visitors may be exposed to adverse asbestos concentrations when contractors used the road to access a project. It also solved a mystery regarding elevated asbestos concentrations at an ambient air monitoring station near the road. If significant concentrations of asbestos are reported in the air samples, it would imply that asbestos is present in rock and soil at the quarry site. If little or no asbestos is reported, it would support a conclusion that the quarry rocks are not NOA-bearing. It is recommended that ABS sampling be conducted to augment the rock testing.

Construction Area Activity Monitoring

The perimeter monitoring station array provides, if designed properly, verification that offsite receptors are not exposed above prescribed thresholds. They do not provide information regarding individual emission sources or potential dust generated off site due to trackout. It is recommended that an additional component of air sampling be conducted at the points of highest potential emission activities such as the rock crushing and processing facility and the main quarrying operations. In addition, because wheel washes and other trackout prevention methods do not necessarily prevent trackout, it is recommended that additional air monitoring stations be established along roads where haul trucks may track out dust near and through the community.

Reliability of Test Data from the Diabase

The QGSSP focuses on testing of veins, and does not include the diabase or any other lithologic unit. It cites previous data tested by EMSL Laboratories that found no asbestos detected. Review of several reports attached to a letter from Hanson Aggregates Pennsylvania LLC to the Pennsylvania DEP, dated October 29, 2018, presents some questions. In particular, the lab report states that the preparation method utilized CARB 435 Prep (milling). It does not state what milling apparatus was used. Based on concerns regarding over-pulverization of samples and interlaboratory variations in asbestos reporting, CARB tested several milling methods, and recommended in their CARB 435 guidance document that a disc pulverizer be used. However, at the ASTM International Beard Asbestos Conference last April, EMSL presented a study using spiked samples and employing a milling method other than the disc pulverizer. EMSL reported that samples spiked with low concentrations of amphibole asbestos yielded no, or greatly reduced levels of, asbestos detected after milling, and was unable to suggest the reason. Over-pulverization was most certainly the reason, which was a key reason why CARB recommends the disk pulverizer in its CARB 435 Implementation and Guidance Document. If the diabase samples were prepared using the same equipment presented at the conference, and the diabase contains low concentrations of asbestos, then the laboratory results are highly suspect and the diabase should be resampled and appropriately tested.

Processed Aggregate Stockpile Sampling and Testing

The information provided by applying the CARB 435 sampling and testing protocol is of value, and should be used to augment but not as a surrogate for data collected from a well-designed sampling program. In particular, the results provide concentrations that represent a weighted average of

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asbestos on a site, and may be misleading when used to assess potential for exposures to the public who reside offsite.

The procedures and intent of sampling protocols for processed material becomes apparent when considering CARB's four documents that collectively specify the procedure for sampling, purpose of the sampling protocol, and purpose of the procedures (CARB Method 435 (CARB 1991); CARB 435 Implementation Guidance (CARB 2017); CARB ATCM for surfacing applications (CARB 2001); and CARB ATCM for Construction, Grading, Quarrying and Surface Mining Operations (CARB 1992). The CARB 435 protocol is required to test materials for its use for surfacing applications. The test invokes a binary response action: if the test result is 0.25% or greater, then the material is defined as a Restricted Material, and cannot be bought, sold or used for the purposes of surfacing applications. It is not restricted for other uses such as fill. The intent is provided in the Construction ATCM. In the section titled *Post Construction Stabilization of Disturbed Areas*, roads, stockpiles, and disturbed areas must be stabilized using one of four methods: 1) establishment of a vegetative cover, 2) placement of at least three inches of non-asbestos-containing material (interpreted to mean less than 0.25% by CARB 435), 3) paving, or 4) any other measure deemed sufficient to prevent wind speeds of ten miles per hour or greater from causing visible dust emissions. Thus, the purpose of the CARB 435 protocol as applied to the Surfacing ATCM is to prevent significant re-entrainment of asbestos particles by wind, and is not intended to establish the potential for exposure during disturbance.

The CARB 435 protocol is not applicable for the use for regulatory compliance (outside of surfacing applications), and the mixing and compositing of materials is not compliant with EPA and OSHA requirements for the purposes of triggering response actions such as engineering controls and air monitoring. Consider the process: material from a quarry is mined, crushed and screened to produce a specified size distribution. The various rock units, therefore, have been homogenized, providing a material that in effect produces a weighted average of the asbestos content. If the diabase is a non-asbestos unit, for example, and asbestos is present in the veins, the result will be a very low "diluted" level of asbestos. The stockpile is sampled using an incremental sampling approach (compositing) to further determine the average asbestos content. The CARB 435 method requires that all samples collected must be averaged, and the numeric average used for compliance. All sample results, regardless of who collected the sample set, must be included in the sample set for averaging. The overall goal is to achieve the most precise measurement of the average asbestos concentration in a mixture of one or more lithologies.

To fully characterize asbestos at a site, each rock type and variations within a rock unit must be sampled individually using both an incremental sampling approach to account for natural variation in a unit combined with targeted sampling to establish the highest concentration of asbestos within a unit. Once the occurrence, location, and concentration of the rock units, and even the stockpiles, is fully evaluated, the actual concentrations in air during disturbance becomes the critical part of the project. Personal air monitoring using PCM and the NIOSH 7400 method is appropriate for OSHA compliance, and perimeter combined with construction area activity sampling and along roads off of the site and tested by TEM will provide the verification that offsite receptors are not adversely exposed.

Level of Investigation and Standard of Practice

The characterization of NOA in rocks and soil is a highly complex and technical field, and each site is unique in terms of lithology, structure, geologic history, and occurrence of NOA. The NOA investigation must be designed to incorporate these variations. In addition, the level of investigation and approach is often driven by the overall goal and relative risk that the project may present. In the case of the Rock Hill quarry site, the standard of practice for a geologic NOA investigation is elevated due to the following two issues:

1. Rock Cannot be Adequately Wetted

Typical NOA project sites involve weathered rock or loose unconsolidated sediments or materials that can be adequately wetted using standard water application techniques. Once wetted at the source of disturbance, the material remains wetted, and the potential for fugitive emissions remains low during the source-to-disposition process (for example, cutting and filling on a common commercial or grading project). These types of projects are successfully completed on a daily basis in northern California where chrysotile-bearing serpentinite is common. However, neither the Rock Hill quarry project nor the materials to be disturbed are of this type. As correctly noted in their response no. 6 to a question regarding blasting (Response to DEPs comments on the AAMP by Compliance Solutions dated May 12, 2019), *"During normal blasting, there is no effective dust control method"*. The reason for this is that hard rock cannot be wetted, and therefore, fine asbestos particle emissions cannot easily be controlled. Fine particles cannot be captured by airborne misting methods. As a result, a unit volume of rock becomes a repeated emission source throughout the process:

1. Drilling - emissions are not effectively captured by shields and vacuum systems that are not designed for fine asbestos particles,
2. Blasting - no dust control measures are effective,
3. Sorting and sizing - pneumatic hammers with no effective dust control measures (pressure sprayers only disperse the fine particles, and do not capture them),
4. Bulldozing - where rock is moved and crushed beneath metal tracks (with emissions blown away by large engine cooling fans),
5. Excavation and loading - (also with crushing beneath the tracks),
6. Hauling - to the crushing and screening operations,
7. Crushing and screening - a particularly high emission source with no effective dust control measures (misters do not capture fine asbestos particles because the size of the water droplet is too large compared to the size of fine asbestos particles- see NIOSH Dust Control Handbook for Industrial Mining and Processing, Chapter 2- Water Spray Systems, Subsection 1- Principles of Wet Spray Systems, Subsection 3- Controlling Water Droplet Size).
8. Hauling - processed material,
9. Treatment of vehicles before leaving the site - Standard wheel washes at the egress points are designed for large particles but not fine asbestos particles. Unless designed as a single pass system, recirculated water containing fine asbestos particles are tracked off site as water drips from vehicles.

2. Residential Receptors are Located Near the Site

According to the AAMP, residential receptors and a school are located nearby, as close as 65 feet from the perimeter of the site. This close proximity increases the potential for adverse exposure. Asbestos concentrations can be particularly elevated on cold days with low winds when little dispersion occurs.

Summary

The combination of disturbance of hard, crystalline rock that cannot be adequately wetted, the repeated emission source of the material, the use of heavy equipment with high emission potential, and close proximity to residential receptors, combine to elevate the quarry project to a potential high-emission and asbestos concentration status. EPA and general industry have come to recognize that asbestos emissions, particularly from amphibole asbestos containing sites, are much more based on activities than the concentrations of asbestos in the ground, with low concentrations in source materials leading to high airborne emissions when disturbed in highly energetic ways such as occur at a quarry site. The dust control measures and air monitoring program cannot be adequately designed without highly reliable data collected during the NOA investigation. A finding at the quarry site of "no asbestos present" as has been cited for the diabase in the documents under review, requires the standard of practice for the geologist conducting the investigation to be elevated above standard regulatory protocol.

Comment 1: The NSSGA Qualitative Geologic Survey Procedure, Which is the Basis for the QGSSP, is Not Appropriate for an NOA Investigation to Assess Potential for Exposure to the Public.

The QGSSP under review mirrors and appears to be derived from the procedures specified in the NSSGA Mineral ID and Management Guide (NSSGA 2009). The stated goal of the program outlined in the Identification Guide is to *"identify and manage potential areas where protocol mineral fibers occur in order to avoid producing aggregate materials which release such protocol mineral fibers in excess of federal, state, or local limits related to asbestos exposure, including Permissible Exposure Limits (PELs) established by the Occupational Safety and Health Administration and Recommended Exposure Limits (RELs) established by the Mine Safety and Health Administration"*. The reference to PELs and RELs suggest that the focus of the program is for worker protection, and that success is tied to worker exposure below regulatory thresholds that have been established for workers. There is no reference to potential exposure to offsite receptors. Thresholds for public exposure are generally much lower than for workers, and the test methods used to determine airborne concentrations are vastly different (see the discussion on air test methods, below). The goal of an NOA investigation should be to provide an accurate and complete data set so that informed decisions can be made regarding both worker and public potential exposure.

The document also states: *"The program outlined in the Identification Guide is intended to be tailored by geologic personnel or consultants such that it is appropriate for the geologic and production realities of a particular site".* This passage suggests that the survey may be modified in accordance with achieving a desired outcome at the quarry, in this case, impacts related to "production realities". An NOA investigation should be unbiased, not tailored to meet a desired outcome, and be fully transparent.

The QGSSP is, therefore, based on a procedure that was designed for the internal use of the mining industry, and it is not consistent with general standard of practice for geologists conducting NOA investigations. This subject is discussed in a later section, below.

Comment 2: The QGSSP Definitions of "Asbestiform", and "Asbestos" are Ambiguous and Subjective, and Cannot be Determined by Current Test Methods.

The QGSSP refers to "asbestos" and "asbestiform", and uses these terms to differentiate NOA from non-NOA materials. There is no consensus regarding the definition of these terms among the NOA scientific community, and there is no regulatory-approved test method to differentiate between elongate mineral particles and "asbestos" particles of the same amphibole mineral. This has led many laboratories to use the properties of commercial asbestos as the definition (see the definition in the NSSGA (2003), for example), and apply it to every natural occurrence of asbestos. Many in the scientific and regulatory community find this inappropriate, and advocate a broader definition for NOA (see the introduction of Erskine and Bailey, 2018, for further details).

The National Institute of Occupational Safety and Health (NIOSH) described the problem as follows:

> "Imprecise terminology and mineralogical complexity have affected progress in research. "Asbestos" and "asbestiform" are two commonly used terms that lack mineralogical precision. "Asbestos" is a term used for certain minerals that have crystallized in a particular macroscopic habit with certain commercially useful properties. These properties are less obvious on microscopic scales, and so a different definition of asbestos may be necessary at the scale of the light microscope or electron microscope, involving characteristics such as chemical composition and crystallography. "Asbestiform" is a term applied to minerals with a macroscopic habit similar to that of asbestos. The lack of precision in these terms and the

difficulty in translating macroscopic properties to microscopically identifiable characteristics contribute to miscommunication and uncertainty in identifying toxicity associated with various forms of minerals. Deposits may have more than one mineral habit and transitional minerals may be present, which make it difficult to clearly and simply describe the mineralogy" (NIOSH, 2011).

EPA concurrence with the view that the properties of asbestos in building materials should not be universally applied to NOA is suggested in a response to comments by the NSSGA and R.J. Lee Group regarding asbestos in the California El Dorado Hills, a key investigation that supported the NOA regulations in California.

In response to a comment regarding the length and width of fibers as an indicator of asbestos, EPA responded:

> "The R. J. Lee Report further states that EPA's data inflated the asbestos fiber count by ignoring the Agency's own "definition" of asbestos. To support this claim, the R.J. Lee Report cites the glossary of "Method for Determination of Asbestos in Bulk Building Materials", EPA 600/R 93/116, 1993, which states, in part, "With the light microscope, the asbestiform habit is generally recognized by the following characteristics: Mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 microns." The building material analytical method is designed to detect commercially processed asbestos in items like floor tiles, roofing felts, paper insulation, paints, and mastics, not naturally occurring asbestos on air filters or in soil samples. To present the 20:1 aspect ratio for commercial grade asbestos as a universal EPA policy, and to advocate its use as an appropriate standard for analyzing air samples of naturally occurring asbestos is inappropriate and contradictory to use of the PCME dimensional criteria as a tool for assessing exposure risk" (EPA, 2006).

In response to the elimination of particles that do not meet the characteristics of commercial asbestos (essentially the practice of screening apparent cleavage fragments from the test), EPA responded:

> "The R. J. Lee Report relies heavily on the geologic distinction between asbestos fibers and cleavage fragments of the same dimensions, with the implication that exposure to cleavage fragments is benign and of little or no health significance. For the purposes of public health assessment and protection, EPA makes no distinction between fibers and cleavage fragments of comparable chemical composition, size, and shape. The EPA Region 9 approach, which is supported by most public health agencies and scientists, as well as the American Thoracic Society, is based on the following: (1) The epidemiologic and health studies underlying EPA and Cal/EPA cancer risk assessment methods were based on exposures to both cleavage fragments and fibers, and were unable to distinguish between the two, (2) The most recent panel of experts to review asbestos risk assessment methods, the 2003 Peer Consultation Panel convened by EPA, concluded that "it is prudent at this time to conclude equivalent potency [of cleavage fragments and fibers] for cancer," (3) No well-designed animal or epidemiological studies have adequately tested the hypothesis that cleavage fragments with the same dimensions as a fiber are benign or that the human body makes any distinction, (4) Studies that purport to show that cleavage fragments are benign are questioned by many asbestos health experts, (5) There are no routine asbestos air analytical methods, including those used by EPA, NIOSH, the Mine Safety and Health Administration (MSHA), the American Society for Testing and Materials (ASTM), and ISO which differentiate between cleavage fragments and crystalline fibers on an individual fiber basis" (EPA 2006).

The problem is further exacerbated when laboratories rely on reference materials supplied by the National Institute of Standards and Technology (NIST) to report fibers as asbestos. For example, if a sample of asbestiform blueschist at the Calaveras Dam site is sent to a commercial -asbestos based laboratory, the fibrous amphibole, glaucophane, would be declared a non-asbestos particle because

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the amount of aluminum in the mineral exceeds the amount in the reference material for crocidolite in building materials. Mineralogists consider fibrous glaucophane to be crocidolite (Amphibole Nomenclature, IMA 1978, and NIOSH Pocket Guide to Chemical Hazards), but the lab would report no asbestos present. If the properties of commercial asbestos were to be applied at the Calaveras Dam site, no respiratory protection for workers would be required by OSHA, no asbestos-specific dust control measures would be required by the California Air Resources Board, and no perimeter monitoring to verify that offsite receptors would be required as well. The result would have been a clear overexposure to workers, and a likely overexposure to offsite receptors. Another example is the Libby superfund site, where amphibole chemical compositions grade from the “regulated” tremolite to the “non-regulated” winchite and richterite. If the properties of commercial asbestos were applied, the richterite and winchite compositions would not be reported, and airborne concentrations and exposures would have been severely understated. These examples illustrate a need to rely on the test methods to determine whether a particle under the microscope is defined as a fiber (rather than arbitrary field methods- see Comment 3, below), and reporting all compositions of amphiboles. This broader data set can then be interpreted, and informed decisions made.

Comment 3: The Field Pre-Screening Procedure in the QGSSP is Neither Consistent with Standard of Practice for a Geologic Assessment for NOA, Nor Likely Compliant with Regulatory Protocol.

The sampling protocol prescribed in the QGSSP begins with a procedure as stated on page 3: *“Found mineral veins will be examined using a hand lense and fine steel pick to assess the presence of fibrous mineral morphology. If potentially suspect mineral morphology is identified, the mineral veining will be photographed and sampled in the following manner…”*.

This procedure is certainly an aspect of every field investigation, but reliance upon it to discriminate the presence, or absence of asbestos, is not consistent with the standard of practice for a geologic assessment for NOA. The underlying assumption is that all NOA is similar in morphology to commercially exploitable commercial-grade asbestos that was mined for the application in building materials (see the definition of asbestos in the NSSGA Mineral ID and Management Guide). This is an incorrect assumption. Large veins or other occurrences in rocks that can be detected visually or using a hand lense are relatively rare. Many igneous and metamorphic rocks are fine grained or include mineral components that are fine grained, and can be detected only through petrographic analysis of thin sections, polarized light microscopy of pulverized samples using oil immersion techniques, or transmission electron microscopy. Even in many building materials where significant quantities of commercial grade asbestos were applied, the asbestos cannot be detected using a hand lense. Examples include floor tiles, plasters, window putty, mastics, sheetrock and joint compound, and many others. If this method was to be used to screen materials from sampling and analysis, the majority of asbestos containing building materials would be assumed to be non-asbestos containing. The application of this screening method in rocks has a similar result: the majority of rocks that contain asbestos would be screened out for testing and assumed non-NOA. Three recent important investigations illustrate this point. At the Libby Montana superfund site (EPA 2014), the asbestos that coexists with vermiculite cannot be detected using the QGSSP field protocol. At the Boulder City Bypass project site, asbestos was first discovered in granitic rocks and sediments derived from granitic rocks using scanning electron microscopy and x-ray diffraction techniques (Buck and Goossen, 2013), even though these rocks have been studied by geologists for decades. At the Calaveras Dam Replacement Project site, fibrous amphiboles were documented in blueschist for the first time using TEM, a significant discovery considering that these rocks have been studied by numerous geologists for more than a hundred years (Erskine and Bailey, 2018). The initial field technique should be used to identify each rock type that will be subjected to standard testing techniques, but not used as a subjective screening tool to eliminate samples from testing.

The procedure in the QGSSP is also not likely compliant with procedures for asbestos investigations where required by EPA and OSHA, nor consistent with the standard practice outlined in the CGS Special Publication 124. The procedure for asbestos in building materials and NOA in rock and soil is

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the same: each suspect material ("homogeneous area") is differentiated by color, texture, condition, and age, and each are to be sampled and tested independently. On a site where suspect asbestos containing materials are present, each geologic unit must be assumed to be Asbestos-Containing Material (equal to or greater than 1% asbestos) unless otherwise determined by appropriate testing. There can be no pre-screening screening using field and visual methods.

Comment 4: The Test Methods Prescribed in the QGSSP for Rock, Water and Air May Severely Underestimate Asbestos Concentrations.

Test methods for asbestos in bulk, air and water are somewhat unique in that the number of particles, and therefore concentrations, differ depending on the test method selected. The method that is selected must be based on the regulatory requirement combined with the information that is needed for an informed decision. Some methods have an inability to detect fine particles. Others report fibers of particular lengths and widths, and eliminate the remaining fibers. In the case of air, for example, a single sample can yield as many as five different concentrations depending on the test method selected. Which one to use? The test methods that are prescribed in the QGSSP are inappropriate largely because they are not the correct method for the application that it was designed for, or do not reveal the data of interest. In each case, the concentration of asbestos can be severely underestimated, including a finding of no asbestos present when this may not be the case. The following is a summary of the test methods that are prescribed, a description of their deficiencies, and recommendations for alternative methods that meet the standard of practice for NOA investigations.

Testing of Rock and Soil

The testing protocol and test methods prescribed in the QGSSP are described in its Attachment 1: Sample Analysis Procedures and Methods. The following is the procedure prescribed in Attachment 1 (in black font), with comments at various points (indented in red italics).

Attachment 1
Sample Analysis Procedures and Methods
(From the QGSSP)

"For obtaining a representative sample from a large bulk sample, the AASHTO procedures for reducing the sample should be used".

> *The AASHTO procedures for reducing the sample was not designed for NOA investigations. The sample collection and preparation should follow, as a baseline, the CARB 435 Method (CARB 1991) and in particular, the CARB implementation guidance document that investigated deficiencies and recommends improvements (CARB 2017). It should be noted that in response to comment 2 in the April 25th Response to PA DEP and Rockhill Township document, Earthres stated that the CARB 435 method for sample frequency was not designed for the site because the CARB 435 method was originally designed for serpentine aggregates. However, CARB later specified that the CARB 435 method be used for "aggregate and other bulk materials" (see the subheading titled "test methods" in CARB, 2002). The CARB 435 method and guidance document, while having deficiencies that are corrected using TEM augmentation (see below), are considered the standard of practice for collection, sample preparation, and testing. It should be noted that the sampling frequency selected for characterization at the site and a frequency selected for characterization of processed aggregate material are different and selected for different reasons and purposes. This subject and recommendations are described below Comment 5: Frequency of Testing for Processed Aggregate Stockpiles and other units.*

"The subsequent analyses of the submitted samples will follow a three-step procedure: 1) Basic microscopic analysis to assess the presence of asbestiform mineral habitat";

Basic microscopic analysis, or any microscopic analysis cannot definitively determine whether a particle is asbestiform (see Comment 2 and 3, above).

2) "Polarized Light Microscopy (PLM) to determine the presence and asbestos mineral type, if present";

PLM analysis, if employed, should follow the CARB 435 method which assigns a numeric value based on point counting. The use of Table 3 in that document is considered to be erroneous for NOA, and should not be used.

"and, 3) Should positive results be indicated by PLM, follow-up Transmission Electron Microscopy (TEM) analysis will be completed to confirm the minerals present and their morphology".

It has been well established that PLM analysis cannot detect small and narrow fibers, particularly this that are less than 0.25 microns in width. This is a significant cutoff point because asbestos fibers average about 0.3 microns, and fibers less than about 0.25 microns are thought to have a higher toxicity than wider fibers. Because of this limitation, PLM is generally used as a pre-screening. If a trace amount of asbestos is detected (<0.25% as determined by the method), or asbestos is not detected, then the sample is tested by TEM to truly quantify the concentration in weight percent, of verify that it is not present at an analytical sensitivity of 0.005 – 0.0001 structures per gram. This is the procedure used by the California Department of Toxic Substances Control for school sites, and is considered the standard of practice for NOA sites.

"The techniques and methods to be employed in sample analysis are provided below:

• A geologist will inspect hand and core samples initially using a stereo binocular microscope, with magnification ranging from 10x to 60x. Using a fine steel pick (dental pick) the geologist will scrape the surface of the suspect mineralization to determine if any of the minerals display typical asbestiform habit and characteristics such as fiber bundles, splayed ends, or matted or fibrous masses".

See Comments 2 and 3, above. While observing minerals in hand sample and under a stereo binocular microscope is standard practice, a determination, other than an opinion, if a particle is asbestiform cannot be made, and therefore, cannot be used to screen out the sample for proper testing.

• "Further examination of the sample will then be conducted using the Polarized Light Microscope (PLM) using EPA 600/R-93/116".

This method is designed for commercial asbestos in building materials. The CARB 435 method and guidance document incorporates this method and adds needed protocols for sample preparation and other important procedures that are specific to rock and soil.

• "If asbestiform minerals are found, representative samples will be further analyzed by Transmission Electron Microscopy per EPA 600/R-93/116 to confirm mineral identification and morphology".

The reporting of asbestos cannot be pre-screened for testing based on an arbitrary definition of "asbestiform". See Comments 2 and 3, above. It is recommended that each lithology or structure at the site be tested by both CARB 435 and TEM. CARB 435 can identify large bundles, and TEM can identify all fibers and provide a concentration needed for OSHA compliance (certain mandatory controls and protection are triggered at the 1% level, including mandatory use of respirators).

• "Where appropriate, the microscopic PLM and/or TEM analyses will include a count of the asbestiform fibers, representative digital images, and measurements of the width and length dimensions of found fibers counted".

> *Both analyses should include a count and concentration (or value in the case of PLM) of asbestos. All structures defined as fibers or bundles per the test methods should be included, not just those determined by an arbitrary definition of "asbestiform". No counting rules allow for the elimination of countable structures based on an opinion of whether the structure is asbestiform in habit or not.*

Testing of Water

Appendix 1 of the QGSSP provides the protocol for the testing of water at the site. It states:

"Water samples will be collected as grab samples and will be analyzed by TEM per EPA 100.2."

Some water samples have been collected at the site and the laboratory reported no asbestos detected. These results should not be accepted because the test method was not designed for the intended purpose, and may severely under report asbestos in the sample. There are two standard EPA methods for reporting the concentration of asbestos in water: EPA 100.1 and EPA 100.2. Both methods are similar in the collection, sample preparation, identification of asbestos fibers, and calculation of concentration. They differ in one significant aspect: EPA 100.1 counts and reports all fibers that are greater than 0.5 microns in length, while EPA 100.2 counts and reports fibers that are greater than 10 microns in length. EPA 100.2, the method specified in the QGSSP and the method used for samples collected at the site, was designed for potable water supplies for the purpose of measuring asbestos concentrations against the EPA drinking water standard of 7 MFL (million fibers per liter) represented by fibers that are greater than 10 microns in length. This method should be used only for potable water quality compliance purposes. For all other applications, EPA 100.1 is the standard. This method reports all lengths and widths (above 0.5 microns in length), and provides a complete data set regarding the dimensions and concentration of asbestos in water.

To get a feel for the importance of the different counting rules, consider the presence of asbestos in California reservoirs. Reservoir water in northern California where serpentinite and other NOA-bearing rocks are present in the reservoir's watershed contain asbestos, a subset of particles that are delivered to the reservoir through winter storm runoff. A detailed analysis of chrysotile and amphibole asbestos within the Calaveras reservoir was conducted to assess potential impacts to workers and offsite receptors due to the use of millions of gallons of water applied for NOA dust suppression and control (the primary concern was the application of asbestos in areas outside of the OSHA Regulated Areas, and the possibility of the escape of asbestos as fine airborne water droplets evaporate on warm days). Over the time period of two years, the average concentration of asbestos was approximately 50 MFL, a concentration that is comparable to other northern California reservoirs. Over the project duration, this equated to approximately 10^{12} fibers applied to the site through hoses, sprayers and water trucks. However, no fibers that were detected exceeded 10 microns in length. When the counting rules of EPA 100.1 were applied, the average concentration was 50 MFL. When the counting rules of EPA 100.2 were applied, the laboratory reported no asbestos detected. Therefore, the water samples tested at the Rock Hill quarry site by EPA 100.2, with no asbestos detected, did not provide a reliable assessment of asbestos concentration. Assuming that the filter preparation of the water samples has been archived by the laboratory, they should be reanalyzed using the counting rules of EPA 100.1. A reported concentration of asbestos in the water would indicate that asbestos is present in the source material of the particles in the water. A negative test at a low analytical sensitivity may suggest that little or no asbestos is present in the source materials.

Testing of Air

The Asbestos Air Monitoring Plan (AAMP) describes the procedures and test methods for the analysis of samples collected at perimeter air stations. The purpose of the perimeter stations is usually to verify that the dust control measures are effective, and the concentration of asbestos leaving the site will not produce an adverse exposure to offsite receptors. The collection and test methods for perimeter stations and worker personal monitoring are distinctly different, and the results are compared to very different thresholds. It is important that the worker personal samples are collected in accordance with OSHA mandated methods for comparison with the OSHA asbestos Permissible Exposure Limit (PEL) of 0.1 fibers per cubic centimeter (0.1 f/cc), and perimeter samples are collected and analyzed in accordance with EPA standards, for comparison with a risk-based threshold. In California, the standard risk-based threshold for sites where offsite receptors are located within a mile of the perimeter is 0.016 asbestos structures per cubic centimeter (0.016 s/cc). Note that for each type of monitoring (personal vs. perimeter), the collection media (0.8 micron vs. 0.45 micron filter pore size), the counting rules (fibers greater than 5 microns in length and greater than 0.25 microns in width vs. all structures greater than 0.5 microns in length), and identification of a countable particle (fibers vs. structures) are different, and cannot be directly compared. This will be discussed further below.

The procedures and analytical techniques used for the perimeter monitoring are inappropriately applied for exposure assessment to offsite receptors because they are designed for worker protection and OSHA compliance. The standard for OSHA compliance is the application of the NIOSH 7400 and NIOSH 7402 methods, which are specified in the AAMP. NIOSH 7400 specifies a 0.8-micron pore size filter for two reasons. First, OSHA is interested in fibers that are greater than five microns in length, and a 0.8-micron filter will adequately capture the particle size of interest, but this is not true for perimeter and ambient monitoring where asbestos structures of 0.5um in length would pass through the filter.

The required protocol specified by NIOSH 7400, and proposed in the AAMP, begins with the collection of air in the breathing zone of the worker using portable low-flow pumps (the AAMP specifies sample collection at a height equal to the breathing zone). The sample is then analyzed by Phase Contract Microscopy (PCM) using a strict set of counting rules. PCM cannot differentiate asbestos fibers from non-asbestos fibers, so the concentration of all fibers that meet the counting criteria are reported, and will include both asbestos and non-asbestos fibers. An 8-hour time weighted average (TWA) is then calculated, and this value is compared with the PEL. Exceedance of the PEL triggers additional dust control measures and respiratory protection to reduce the exposure to below the PEL. When exposures exceed the PEL, the NIOSH 7402 method may be employed. This method uses TEM to calculate the ratio of asbestos to non-asbestos fibers, and this ratio is then applied to the original concentration, often reducing the final TWA. This asbestos-only concentration is then compared to the PEL. Note that the NIOSH 7402 method does not allow a concentration to be reported that can be used as a surrogate for the PCM result. Only the ratio of asbestos to non-asbestos is reported, and applied to the original sample (note that a concentration can be calculated, and the value used for management purposes, but not for compliance or comparison with a site threshold).

Perhaps the most critical component that is relevant to offsite exposure is the counting rules employed by the 7400 method. It counts and reports only fibers that are greater than 5 microns in length and 0.25 microns in width. All fibers that are less than 5 microns are not included, and all fibers less than 0.25 microns in width are not reported, and therefore, the AHERA-equivalent concentration is severely under reported for offsite exposure analysis. For example, a dimensional analysis of asbestiform amphibole fibers at Calaveras Dam perimeter stations showed that only 6% of the fibers and bundles met the NIOSH 7400 size criteria, and therefore, the concentration reported at the perimeter stations would have been 6% of the actual concentration.

EPA methodology for non-workers specify a 0.45-micron filter because loading is lower at a distance from soil disturbance, and the test method to be applied is the method referred to as the AHERA method (Asbestos Hazard Emergency Response Act, 40 CFR Pt. 763, Subpart E, App. A), which counts asbestos structures that are greater than 0.5 microns in length. The AHERA method is the standard of practice for establishing fugitive airborne concentrations, and should be employed at the quarry site.

Comment 5: Frequency of Testing for Processed Aggregate Stockpiles and Other Units.

Several comments and responses in various documents are related to the appropriate frequency of testing. In response to a comment by the East Rockhill Township (letter dated April 17, 2019), Earthres responded in a letter dated April 25, 2019: *"However, as California has the most developed programs and guidance for asbestos determinations, we surmise that the Department mandated a conservative (greater) initial sampling frequency for the processed aggregate stockpiles based on that available guidance".* This is a sound decision because the CARB 435 method and subsequent improvements in the CARB 435 Implementation Guidance Document was developed largely to assure that samples collected at the stockpiles are representative of the material, and that the material remains representative throughout the sample preparation and testing process. It should also be noted that these documents should not be considered in isolation. Two other relevant documents, the CARB ATCM for surfacing applications (CARB 2001) and the CARB ATCM for Construction, Grading, Quarrying and Surface Mining Operations (CARB 2002) also represent restrictions and practices developed following years of experience with NOA projects. They should not be considered "conservative", rather, they represent the core of the standard of practice for NOA projects, and should be used as a starting point, with additional practices applied where appropriate.

To reiterate a point made in Comment 4, the statement by Earthres that the CARB 435 method for sample frequency was not designed for the site because the CARB 435 method was originally designed for serpentine aggregates is not correct. A review of the four CARB documents will reveal that the CARB ATCM for surfacing applications define aggregate as "a mixture of mineral fragments, sand, gravel, cobbles, rocks, stones, or similar minerals that may or may not be crushed or screened". The ATCM for construction clarifies the use of CARB 435 for non-serpentinite sites as follows: *"References in ARB Test Method 435 to "serpentine aggregate" shall mean "gravel" or other "bulk materials" to be tested for asbestos content"*.

Processed aggregate stockpiles, in situ rocks on the bench faces, and rocks occupying the boulder field are independent entities, and require testing independently with a frequency based on the intent of the sampling. The sampling protocol and frequency for the overall site has been discussed above. Comments on the processed aggregate materials and boulder field are provided below.

Processed Aggregate Stockpiles

CARB Method 435 (CARB,1991) originally specified a single test for 1000 tons of aggregate for piles and conveyor belts. The test method was to be applied to a companion Asbestos Airborne Toxic Control Measure (ATCM) that specified restrictions for the sale and use of aggregate material for surfacing applications (CARB 2001, reviewed in 2008). The CARB 435 method provides a value related to the surface area projection of particles, not a true concentration. Restrictions for surfacing applications are placed at 0.25%. After several years of review and study, CARB conducted extensive tests and updated protocols in the CARB 435 Implementation Guidance Document (CARB, 2017). One improvement was increasing the sample frequency to a minimum of three random grab samples per 1000 tons. It goes on to state: *"In situations of observed aggregate heterogeneity, such as notably different rock types that may indicate variable sources of aggregate material, ARB staff recommends collecting more than the minimum of three grab samples, each consisting of about 20 to 30 increments".*

Although the sampling frequency meets the minimum CARB requirement for the use of material for surfacing applications, such as use on the surface of a highway embankment, the frequency is too low to provide assurance for material being processed and hauled through residential or commercial areas.

Also note that the CARB 435 test uses PLM as the required microscopic method. As discussed above, PLM cannot detect fine particles, and if potential health risk is the issue, TEM should be employed as well.

It should be emphasized that the concentration of asbestos in rock cannot be equated to the potential for airborne asbestos. EPA has determined that very low concentrations in rock and soil can result in elevated airborne concentrations resulting in adverse exposures to the public. Based on this determination, the California Department of Toxic Substances Control uses a threshold of 0.01% by weight, measured by TEM, as a threshold for response actions such as capping and long-term NOA management on school sites.

The most direct way to assess the potential for airborne emissions of asbestos is through direct air testing using TEM. CARB specifies air testing as follows: "*Analysis of all air samples shall follow the analytical method specified by the United States Environmental Protection Agency, Asbestos Hazard Emergency Response Act (AHERA) criteria for asbestos (40 CFR, Part 763 Subpart E, Appendix A, adopted October 30, 1987), with the following exceptions: (A) The analytical sensitivity shall be 0.001 structures per cubic centimeter (0.001 s/cc); and (B) All asbestos structures with an aspect ratio greater than three to one (3 to1) shall be counted irrespective of length".* This is what is referred to as the CARB/AHERA method using TEM, and is the standard practice on NOA sites.

Area-specific air monitoring may assist at areas where high disturbance activities occur. One example, is the rock crushing facility. At the Calaveras Dam project, the Certified Industrial Hygienist for the Contractor measured high emission rates, airborne asbestos concentrations, and personal exposures associated with rock crushing operations. The concern for worker exposure and potential unacceptable asbestos concentrations at a nearby perimeter monitoring station, combined with logistical challenges, led the Contractor to discontinue crushing operations and instead import aggregate material for finger drains, blanket drains, chimney drains and lateral filters during dam construction.

It is recommended that, in place of additional testing above that required to achieve a sample set that is representative of each rock unit, the air monitoring program include Construction Area Activity monitoring near the points of major rock disturbance and locally where the generation of dust may impact offsite receptors. This system was successfully used at the Calaveras Dam project. Three areas that would benefit from this second layer of air testing would be at the rock crushing facility, surrounding the primary quarrying area during all disturbance activities, and along roads where hauling of material may track out NOA onto the public streets. Air samples should be collected and tested by the CARB/AHERA TEM method, not PCM by the NIOSH 7400 method which is designed for worker exposure.

<u>Boulder Field</u>

The boulder field is not processed aggregate, and is more aligned with the undisturbed rocks at the site. It is recommended that the approach for investigation be included into the site survey as a separate unit. The approach and frequency of sampling should mirror the overall investigation, and an independent data set be collected. The boulders should be inspected for differences in lithology, color, texture, mineralogy, and each sub unit be sampled and tested independently. The number of samples should not be tied exclusively with the tonnage of material. Rather, the sample set for each sub-unit should be adequate to characterize the materials and be considered representative of each material. It is appropriate, considering that these materials are now out of place, to use the frequency as a guide and use the three samples per 1000 tons as a lower limit. This frequency may not achieve representativeness, and more samples would be required. Once the material is processed, an additional test by CARB 435 protocol will be required for this material that consists of a composite of each geologic unit that is represented in the volume of rock processed.

Summary of Recommended Procedures for NOA Sampling and Testing

The QGSSP as written is procedurally and technically flawed, and should be revised to meet a standard of practice for a geologic investigation for NOA. While the standard of practice may vary from site to site, the standard should be elevated due to the intensity of rock disturbance during quarrying operations and the close proximity to residential receptors. The procedures employed at the Calaveras Dam and Boulder City Bypass projects should provide the model. Both projects were completed successfully, with all challenges that come with unforeseen conditions solved. If no asbestos is present, or sufficiently low concentrations that would not drive significant response actions are present, then the geologic investigation should produce sufficient, complete and accurate data to provide a high level of confidence that this is the case.

The following is an outline of the sample procedures and testing requirements recommended to meet the project goals:

- A thorough geologic survey should be conducted to identify each lithologic and structural unit "homogeneous area" that may contain different compositions or concentrations of amphiboles. Differences with in the diabase such as grain size, color, composition, presence of xenoliths, veining, ductile and brittle shearing, and other units that can be distinctly broken out or mapped should be tested independently.

- Duplicate samples should be set aside for quality assurance purposes.

- Each unit should be sampled using both incremental and targeted methods. Sample frequency should be a minimum of three samples from small volume units such as xenoliths, to a minimum of ten for large volume units. If the diabase is relatively homogeneous, then the frequency should be elevated to 30 or more incrementally composited samples. Units of particular concern such as the green veining should be sampled at a higher frequency to characterize differences across the site because of the geologic conditions operating during vein formation is not known, veining may have occurred over a large period of time (perhaps millions of years) during a phase where fluid processes and chemistry is changing, and visual inspection may not be adequate to differentiate significant mineralogic and chemical differences of veins that appear to be similar. In each case, the frequency should be sufficient to collect a sample set that is representative of the unit, and sufficient to characterize differences that may not be visually apparent.

- The out of place rocks comprising the boulder field should be sampled as per the site materials, but considered a separate unit. Because they are out of place, it is appropriate to use the frequency as a guideline for minimum sample frequency, but the overall objective is to collect a sample set of each lithologic and structural unit that is representative of those units.

- To address concerns for potential exposure, the sampling of processed aggregate material should be at a higher frequency than the three per 1000 tons (minimum) requirement specified in the CARB 435 guidance document.

- Samples should be prepared by the CARB 435 method and CARB 435 guidance document, with milling by a disc pulverizer. The milled samples should be mixed by using a four-axis mixer to prepare a homogeneous sample.

- Samples should be tested using both PLM, using the CARB 435 method, and TEM, using the EPA 600/R-93/116 and CARB-modified bulk TEM protocol modified for NOA analysis (CARB/AHERA method). Amphibole fibers by PLM should not be excluded from reporting on the basis of inclined extinction. Amphibole structures by TEM should not be excluded on the basis of a chemical dissimilarity with those in building materials or reference materials for building materials. All amphiboles should be included in the analysis, and each should be identified per the International Mineralogical Association classification system.

- Water samples should be analyzed using EPA Method 100.1, using the same mineralogical classification specified above for rock samples.

- Air samples that are not for personal protection purposes should be sampled and analyzed by the AHERA method, with the same requirements for mineralogical classification specified for rock samples.

- It is recommended that thin sections of each rock unit be prepared for petrographic analysis. The analysis of the minerals *in situ* is a powerful technique to investigate the presence of fine structural detail such as fibrous overgrowths coexisting with non-asbestiform minerals, asbestos in micro-veins, and other microstructural features.

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Appendix

Regulations, Publications and Guidance Documents

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NIOSH, 1994b, Asbestos by Transmission Electron Microscopy (TEM), NIOSH Method 7402, Issue 2.

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Geologic Investigations Hazardous Materials Naturally Occurring Asbestos

September 1, 2019

Subject: Final Revision REV 3
Review of Asbestos Test Results
Rockhill Quarry
East Rockhill Township
Bucks County, PA

This report presents a technical review of four laboratory reports posted on the East Rockhill Township web site, and provides recommendations for additional testing and alternatives to avoid the potential exposure to residents and school children located near the quarry site.

The four reports that were reviewed are as follows:

- June 26 2019 lab sample May 30 2019 (2019-06-27-Lab-Results-sample-receipt-5-30-2019-LLH901997-7)

- June 26 2019 lab sample June 3 2019 (2019-06-26-Lab-Results-sample-receipt-5-30-2019-LLH901997-8)

- June 27 2019 lab sample May 30 2019 (2019-06-26-Lab-Results-sample-receipt-6-3-2019-LLH901997-9)

- June 27 2019 lab sample June 3 2019 (2019-06-27-Lab-Results-sample-receipt-6-3-2019-LLH901997-10)

Purpose

The scope of this review was as follows:

- Was the chosen test method appropriate to assess the potential risk to offsite receptors, particularly children who are particularly at risk to asbestos exposure?
- Does the method used to quantify the asbestos content provide an accurate representation of the actual concentration of asbestos in the samples?
- Are there limitations of the chosen test method that prevents full detection of asbestos fibers?
- Was the chosen test method adhered to as designed, or was there a modification to the analysis or reporting requirements? If so, did the modification enhance the analysis by overcoming some deficiencies, or did it under report the asbestos concentration?
- Are there alternative test methods that can better quantify the concentration of asbestos for the purpose of assessing potential health risk?

This review and recommendations that follow represent the opinion of the author and based on experience running an asbestos testing laboratory, more than 32 years of experience in the field of NOA, consulting for clients who are concerned with both regulatory compliance and potential risk to offsite residents, consulting on sites where oversight is required by regulatory agencies, and involvement within the NOA scientific community. One missing piece of information that would have been helpful in the review was not available: the test results were not accompanied by a report that described the sampling protocol, test method procedures, and identification of deviations and enhancements to the chosen method. However, there appears to be sufficient information within the lab bench sheets that allow interpretation of the methods used. All of these factors were considered as the basis of this opinion.

Why is a sampling and testing program using standard of practice, accepted analytical test methods, and enhancements that are applied to NOA important?

Quarrying at the Rockhill quarry site constitutes a high-risk operation because of four factors that contribute to potential risk of exposure. The four factors are described below:

1. Rock cannot be adequately wetted

Typical NOA project sites involve weathered rock or loose unconsolidated sediments or materials that can be adequately wetted using standard water application techniques. Once wetted at the source of disturbance, the material remains wetted, and the potential for fugitive emissions remains low during the source-to-disposition process (for example, cutting and filling on a common commercial or grading project). However, neither the Rockhill quarry project nor the materials to be disturbed are of this type. Hard rock cannot be wetted, and therefore, asbestos particle emissions cannot easily be controlled. Fine particles cannot be captured by airborne misting methods.

2. During quarry operations, a unit volume of rock becomes a repeated emission source throughout the process.

Most construction projects involve a two-step disturbance process where asbestos emissions are generated: excavation, bulldozing or scraping of material, and placement and compaction into fill. A quarry, however, is a multi-emission operation. Consider the various points of emissions during quarrying operations and transporting processed aggregate material on public roads through residential areas:

1. Drilling - emissions are not effectively captured by shields and vacuum systems that are not designed for fine asbestos particles,

2. Blasting - no dust control measures are effective,

3. Sorting and sizing - pneumatic hammers with no effective dust control measures (pressure sprayers only disperse the fine particles, and do not capture them),

4. Bulldozing - where rock is moved and crushed beneath metal tracks (with emissions blown away by large engine cooling fans),

5. Excavation and loading - (also with crushing beneath the tracks),

6. Hauling - to the crushing and screening operations,

7. Crushing and screening - a particularly high emission source with no effective dust control measures (misters do not capture fine asbestos particles because the size of the water droplet is too large compared to the size of fine asbestos particles),

8. Hauling - processed material,

9. Treatment of vehicles before leaving the site - Standard wheel washes at the egress points are designed for large particles but not fine asbestos particles. Unless designed as a single pass system, recirculated water containing fine asbestos particles are tracked off site as water drips from vehicles.

3. Residential receptors and school children are located near the site

Because the latency period for asbestos-related disease begins with the onset of first exposure, young children are particularly at risk from asbestos exposures. It is reported that children occupying residences are located as near as 300 feet from the quarry, and several schools are located within 5 miles of the site boundary (see Table 1). The overall risk is greatly elevated as compared to workers at the site and adults that reside or work nearby. The children at Upper Bucks Christian School/Daycare located only 0.5 miles from the quarry are particularly at risk. Asbestos concentrations diminish as a function of distance, and although children as far as five miles from the quarry may be exposed, the risk to those who reside or attend schools within a mile of the asbestos source is significantly elevated. Based on experience over the last two decades, California air resource agencies, who have the most developed rules and regulations for NOA in the country, use the one-mile distance as a trigger for mandatory air monitoring to verify that the required dust control measures are effectively preventing adverse exposures.

4. Asbestos-containing soil and aggregate will be transported through residential communities

As noted above, asbestos concentrations diminish with distance, and children within residences and at schools located outside of the arbitrary one-mile distance have a lowered risk for adverse exposure. However, the hauling of asbestos-containing soil and aggregate through residential areas change this general assumption. Soil and mud track out prevention measures at egress points of construction sites are not particularly effective for fine asbestos particles, and coverings on haul trucks are not designed to contain asbestos. As a result, children at locations considered to be far-source receptors become near-source receptors due to accumulated spillage from haul trucks and track out on public roads.

Summary of Findings and Recommendations

<u>Findings</u>

Significant and actionable concentrations of actinolite asbestos was reported in numerous samples at the Rockhill quarry.

The key data from the reports are presented in Table 2. Columns 2 and 3 summarize the data that was reported for “asbestos fibers” (highlighted in blue). Columns 4 and 5 summarize the data that was reported for “non-asbestos fibers”, and identified as “non-asbestos fibers-cleavage fragments” (highlighted in green). Column 6 summarizes the Total Asbestos using EPA’s definition of an asbestos fiber and required for reporting using the test method that was specified in the lab reports. This concentration is, essentially, the sum of the two results that were differentiated using morphological and/or extinction angle criteria. Column 6 should be used as the asbestos result because neither EPA, reporting requirements specified by lab test methods, the laboratory community, nor Professional Geologists recognize differential counting as a means to reduce the reported asbestos concentrations. These issues, and other deficiencies in regards to the choice of the test method and the likely under reporting of asbestos, are described below.

The levels of asbestos that were reported are actionable regardless of which column is referenced. Using activity-based sampling to assess exposures at the Oak Ridge School in the El Dorado Hills, California, the Federal Agency for Toxic Substances and Disease Registry (ATSDR) conducted a risk assessment for airborne asbestos concentrations from disturbance of soils at the site. The asbestos concentrations in soil were comparable with those found at the Rockhill quarry (>75% of samples had asbestos concentrations below 1%). The ATSDR found that the risk was significant,

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and comparable to ambient levels nearby active quarries (see the two highlighted sections in Appendix A). Based on this study and other data, the California Department of Toxic Substances Control (DTSC) set 0.01% asbestos as the threshold to require asbestos mitigation such as capping at school sites, and air monitoring during construction.

The limit of quantitation of the chosen test method is too high to assess whether an actionable concentration of asbestos is present.

Notwithstanding the deficiencies in the chosen test method described below, the limit of quantitation of 0.1% is ten times the accepted action level of 0.01%. As a result, the analyses likely under reported the concentration of asbestos.

The chosen test method is not appropriate for Naturally Occurring Asbestos.

The laboratory reports identified test method EPA/600/R-93/116 as the method chosen to analyze the samples. This method was designed specifically for asbestos in building materials, which uses a protocol designed to test for asbestos that was mined commercially and incorporated in building materials. The method, when not enhanced to test for non-commercially exploitable asbestos, can severely under report the actual asbestos content through the elimination of amphibole compositions that were not mined commercially. It is possible, if not likely, that the laboratory under reported the asbestos content in the materials sampled. This deficiency can be corrected by utilizing Transmission Electron Microscopy (TEM) to augment the analysis.

The chosen test method cannot detect fine asbestos fibers.

Test method EPA/600/R-93/116 uses Polarized Light Microscopy (PLM) to identify amphiboles. The method was designed to detect asbestos in building materials where asbestos consisted of large macroscopic bundles and masses and applied in large quantities. Fine fibers, generally considered to be <0.25μm in diameter, are invisible, and cannot be detected. The problem is exacerbated when concentrations are < 1%, the concentration that the test method was originally designed to test for. It is likely that more asbestos is present in the samples, and the laboratory under reported asbestos because the fine particles are not visible by PLM. This deficiency can be corrected by utilizing TEM to augment the analysis.

The chosen technique used to quantify asbestos concentrations does not adequately quantify asbestos concentrations.

The point counting method that was chosen to quantify asbestos concentrations relies on counting the percentage of asbestos particles relative to non-asbestos particles in a population of 1,000 particles. The percent asbestos that is reported, such as 0.1%, is not a valid concentration. The reported value is not related to weight percent or fibers per gram of material, rather, it is related to the surface area (or more accurately, the widest dimensions of particles) as viewed down the microscope and projected on a two-dimensional plane. Thus, the reported value is, at best, and area percent. This deficiency can be corrected by utilizing TEM to augment the analysis, which can accurately determine the weight percent of asbestos as well as the number of fibers per gram of material.

The laboratory differentiated particles of the same composition as "asbestos" and "cleavage fragments", which under reports the amount of asbestos detected. The test method selected to analyze the samples does not allow for this arbitrary differentiation.

The chosen test method provides the procedures to analyze for and report the relative proportion of asbestos in a sample. The method specifies that all particles that meet the definition of a fiber be counted, and all amphibole fibers that belong to one of the five "regulated" amphiboles be reported as asbestos. However, the lab reports differentiate amphibole fibers into two categories: "asbestos" and

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“non-asbestos cleavage fragments”. The practice excludes fibers that meet the EPA definition of asbestos from being reported as asbestos. The practice of differential counting is not accepted by EPA, and has documented this position publicly in written form in a rebuttal to arguments posed by the R.J. Lee Group (see highlighted areas in Appendix B). There is no approved or recognized test method that specifies the protocols for such a differentiation, so the laboratory apparently uses an arbitrary standard that has neither been peer reviewed nor accepted. Based on the notations in the lab bench sheets, the analyst appears to have used an optical property called parallel vs. inclined extinction to differentiate separate fibers that were interpreted to have crystallized in the asbestiform habit from those that crystallized in the crystalline form. Non-asbestiform minerals become fibers by fracturing along planes of weakness called cleavages, often producing fibers that are dimensionally equivalent to asbestiform fibers, and therefore, are counted as, and considered to be, asbestos. It is recognized that it is the dimensional properties (length and width) of a particle that produces a toxicity, and not the mechanism that created the fibers. Therefore, the lab reports severely under report the concentration of asbestos (see column 2 vs. column 4 in Table 1). Assuming that the testing of the materials was conducted in accordance with the specified test method, the actual concentration that should be reported is shown in column 6. Therefore, the laboratory underestimated the concentration by a factor of 800% (0.02% vs. 0.16%).

Recommendations

The review of the laboratory test results found that the laboratory methods, quantitation methods, and inappropriate deviations from standard of practice indicate that the sampling and analysis program that was implemented at the Rockhill quarry site is inadequate and deficient to assess and quantify the concentration of asbestos. The test method was inappropriate for Naturally Occurring Asbestos and cannot detect fine particles; the point counting method of quantitation neither quantifies asbestos concentrations nor reached a limit of quantitation needed for the purposes of assessing potential health risk; and the arbitrary differential counting method used to reduce the reported amounts of asbestos is not acceptable for the purposes of health risk evaluations.

The following are recommended alternatives that can be considered to fully characterize the asbestos concentrations in the materials, and produce data that can allow an informed decision regarding the potential risk to residents and children at the nearby school.

1. The asbestos sampling was conducted by a representative of the quarry owner/permit holder, as was the analytical testing. The purpose and goals of the testing for a quarry operator vs. a public agency that is interested in the health and safety of residents is very different. The results that were reviewed should not be relied upon for the purposes of potential health risk by fugitive asbestos particles. To avoid a conflict of interest, either real or perceived, and produce test results that will be considered reliable, the Pennsylvania Department of Environmental Protection (DEP) should contract with a Professional Geologist and qualified testing laboratory who are not affiliated with the mining industry.

2. The Professional Geologist should re-sample the materials that are of interest.

3. Samples should be prepared by the CARB 435 method and CARB 435 guidance document, with milling by a disc pulverizer. The milled samples should be mixed by using a four-axis mixer to prepare a homogeneous sample.

4. The samples should be tested using both PLM, using the CARB 435 method, and TEM, using the EPA 600/R-93/116 and CARB-modified bulk TEM protocol modified for NOA analysis (CARB/AHERA method). Amphibole fibers by PLM should not be excluded from reporting on the basis of inclined extinction. Amphibole structures by TEM should not be excluded on the basis of a chemical dissimilarity with those in building materials or reference materials for building materials. All amphiboles should be included in the analysis, and each should be identified per the International Mineralogical Association classification system.

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5. It is recommended that thin sections of each rock type be prepared for petrographic analysis. The analysis of the minerals *in situ* is a powerful technique to investigate the presence of fine structural detail such as fibrous overgrowths coexisting with non-asbestiform minerals, asbestos in micro-veins, and other microstructural features.

6. To provide additional information regarding the potential risk to residents and school children, in advance of any quarrying operation, it is recommended that an air modeling be conducted to provide a predictive capability to airborne dust concentrations at off-site locations. The standard modeling program is EPA's AERMOD, a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence and other inputs. Using standard EPA emission rates for equipment at the site, particle concentrations can be evaluated at any point offsite for the duration of the project. Air modeling is fairly commonplace at sites such as quarries where high emissions are predicted, and the data from the model can be used to calculate a risk-based threshold for the site perimeter program.

7. Consider using an alternative quarry for the Turnpike Milepost A31-A38 project. At least four quarries located at comparable distances from the turnpike project as the Rockhill quarry (see Table 3). One, Naceville Materials, is located less than a mile from the project. Supplying aggregate and other materials from one of these quarries would significantly reduce, or eliminate, the potential for asbestos exposure from operations at the Rockhill quarry and along quarry hauling routes on public roads and through residential neighborhoods.

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Table 1

Schools Located Within 5 Miles from the Rockhill Quarry

	SCHOOLS WITHIN 5 MILES OF ROCKHILL QUARRY					
	SCHOOL NAME	GRADES TAUGHT	STREET ADDRESS	COMMUNITY	DISTANCE MILES [1]	# STUDENTS [2]
Quakertown School District						
1	Strayer Middle School	6-8	1200 Ronald Reagan Dr	Quakertown	1.9	835
2	Richland Elementary	K-5	500 Fairview Ave	Quakertown	2.3	452
3	Quakertown Community High School	9-12	600 Park Ave	Quakertown	2.8	1661
4	Quakertown Elementary School	K-5	123 S 7th	Quakertown	3.0	285
5	Quakertown Sixth Grade Center	6 only	349 S 9th St	Quakertown	3.1	425
6	Trumbauersville Elementary	K-5	101 Woodview Dr	Trumbauersville	4.0	391
					Sub-Total	**4049**
Pennridge School District						
1	Robert B. Diebler Elementary	PreK-5	1122 W Schwenkmill Rd	Perkasie	1.0	413
2	Pennridge High School	9-12	1228 N 5th St	Perkasie	1.4	2343
3	Pennridge North Middle School	6-8	1500 N 5th St	Perkasie	1.6	620
4	Patricia A. Guth Elementary	K-5	601 N7th St	Perkasie	1.7	453
5	Pennridge South Middle School	6-9	610 S 5th St	Perkasie	2.6	487
6	West Rockhill Elementary	K-5	1000 Washington Ave	West Rockhill	2.6	365
7	Sellersville Elementary	K-5	122 W Ridge Ave	Sellersville	3.8	441
8	Pennridge Central Middle School	6-8	144 N Walnut St	Perkasie	4.0	682
9	Margaret M. Seylar Elementary	K-5	820 Callowhill Rd	Perkasie	4.1	445
					Sub-Total	**6249**
Private Schools/County Schools						
1	Upper Bucks Christian School/Daycare	Infancy - 12	754 E Rockhill Rd	Sellersville	0.5	221
2	Quakertown Christian School, Main	PreK-12	50 E Paletown Rd	Quakertown	1.1	230
3	Bucks County Intermediate Unit (ELC)	K-12	143 Rocky Ridge Rd	Quakertown	1.3	136
4	Childrens Developmental Program	6 wks - 5 yrs	995 Doylestown Pike	Quakertown	2.2	Not Available
5	Faith Christian Academy	K-12	700 N Main St	Sellersville	2.2	322
6	United Friends School - Broad St	Pre-K-8	1018 W Broad St	Quakertown	3.3	106
7	Noah's Ark Preschool and Day Care (FCA)	Infancy thru K	116 Ridge Rd	Sellersville	3.5	Not Available
8	St. Isidore's Elementary School	Pre-K-8	603 W Broad St	Quakertown	3.3	299
9	The Goddard School/Daycare	Infancy thru K	138 Mill Rd	Quakertown	3.7	Not Available
					Sub-Total	**1314**
ESTIMATED TOTALS [2]						
	# SCHOOLS AT RISK FOR EXPOSURE TO ASBESTOS FROM ROCKHILL QUARRY					**24**
	# CHILDREN IN LOCAL SCHOOLS AT RISK FOR EXPOSURE TO ASBESTOS FROM ROCKHILL QUARR					**11612**
	Children within 1 mile	**634**				
	Children within 2 mile	**5251**				
	Children within 3 mile	**8823**				
	Children within 4 mile	**11167**				
	Children within 5 mile	**11612**				

NOTES:

1. Distance can vary slightly due to quarry size; values reported were measured within Rockhill Quarry mining area using Google Maps and other apps

2. Annual student enrollments can vary slightly; totals include most schools within a 5 mile radius of Rockhill Quarry

Table 2
Summary of Asbestos Testing

Sample ID	Asbestos	Species	Non-Asbestos Fibers	Species	Total Asbestos (EPA Criteria)
June 26 2019 lab sample May 30 2019					
#1 -CB-1 #1	0.2	Actinolite	0.1	Actinolite	**0.3**
#2 -CB-1 #3	ND		0.2	Actinolite	**0.2**
#3 -CB-2#4	ND		0.2	Actinolite	**0.2**
#4-CB-2#5	ND		0.1	Actinolite	**0.1**
#5 -CB-2 #6	0.1	Tremolite	0.3	Actinolite	**0.4**
#6 -CB-3 #7	ND		0.3	Actinolite	**0.3**
#7 -CB-3 #8	ND		0.2	Actinolite	**0.2**
#8 -CB-3 #9	ND		<0.1	Actinolite	**0.05**
#9- CB-4 #10	ND		<0.1	Actinolite	**0.05**
June 26 2019 lab sample June 3 2019					
1 - RH #1	ND		<0.1	Tremolite	**0.05**
2- RH#2	<0.1	Actinolite	0.5	Actinolite	**0.505**
3- RH#3	ND		<0.1	Actinolite	**0.05**
4-RH#4	ND		<0.1	Actinolite	**0.05**
5-RH#5	ND		<0.1	Actinolite	**0.05**
6-RH#6	ND		<0.1	Actinolite	**0.05**
7-RH#7	<0.1	Tremolite	<0.1	Actinolite	**0.1**
8-RH#8	ND		<0.1	Actinolite	**0.05**
9-RH#10	ND		<0.1	Actinolite	**0.05**
10-RH#11	<0.1	Actinolite	<0.1	Actinolite	**0.1**
11 -RH #12	<0.1	Actinolite	0.3	Actinolite	**0.305**
12 -RH #14	<0.1		0.5	Actinolite	**0.505**
13 -RH#18	ND		<0.1	Actinolite	**0.05**
June 27 2019 lab sample May 30 2019					
#1 - DB-1	0.1	Actinolite	0.2	Actinolite	**0.3**
#2 - DB-2	ND		ND		**0**
#3 - DB-3	ND		ND		**0**
#4 - DB-4	ND		ND		**0**
#1 - Hand Sample #1	ND		0.1	Actinolite	**0.1**
#2 - Hand Sample #2	ND		ND		**0**
#3 - Vein 7	0.1	Actinolite	0.4	Actinolite	**0.5**
June 27 2019 lab sample June 3 2019					
14 - RH #22	ND		<0.1	Actinolite	**0.05**
15 - RH #23	ND		<0.1	Actinolite	**0.05**
16 - RH #24	ND		ND		**0**
17 - RH #25	ND		<0.1	Actinolite	**0.05**
18 - RH #26	<0.1	Actinolite	ND		**0.05**
19 - RH #27	ND		ND		**0**
20 - RH #28	ND		ND		**0**
21 - RH #29	<0.1	Actinolite	0.2	Actinolite	**0.205**
22 - RH #30	ND		0.2	Actinolite	**0.2**
23 - RH #31	ND		0.2	Actinolite	**0.2**
24 - RH #32	ND		0.3	Actinolite	**0.3**
25 - RH #33	ND		0.8	Actin. and Tremolite	**0.8**
AVERAGE	**0.02**		**0.14**		**0.16**

Notes:
Asbestos= Concentrations reported as "asbestos" by the laboratory
Non-Asbestos Fibers= Concentrations reported as "non-asbestos fibers" by the laboratory
Total Asbestos= Concentrations calculated using EPA criteria.
ND= No fibers detected.
<0.1= Fibers detected but none fell on one of the 1,000 counting points.
Average Concentrations: The average concentrations were calculated using a value of 1/2 the limit of quantitation for trace concentrations (<0.1%) and zero for samples where no asbestos was detected.

Table 3

POTENTIAL ALTERNATIVE SOURCES OF STONE FOR R.E. PIERSON INC. / PA TURNPIKE PROJECT

	QUARRY NAME	LOCATION	MIILES from ROCKHILL QUARRY	MIILES to 125 Ridge Rd, Tylersport*
1	H&K Materials	300 Skunk Hollow Rd, Chalfont, PA 18914	8.4	11.5
2	Hanson Aggregates	262 Quarry Rd, Ottsville, PA 18942	12.4	17.0
3	Naceville Materials	2001 Ridge Rd, Sellersville, PA 18960	6.1	0.8
4	Plumstead Materials	5031 Point Pleasant Pike, Doylestown, PA 18902	15.1	19.0
5	Harleysville Materials	460 Indian Creek Rd, Harleysville, PA 19438	14.0	7.1
6	Highway Materials Inc, 9303	1128 Crusher Rd, Perkiomenville, PA 18074	13.2	6.4
-	Rockhill Quarry	North Rockhill Rd, East Rockhill, PA	-	6.9

**** Staging area for PA Turnpike Project***

Appendix A

Technical Information Sheet

ATSDR Evaluation of Community-Wide Exposure to Naturally Occurring Asbestos

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Asbestos

Technical Information Sheet

ATSDR Evaluation of Community-Wide Exposure to Naturally Occurring Asbestos

This fact sheet was written by the Agency for Toxic Substances and Disease Registry (ATSDR), a federal public health agency. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposure and disease related to toxic substances.

Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation

DEPARTMENT OF HEALTH & HUMAN SERVICES·USA
ATSDR

CS225087-A

Asbestos Technical Information Sheet

INTRODUCTION

El Dorado Hills is one of many areas throughout the United States that has naturally occurring asbestos (NOA) in local soil and rock formations. Research on people who worked with commercial asbestos in the past has proven that breathing in asbestos increases the risk of cancer and respiratory disease. Some researchers believe the type of asbestos found in El Dorado Hills—amphibole asbestos—is more potent in causing disease than other types of asbestos.

ATSDR was involved in evaluating NOA exposures at Oak Ridge High School in El Dorado Hills in 2004-2006. Local residents, academic researchers, and environmental and public health agencies have expressed concern about potential community exposures to NOA in the wider community around El Dorado Hills. Activity-based sampling conducted by the U.S. Environmental Protection Agency (EPA) in 2004 showed that people performing typical outdoor recreational activities could breathe in high levels of NOA, compared to reference samples. Community members asked ATSDR what this finding meant to their health and what they should do to protect their health.

ATSDR's Health Consultation on Community NOA Exposure in El Dorado Hills

ATSDR has completed its evaluation of community exposures in El Dorado Hills. The report is available on ATSDR's web site and a CD or paper copy can be requested from ATSDR. The report was peer reviewed by independent experts, and a draft was available for public comment from March 29 to June 30, 2010. ATSDR visited the community in May 2010 to discuss the health consultation findings. The final health consultation responds to public comments received and clarifies ATSDR's conclusions and recommendations.

How Did ATSDR Evaluate the EPA Activity-based Sampling Data?

ATSDR worked with people from the area to develop reasonable assumptions about how often, throughout life, people would take part in the various activities represented by the EPA data. Using these assumptions, we developed asbestos exposure estimates for a range of outdoor activities. We considered both mid-range and high-end estimates of the amount of asbestos breathed in during each activity. In developing exposure estimates, ATSDR assumed all people were exposed to a background level of asbestos in the air. We used the EPA reference samples to represent this background level.

We used these exposure estimates with several different risk assessment methods to get a general idea of the additional risk of cancer this exposure might cause in the community at large. We used 5 risk assessment methods:

- The EPA "IRIS" method accepted for use in Superfund analyses.
- An EPA 1986 method which was the basis for the IRIS method and which specifically accounts for early life exposures. ATSDR applied updated mortality statistics in using this method.
- The Cal-EPA method typically enforced by the California Air Resources Board.
- ATSDR also examined a non-standard modification of the Cal-EPA method which uses a different method to obtain fiber concentration.
- The Berman Crump method, a proposed method not used for regulatory purposes. El Dorado Hills community members and stakeholders asked ATSDR to include this method because it assigns greater disease potency to amphibole asbestos – the type present in El Dorado Hills.

ATSDR compared the risk estimates to ranges used by EPA for determining acceptable risk at Superfund sites.

ATSDR also compared the EPA sampling data to other asbestos sampling data available from El Dorado Hills as part of its evaluation. The other data, while informative, was not detailed enough to use for risk assessment.

CONCLUSIONS

ATSDR reached two important conclusions:

Conclusion 1

Breathing in naturally occurring asbestos (NOA) in the El Dorado Hills area, over a lifetime, has the potential to harm people's health.

Basis for conclusion

- The general level of NOA in El Dorado Hills is somewhat higher than asbestos levels reported for other urban and rural areas in the U.S. and is similar to levels reported near local sources such as quarries. Activities that disturb NOA could result in brief exposures to higher levels of asbestos. (See Figure 1).
- Each of the four risk assessment methods used has considerable uncertainty, but they all gave similar results: the predicted increased risk of cancer ranged from too low to be of concern to a level high enough that action to prevent exposures would be warranted. (See Figure 2).
- Any one person could have markedly higher (or lower) exposures than the general estimates made in this report, depending on how and how often they encounter NOA in their daily activities.

Next steps

The following actions will reduce the likelihood for people to breathe NOA:

Increase Awareness

- El Dorado County should continue to review the community's knowledge about the presence and associated risk of NOA and to provide information about ways to manage the risk. ATSDR can provide technical assistance, if requested.
- El Dorado County should implement, to the extent possible, effective ways to:
  - » Maintain current records of locations known to contain NOA and
  - » Notify current and prospective landowners of the possibility for NOA to exist in soil or bedrock on their property.

Limit Exposure

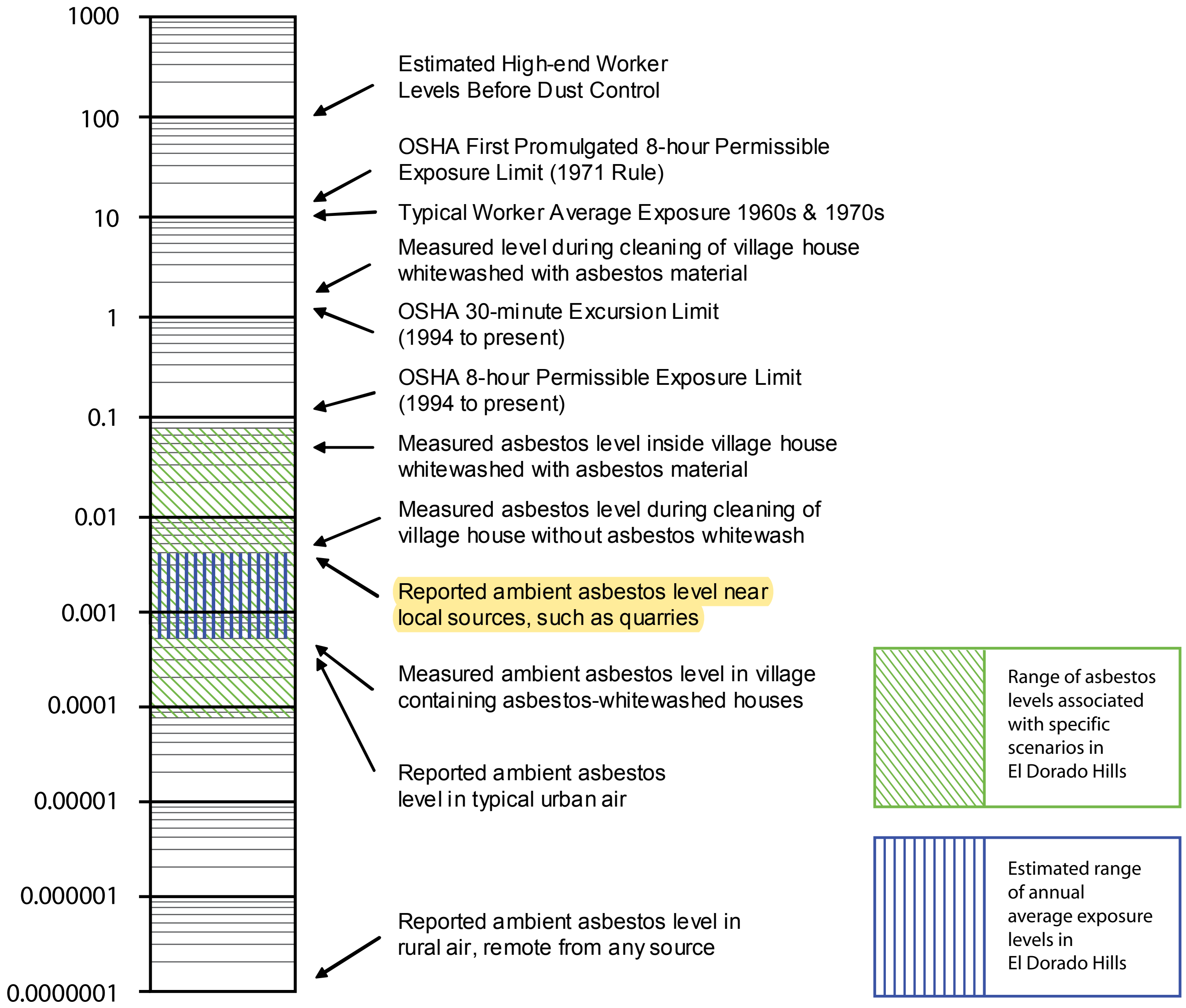
- State and local entities should continue to enforce applicable dust regulations throughout the community, which will reduce releases of NOA. For sites subject to asbestos hazard mitigation requirements, these regulations involve:
  - » Prohibition of visible dust emissions outside the property line or more than 25 feet from the point of dust-disturbing activities,
  - » Implementation of procedures to prevent vehicles and equipment from releasing dust or tracking soil off-site, and
  - » Requirements for asbestos dust mitigation plans, notification of authorities prior to work, and record-keeping.
- Community members and groups should learn how to reduce their exposure to NOA while conducting their normal activities. For example, exposure can be reduced by:
  - » Cleaning homes with a wet rag instead of a dry duster,
  - » Wetting down gardens before digging, or
  - » Staying on paved paths and roads during outdoor activities.

ATSDR has more recommendations online at: www.atsdr.cdc.gov/noa.

Asbestos Technical Information Sheet

Figure 1.

How Do the Levels of El Dorado Hills NOA Compare with Other Asbestos Levels?



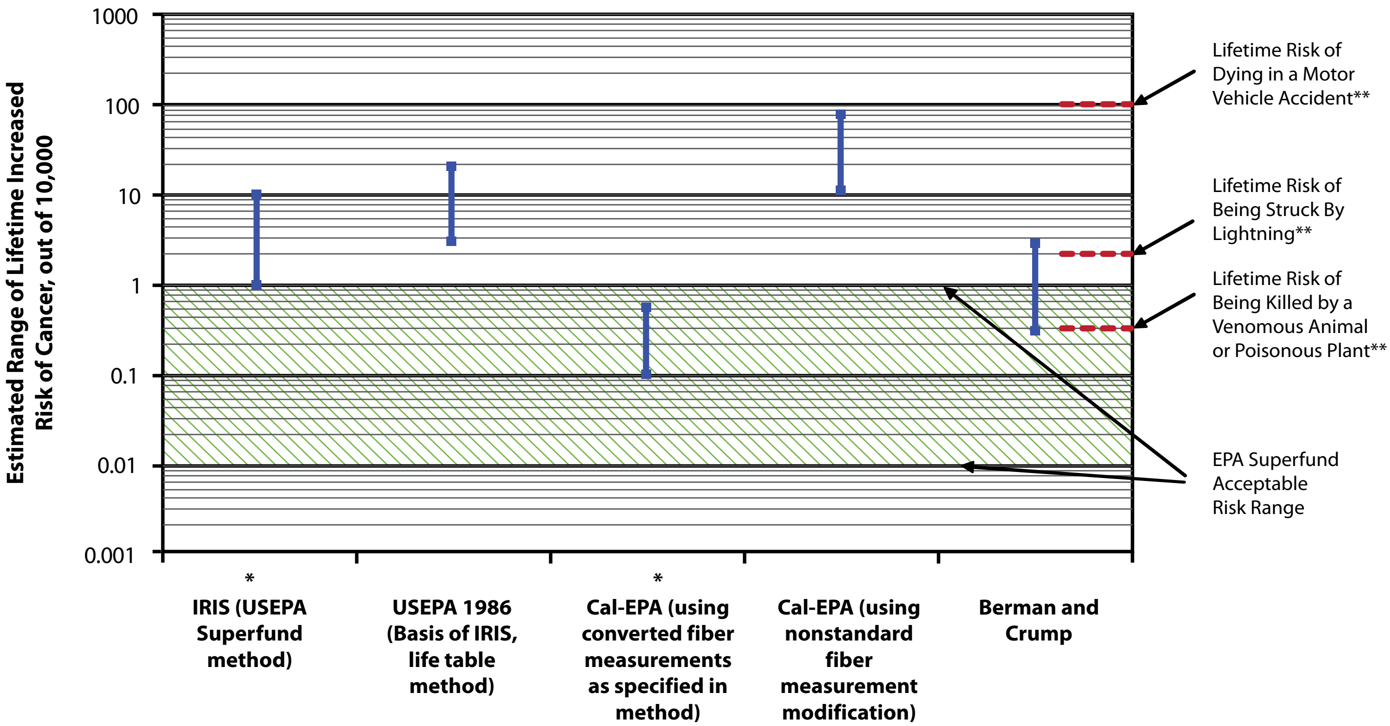
This schematic compares the range of asbestos levels measured for specific activities and estimated annual averages for El Dorado Hills with: general estimates of past worker exposure levels during a typical work day; "environmental" exposure levels for different situations in towns where local asbestos deposits were used for whitewashing houses (and people had increased rates of asbestos related disease); ambient asbestos levels reported for various locations in the United States; and past and present occupational 8-hour and 30-minute exposure limits. The estimates are placed on a "log" scale, which allows widely different values to be seen on the same graph—each heavy line is a value ten times the next lower heavy line. The overall exposure any person receives is a function both of the level and the length of time for which the exposure continues. The concentrations shown are approximate and are for comparison and context only.

SOURCES

- OSHA (Occupational Safety and Health Administration). Introduction to 29 CFR Parts 1910, 1915, 1926, occupational exposure to asbestos. 1994.
- Luce et al. Assessment of environmental and domestic exposure to tremolite in New Caledonia. Arch Env Health 2004;59(2):91-100.
- Agency for Toxic Substances and Disease Registry. Toxicological profile for asbestos (update). September 2001.
- Other assumptions described in ATSDR Health Consultation for El Dorado Hills, March 2010.

Figure 2.

Ranges of Estimated Lifetime Increased Risk of Cancer from NOA Exposure for Various Risk Assessment Methods



* Regulatory Methods
** General Risks estimated from Mortality Data and included at the request of community stakeholders for comparative purposes only.

Conclusion 2

Reducing exposures to NOA will protect people's health and is warranted in El Dorado County based on estimates of past exposures. State cancer registry information indicates that the community's health has not been impacted at this time. However, health impacts to individuals from past exposures are highly variable and may take years before the cancer registry detects them.

Basis for conclusion

- The association between asbestos exposure and disease is well established. Preventing inhalation of asbestos will reduce risk of disease.
- Mesothelioma incidence, tracked by the California Cancer Registry, is not higher than expected in western El Dorado County at this time. However, mesothelioma may take decades after exposure to appear.
- Although the community in general is estimated to have an increased risk of exposure and disease, individuals' risk may vary widely due to the sporadic nature of NOA occurrences and individual behaviors leading to exposure. Individual assessment by personal health care providers for those who are concerned about past exposures will be more efficient than general community screening in treating any health effects that may appear.

Next Steps

- State authorities should continue to monitor asbestos-related cancer incidence rates in the area.
- Community members should consult with their personal medical provider about their individual health concerns arising from NOA exposure.
- ATSDR encourages further research on NOA exposures and community health by governmental, academic, and other organizations. ATSDR may refine the conclusions and recommendations of this health consultation as results of ongoing asbestos research become available.

Photo of asbestiform tremolite, El Dorado County, California seen in hand sample (above) and scanning electron micrograph (left), courtesy of US Geological Survey, Denver Microbeam Laboratory.

EVALUATION TIMELINE

Since the 2006 final release of our evaluation of exposures at Oak Ridge High School in El Dorado Hills, ATSDR has been actively working on issues related to this evaluation:

- ATSDR held an expert panel on biomarkers of exposure in 2006 to discuss the state of the science for assessing community exposure to asbestos. Although research continues, reliable methods for measuring asbestos exposures in individuals or communities are not currently available. Using activity-based sampling data and applying risk assessment methods remain the best way to assess community exposures and risk.
- ATSDR responded to the "cleavage fragment" issue raised by the National Stone Sand and Gravel Association (NSSGA) in December 2005. This group questioned whether the asbestos reported in the EPA sampling was truly asbestos or chemically identical but possibly less harmful "cleavage fragments". Because discussions initiated after the release of the NSSGA report cast doubt on the findings of the EPA sampling, EPA requested a geologic analysis of the El Dorado Hills area by the U.S. Geologic Survey (completed in December 2006), and ATSDR requested toxicity studies on which particles contribute to asbestos-related health effects by the National Toxicology Program (studies will take several years to complete).
- ATSDR identified additional analysis that needed to be done on the air sampling filters to allow us to use the risk assessment method that accounts for differing toxicity of amphibole asbestos. Obtaining funding and completing the lab analyses were time consuming; results were not available until late 2007.
- ATSDR also developed and tested a "life table analysis" spreadsheet to account for early life exposures. Although this work was based on that of other researchers, ATSDR updated mortality data, developed an in-house spreadsheet to perform calculations, and developed a written explanation of the theory behind the analysis. We completed these tasks in 2008.
- A draft of the report was sent to external peer review in 2009. The document includes peer review comments and responses/changes made in responses to the comments received.
- ATSDR released a draft health consultation for public comment in 2010. The final health consultation includes changes and responses to public comments received, as detailed in an Appendix.

LEARNING MORE

To learn more, please call ATSDR at 1-800-CDC-INFO and ask for information about the "El Dorado Hills Naturally Occurring Asbestos" site. If you have concerns about your health, you should contact your health care provider.

Asbestos Technical Information Sheet

U.S. Department of
Health and Human Services
Agency for Toxic Substances
and Disease Registry

Appendix B

Response to the November 2005 National Stone, Sand & Gravel Association Report

Prepared by the R.J. Lee Group, Inc

"Evaluation of EA 's Analytical Data from the El Dorado Hills

Asbestos Evaluation Project"

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX

Response to the November 2005 National Stone, Sand & Gravel Association Report Prepared by the R.J. Lee Group, Inc "Evaluation of EPA's Analytical Data from the El Dorado Hills Asbestos Evaluation Project"

April 20, 2006

United States Environmental Protection Agency Region 9
Response to the November 2005 National Stone, Sand & Gravel Association report prepared by the R.J. Lee Group, Inc:
"Evaluation of EPA's Analytical Data from the El Dorado Hills Asbestos Evaluation Project"

This document constitutes the United States Environmental Protection Agency Region 9 (EPA Region 9) response to the major findings and conclusions of the National Stone, Sand & Gravel Association report "Evaluation of EPA's Analytical Data from the El Dorado Hills Asbestos Evaluation Project" prepared by the R. J. Lee Group (R. J. Lee Report). A more detailed analysis will be completed after additional information is received from the R. J. Lee Group and the National Stone, Sand & Gravel Association,[1] and the United States Geological Survey (USGS).

The R. J. Lee Report draws conclusions that are contradicted by the El Dorado Hills data and by generally accepted scientific principles for measuring asbestos exposure.

Overview

The R. J. Lee Group review of the EPA data was contracted by the National Stone, Sand & Gravel Association. The El Dorado County Office of Education funded the three reviewers who wrote letters in support of the R. J. Lee Report and whose reviews are included in this response.

The EPA Region 9 El Dorado Hills Naturally Occurring Asbestos Exposure Assessment was designed to measure the exposures to asbestos fibers, if any, that resulted from sports and play activities that disturbed dust and soil. EPA Region 9 adhered to accepted EPA standards for sampling and analysis, including rigorous quality assurance/quality control, and to the standard methodologies of EPA exposure and risk assessment.

The R. J. Lee Report Criticizes EPA Region 9 for Using Established Scientific and Public Health Protocols - In assessing naturally occurring asbestos exposures in El Dorado Hills, EPA evaluated asbestos exposures using the PCME (phase contrast microscopy equivalent) asbestos fiber size classification. The PCME classification was used because human epidemiological studies, which form the basis of knowledge of asbestos health effects, measured asbestos fiber concentrations using phase contrast microscopy (PCM) analytical methods. PCME is the standard term for fibers counted by more modern analytical methods that are of equivalent size to those fibers that would be seen by PCM analysis, and includes fibers with a length to width aspect ratio of 3 to 1 or greater. EPA considered PCME fibers in our analysis of the El Dorado data to be consistent with the existing health databases and risk assessment

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[1] On March 9, 2006, EPA Region 9 sent a letter to the R.J. Lee Group and the National Stone, Sand, & Gravel Association asking for additional information to support the findings and conclusions of the R.J. Lee Report.

procedures used by EPA, California EPA (Cal/EPA), the World Health Organization, and other federal agencies and international organizations. This approach was rejected by the R.J. Lee Group, which instead advocates use of asbestos fiber definitions which are not health based or supported by the majority of experts in the health community, and which would not allow comparison to the existing epidemiologic data on asbestos related cancers.

The R. J. Lee Report Claims that EPA Region 9 Misapplied Fiber Counting Protocols - The R. J. Lee Report claims that EPA Region 9 inflated the fiber counts in the El Dorado Hills air data by misapplying the International Standards Organization (ISO) method 10312 (the analytical method used by EPA to analyze the El Dorado air samples) and including PCME structures with a 3 to 1 length to width aspect ratio in our analysis. The R. J. Lee Report maintains that EPA should only have counted structures which met the general 5 to 1 aspect ratio fiber size definition described in the body of the ISO 10312 method. However, Annex C and Annex E of the ISO 10312 method specifically authorize the counting of PCME structures with a 3 to 1 aspect ratio. Another example of misleading information is the R.J. Lee Report's statistical evaluation and resulting conclusions regarding the concentrations of asbestos structures detected in the EPA air samples. All of the established EPA, National Institute of Occupational Safety and Health (NIOSH), and ISO analytical methods require the counting of asbestos bundles, recognizing the significance of bundles to proper characterization of asbestos fiber levels. The R.J. Lee Report did not include asbestos bundles in its analysis of the data, thereby undercounting the number of structures.

The R. J. Lee Report Claims that EPA Region 9 Misidentified Amphibole Minerals - The R. J. Lee Report concludes that EPA misidentified actinolite asbestos fibers in the El Dorado soil samples by using inappropriate extinction angle criteria. The R. J. Lee Group conclusion is contradicted by the National Institute of Standards and Technology (NIST) and the major analytical methods used for analysis of asbestos in soil and bulk samples. The R. J. Lee Report also cites an unpublished 1980 draft report to support its contention that structures found in the EPA air samples are not asbestos, and ignores a subsequent 1981 published report by the same author that actually supports the EPA approach.

The R. J. Lee Report Applies a Geologic Definition rather than a Public Health Definition to Characterize Microscopic Structures - The R. J. Lee Report relies heavily on the geologic distinction between asbestos fibers and cleavage fragments of the same dimensions, with the implication that exposure to cleavage fragments is benign and of little or no health significance. For the purposes of public health assessment and protection, EPA makes no distinction between fibers and cleavage fragments of comparable chemical composition, size, and shape. The EPA Region 9 approach, which is supported by most public health agencies and scientists, as well as the American Thoracic Society, is based on the following: (1) The epidemiologic and health studies underlying EPA and Cal/EPA cancer risk assessment methods were based on exposures to both cleavage fragments and fibers, and were unable to distinguish between the two, (2) The most recent panel of experts to review asbestos risk assessment methods, the 2003 Peer Consultation Panel convened by EPA, concluded that "it is prudent at this time to conclude equivalent potency [of cleavage fragments and fibers] for cancer,"[2] (3) No well-designed animal or epidemiological studies have adequately tested the hypothesis that cleavage fragments with the same dimensions as a fiber are benign or that the human body makes any distinction, (4) Studies that purport to show that cleavage fragments are benign are questioned by many asbestos health experts, (5) There are no routine asbestos air analytical methods, including those used by EPA, NIOSH, the Mine Safety and Health Administration (MSHA), the American Society for Testing and Materials (ASTM), and ISO which differentiate between cleavage fragments and crystalline fibers on an individual fiber basis.

The R. J. Lee Report's "Virtual" Review of EPA Region 9's Air Samples is Inconsistent with Established Laboratory Practices - The R.J. Lee Group did not have access to EPA's actual air samples, nor did it collect any air samples of its own. Rather it reviewed limited pictures and spectra data of a small number of EPA's air samples and drew conclusions based on those representations. Such a virtual review is not consistent with the National Voluntary Laboratory Assurance Program (NVLAP) quality assurance procedures nor the verification methods of the National Institutes of Standards and Technology.

Federal Courts Have Supported EPA - Many of the assertions of the R. J. Lee Report are consistent with positions that the R.J. Lee Group took as an expert witness for W.R. Grace in the Libby, Montana litigation. In this litigation, the written opinions of the District and Appeals courts, while not specifically addressing the opinions of the R.J. Lee Group, rule in favor of EPA and expressly hold that EPA's experts and science are credible.[3]

<u>Background</u>

In October 2004, the EPA Region 9 Superfund site assessment program conducted an assessment of exposures to naturally occurring asbestos (NOA) in El Dorado Hills, California. Specifically, EPA Region 9 simulated the sports activities of children and adults at three schools and a community park and, using personal air monitors, measured asbestos levels in the breathing zones of participants. EPA Region 9 also collected samples of ambient air in the area of the sampling at the same time the simulations were conducted to serve as reference samples. The personal activity-based samples were then compared to the reference samples. The Asbestos Hazard Emergency Response Act (AHERA)[4] regulation Z-test for statistical

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[2]USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page viii.

[3] See U.S. v. W.R. Grace, 280 F Supp 2d 1149 (2003): U.S. v. W.R. Grace, 429 F. 3d 1224, 1245 (9th Cir. 2005) (Although debate regarding testing methodology and data analysis is "exceedingly complex", EPA did not ignore accepted scientific principles)

[4]The Asbestos Hazard Emergency Response Act (AHERA) was passed by Congress in 1986 to provide for the inspection and mitigation of asbestos in school buildings. Regulations implementing the Act were promulgated by EPA in 1987.

significance was applied to determine whether there were any statistically significant differences between the personal exposure samples and the ambient reference samples. EPA Region 9 collected over 400 air samples and generated over 7000 data points. All of EPA Region 9's's analyses were conducted by accredited laboratories using recognized methods and procedures with strict quality assurance control, including blind performance samples to check analytical accuracy.

Amphibole asbestos, which many health scientists consider to be even more toxic than chrysotile asbestos, was found in almost all the reference and activity-based samples. Of the 29 different sets of activity-based scenario measurements, application of the Z-test determined that personal exposures from 24 scenarios were significantly elevated over the reference samples. Most importantly, the data showed that children and adults participating in sports activities in areas where asbestos occurs naturally in the surface soils, as it does in El Dorado Hills, can be exposed to asbestos fibers of health concern at up to 62 times the corresponding reference levels.

EPA Region 9 released the data from the assessment in May 2005 and held a public meeting in El Dorado Hills that was attended by more than 1000 members of the public. From the outset of the assessment, EPA Region 9 made clear to the community that EPA's only intent was to gather data on potential exposures. The community and the State and local regulatory agencies could then use the information to make decisions about the significance of those exposures and determine appropriate control measures. Both EPA Region 9 and the Agency for Toxic Substances and Disease Registry (ATSDR) have informed the community that exposure levels are a main determinant of the risk of developing asbestos-related cancers and non-cancer diseases, and that reducing the exposures reduces the risk. Consistent with its intent, EPA Region 9 has actively engaged the State and local regulatory agencies to improve naturally occurring asbestos mapping, monitoring, dust control, and regulation. El Dorado County has recently adopted more stringent dust control ordinances.

<u>Detailed Comments on the R. J. Lee Report</u>

R.J. Lee Finding #1: "Based on Mineralogy, Sixty-Three Percent (63%) of the Amphibole Particles Identified as Asbestos Fibers can not be Asbestos."

The R. J. Lee Report argues that there is too much aluminum in 63% of EPA Region 9's identified fibers for the fibers to be asbestiform.[5] In addition, the remaining 37% (sometimes the Report uses 35%) are not asbestos fibers based on their particle dimensions.

EPA Response

Aluminum - Analysis of the EPA Region 9 El Dorado air samples was performed using the International Standards Organization (ISO) method 10312, a state-of-the-art

[5]Asbestiform: Having the form or structure of asbestos.

Transmission Electron Microscope (TEM)[6] method with energy dispersive spectroscopy (EDS)[7] that has strict counting rules and characterizes the dimensions and chemistry of every fiber identified by the microscopist. Identification of fiber type was performed according to the general guidelines of the International Mineralogical Association (IMA) (Leake, 1997)[8], the international standard for amphibole nomenclature. This same approach for asbestos classification is recommended in the "Research Method for Sampling and Analysis of Fibrous Amphibole in Vermiculite Attic Insulation", EPA 600/R-04/004, January 2004, and was one of the tools used by Meeker et al (2003)[9] to determine the composition and morphology of amphiboles from Libby, Montana.

The R. J. Lee Report claims that 63% of the amphibole fibers identified by the EPA laboratory[10] as actinolite asbestos have concentrations of total aluminum that are too high to form asbestos fibers. According to page 2 of the R. J. Lee Report, "Particles with more than 0.3 aluminum atoms pfu [per formula unit] or about 1.5 percent Al_2O_3 cannot form in the asbestos habit due to crystal lattice constraints." To support its argument, the R. J. Lee Report cites three references. However, on close examination, two of the three references do not agree with the upper threshold limit that the R.J. Lee Group puts on total aluminum content (Leake et al, 1997) (Deer, Howie and Zussman, 1997)[11]. The third reference (Verkouteren & Wylie, 2000)[12] draws its conclusions on examination of a

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[6]Transmission Electron Microscopy (TEM) produces images of a sample by illuminating the sample with an electron beam in a vacuum, and detecting the electrons that are transmitted through the sample.

[7]Energy Dispersive Spectroscopy (EDS) uses measurement of the energy and intensity of X-rays generated when a selected area of a sample is irradiated with an electron beam to identify the mineralogical composition of a structure.

[8]B.E. Leake et al (1997). Nomenclature of Amphibole: Report of the Subcommittee on Amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral Names. American Mineralogist, Volume 82, pages 1019-1037.

[9]G.P. Meeker et al (2003). The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana. American Mineralogist, Volume 88, pages 1955-1969.

[10]In this document, the terms "EPA laboratory" and "EPA Region 9 laboratory" refer to the private laboratories that conducted the analysis of the EPA soil and air samples under contract to EPA Region 9.

[11]W.A. Deer, R.A. Howie, and J. Zussman (1997). Rock-Forming Minerals: Double Chain Silicates, Vol 2, second edition, p 137 - 145.

[12]J.R. Verkouteren and A.G. Wylie (2000). The Tremolite-Actinolite-Ferro-Actinolite Aeries: Systematic Relationships Among Cell Parameters, Composition, Optical Properties, and

small set of fibrous actinolite asbestos samples which the authors partition into asbestos and fibrous "non-asbestos" byssolite using criteria which the IMA specifically recommends against, and which is inconsistent with all standard asbestos analytical methods. Perhaps most important is the fact that all three references agree that it is the IMA criteria which primarily govern the general classification of amphibole type, not the total aluminum content. These references therefore actually support the classification approach taken by the EPA laboratory.

The R.J. Lee Group did not have access to the EPA air samples to conduct their own analyses. Instead, the R.J. Lee Group looked at a limited number of photographs of the recorded EDS spectra. Interferences by other elements in the sample can affect the aluminum total in the spectra. This is especially important because the EPA samples were of air releases from soil, not processed asbestos material. Soils contain non-asbestos mineral and biological particles that can influence element totals in an EDS spectrum, most notably clay particles, which are high in aluminum. The laboratory used by EPA Region 9 identified aluminum-rich actinolite asbestos, by applying the IMA classification guidelines to its direct analysis of the actual sample.[13]

Particle Dimension - As previously stated, the R. J. Lee Report claims that 37% of the fibers counted by EPA in the El Dorado Hills air samples are not asbestos fibers based on their particle dimensions. The report claims that EPA Region 9 inflated the fiber counts by including asbestos structures which do not meet the definition of a fiber as described in ISO 10312. The general ISO 10312 method requires the counting of every asbestos structure with a length to width aspect ratio of 5:1 or greater. As directed by Region 9, the EPA laboratory counted structures with a 3:1 or greater aspect ratio. The R. J. Lee Report states that EPA erred in counting structures with aspect ratios less than 5:1. **Annex C and Annex E of the ISO method clearly authorize the counting of PCME structures with a 3:1 aspect ratio if the data are to be used for exposure or risk assessment purposes, the stated goal of the El Dorado Hills assessment. In fact, the ISO method contains numerous references to PCME fibers. PCME fibers are defined as fibers greater than 5 microns in length, and 0.25 to 3 microns in width with a 3:1 aspect ratio.[14] PCME fibers form the basis for EPA's IRIS toxicity database and the asbestos risk models of California EPA and other federal and international organizations.[15]**

Habit, and Evidence of Discontinuities. American Mineralogist, 85, p. 1239 - 1254.

[13]Personal communication with John Harris, Lab/Cor, January 2006.

[14]World Health Organization (1986). Environmental Health Criteria 53, International Programme on Chemical Safety, Asbestos and Other Natural Mineral Fibres, section 2.3.2.2.

[15]The IRIS asbestos cancer inhalation unit risk, a measure of asbestos cancer potency, is based on the EPA 1986 Airborne Asbestos Health Assessment Update (EPA/600/8-84/003F; 1986). Cal/EPA used a similar approach and data sets to derive its cancer unit risk. Both the IRIS and the Cal/EPA cancer potency values rely on human epidemiological studies that were conducted using phase contrast microscopy (PCM) analytical methods (some were midget

The R.J. Lee Group also manipulates its statistical analysis of the El Dorado Hills air data by ignoring counts of asbestos fiber bundles in its evaluations. Bundles are two or more attached parallel asbestos fibers which can have a significant health impact when they are inhaled and separate into individual fibers. Bundles were counted in the historical epidemiological studies which form the basis of our knowledge of asbestos-related health effects and EPA's IRIS database. **All of the established EPA, NIOSH, and ISO analytical methods require the counting of asbestos bundles, recognizing the significance of bundles to proper characterization of asbestos fiber levels.**

The R. J. Lee Report further states that EPA's data inflated the asbestos fiber count by ignoring the Agency's own "definition" of asbestos. To support this claim, the R.J. Lee Report cites the glossary of "Method for Determination of Asbestos in Bulk Building Materials", EPA 600/R-93/116, 1993, which states, in part, "With the light microscope, the asbestiform habit is generally recognized by the following characteristics: Mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 microns." The building material analytical method is designed to detect commercially processed asbestos in items like floor tiles, roofing felts, paper insulation, paints, and mastics, not naturally occurring asbestos on air filters or in soil samples. To present the 20:1 aspect ratio for commercial grade asbestos as a universal EPA policy, and to advocate its use as an appropriate standard for analyzing air samples of naturally occurring asbestos is inappropriate and contradictory to use of the PCME dimensional criteria as a tool for assessing exposure risk.

The R. J. Lee Report also states that the diffraction pattern analyses produced by the EPA laboratory for the El Dorado Hills air samples demonstrates that the particles identified by the laboratory are not asbestos.[16] The report cites a 1980 unpublished draft study by S.J. Ring to support its conclusion. The R. J. Lee Report does not mention a 1981 published article by the same author which revises the findings such that they no longer support the conclusion of the R. J. Lee Report and, in fact, support the data produced by

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impinger data converted to PCM counts) that could not distinguish fibers that were 5 microns in length or less. PCM cannot distinguish between fibers and cleavage fragments. PCM is not as powerful as current Transmission Electron Microscope (TEM) methods (400X vs 20,000X) as TEM can see the thinner/shorter fibers. However, since EPA's (and Cal/EPA 's) toxicity database relies on human health studies that used PCM, current EPA risk procedures use the more powerful TEM method but report the PCM equivalent (PCME) fibers and only use the PCME counted fibers in a risk assessment. This is because the IRIS asbestos file specifies that only PCME fiber counts be used with inhalation unit risk for risk calculation. See also the reference cited in footnote 11.

[16]Diffraction pattern analyses irradiates a sample with x-rays and then takes an x-ray photograph.

EPA.[17]

R.J. Lee Finding #2: "The Laboratory Procedures did not Comply With the NVLAP Quality Assurance Standard."

The R. J. Lee Report says that the false positive rate in our air samples was 35% when the acceptable limit in the National Voluntary Laboratory Accreditation Program (NVLAP) is 10%.

EPA Response

The laboratories used by EPA Region 9 for analysis of the El Dorado Hills air and soil samples are accredited through the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP is administered by the National Institute of Standards and Technology, a non-regulatory agency within the U.S. Commerce Department. A large part of the accreditation process involves on-site audits performed by NVLAP-certified inspectors who review laboratory operational and quality assurance compliance parameters, including documentation proving compliance with NVLAP requirements for verification analyses. A laboratory must demonstrate that all analysts reporting data meet the false negative and false positive requirements set forth by NVLAP before an accreditation certificate is issued. To make a determination that a laboratory did not comply with NVLAP verification standards would require a very detailed examination of all laboratory generated raw data, project specific information, such as a site-specific EPA issued Quality Assurance Project Plan, laboratory instrument log books, and other data and information not supplied in an analytical report. Interviews with the laboratory manager, quality assurance manager, and involved analysts are also mandatory to make judgement on a laboratory's possible non-compliance. The R.J. Lee Report's conclusion that the EPA laboratory was not in compliance with NVLAP, based on a cursory review of count sheet and other limited data without the in-depth examination detailed above, is therefore invalid and cannot be used to question EPA's analytical results.

EPA chose NVLAP-accredited laboratories for the El Dorado Hills assessment as a minimum quality requirement. For supplemental quality assurance, the laboratories were subjected to on-site audits performed by EPA's Quality Assurance Technical Support group, and both laboratories were sent performance evaluation samples prior to analysis of the El Dorado samples. In addition, the laboratory conducting the air sample analysis was sent double blind performance evaluation samples during the sampling event. In all cases, the laboratories successfully identified the amounts and types of asbestos present on the blind samples within acceptable limits. Further, the El Dorado Hills air and soil data were validated by a third party in accordance with standard EPA quality assurance

[17] S.J. Ring (1981). Identification of Amphibole Fibers, Including Asbestos, Using Common Electron Diffraction Patterns. In Russell P.A. and Hutchings A.E. (Eds), Electron Microscopy and X-ray Applications to Environmental and Occupational Health Analysis, Vol. 2:175-198, Ann Arbor Science Publ., Inc.

procedures and were found to be acceptable for all uses.

R. J. Lee Finding #3: "The Soil Samples do not Demonstrate the Presence of Amphibole Asbestiform Minerals."

The R. J. Lee Report states that the actinolite asbestos fibers identified in the El Dorado Hills soil samples contain too much aluminum to be asbestiform and that the extinction angles of the fibers indicate that they are non-fibrous cleavage fragments. The R.J. Lee Group's analysis of 23 split soil samples from EPA's October 2004 sampling event found no asbestos in the samples.

EPA Response

Aluminum - The R. J. Lee Report states that the aluminum content of the fibers in the soil samples was too high to be asbestiform actinolite and that it was indicative of non-asbestiform actinolite and another amphibole, hornblende, which contains approximately 10-20% by weight Al_2O_3 (5.3-10.6% by weight aluminum). Both the laboratory performing EPA's El Dorado soil sample analysis and the laboratory which analyzed the EPA air samples noted significant quantities of hornblende in the samples, but did not count or report those particles as asbestos. Please see the EPA response to Finding #1 for a further discussion of the aluminum issue.

Extinction Angles - The extinction angle of a fiber evaluated by polarized light microscopy is one of many criteria used to identify mineralogical composition. The extinction angle for amphibole asbestos fibers is the difference in degrees between the long axis of the fiber and the angle at which the fiber optically disappears (the polarization direction where the light passing through it becomes "extinct") when the fiber is rotated under a polarized light microscope. The R.J. Lee Report states that amphibole asbestos fibers have a zero-degree extinction angle and that non-asbestos cleavage fragments have non-zero extinction angles. Therefore, because the EPA soil sample analysis reported extinction angles which, according to the R.J. Lee Group, averaged 12^{o}, the report alleges EPA incorrectly identified cleavage fragments as asbestos fibers.

The R.J. Lee Report's conclusion regarding extinction angles is contradicted by the National Institute of Standards and Technology (NIST) and the major analytical methods used for analysis of asbestos in soil and bulk samples. NIST certifies and provides Standard Reference Materials (SRM) for laboratory instrument calibration and laboratory accuracy measurement. The NIST Tremolite/Actinolite SRM 1867A is a special set of three samples certified by NIST to be of ultra-high purity tremolite, actinolite, and anthophyllite asbestos and is considered the "gold standard" for asbestos analytical laboratories. The material is rigorously characterized and is accompanied by a six-page document that describes the properties of each sample. It is required that all analytical laboratories accredited by NIST/NVLAP have the material in their possession and that they use it to calibrate their operations and to test their analysts. The NIST SRM

1867A certificate which accompanies the samples of tremolite and actinolite states that the reference tremolite can have an extinction angle of up to 16.6 ± 0.3° and that the actinolite can have an extinction angle of up to 15.9±0.2°. When the EPA laboratory processed the NIST actinolite standard in the manner of the El Dorado Hills soil samples, the extinction angles of the fibers in the processed standard sample were consistent with allowed maximum extinction angles for tremolite/actinolite asbestos (~ 10° to 20°) and the extinction angles of the fibers seen in the EPA soil samples.[18]

Further, the laboratory methods of EPA, NIOSH, and other agencies for analysis of asbestos in bulk material all state that tremolite-actinolite asbestos fibers may have zero (parallel) or *non-zero* (inclined or oblique) extinction angles. EPA Method 600/R-93/116[19], the standard method used by all NIST/NVLAP accredited laboratories to test building materials for the presence of asbestos, states in Table 2-2, Optical Properties of Asbestos Fibers, that tremolite-actinolite asbestos has extinction "parallel and oblique (up to 21°)." NIOSH Method 9002[20], the method used for analysis of the El Dorado Hills soil samples, states directly that actinolite and tremolite fibers exhibiting inclined extinction are to be considered asbestos. The method further states that "If anisotropic fibers are found (during PLM analysis), rotate the stage to determine the angle of extinction. Except for tremolite-actinolite asbestos which has oblique extinction at 10-20°, the other forms of asbestos exhibit parallel extinction... Tremolite may show both parallel and oblique extinction."[21]

R.J. Lee Finding #4: "The ISO 10312 Analytical Method can not Distinguish Between Asbestos Fibers and Non-Asbestos Cleavage Fragments."

The R.J. Lee Report states that the ISO 10312 method contains the disclaimer that "The method cannot discriminate between individual fibers of asbestos and non-asbestos analogues of the same amphibole material," and, therefore, EPA inflated the asbestos air concentrations by counting "cleavage fragments."

EPA Response

The ISO 10312 method cannot differentiate between fibers and cleavage fragments with

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[18]M. Bailey (2006). Identification of Asbestiform Tremolite/Actinolite. Naturally Occurring Asbestos Workgroup Meeting Presentation.

[19]USEPA (U.S. Environmental Protection Agency) (1993). Method for the Determination of Asbestos if Bulk Building Materials. EPA Method 600/R-93/116.

[20]NIOSH (National Institute for Occupational Safety and Health) (1992). Asbestos (Bulk) by PLM.. Method 9002 (Issue 2).

[21]NIOSH (National Institute for Occupational Safety and Health) (1992). Asbestos (Bulk) by PLM.. Method 9002 (Issue 2). Qualitative Assessment, Item c, page 4.

the same dimensions and chemical composition. No routine analytical method has a protocol for distinguishing fibers from cleavage fragments on an individual particle basis. Additionally, from a health standpoint, there is no evidence that supports making the distinction.

Cleavage fragment is a geologic term which refers to structures that form when non-fibrous forms of asbestos minerals split along crystallographic planes, as opposed to asbestos fibers which form from crystalline growth. The R.J. Lee Report maintains that there is a toxicological difference between asbestos structures which formed as fiber crystals and fibers which formed by cleavage plane separation. Page 3 of the R.J. Lee Report states that cleavage fragments are "not known to produce asbestos-like disease." **It is the position of EPA, the U.S. Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry (ATSDR) and National Institute for Occupational Safety and Health (NIOSH), and the American Thoracic Society, among others, that microscopic structures of amphibole and serpentine minerals that are asbestiform and meet the size definition of PCM fibers, should be counted as asbestos, regardless of the manner by which they were formed.** There are four reasons why the health agencies have taken this position: (1) The epidemiologic and health studies underlying EPA, and California EPA, cancer risk assessment methods were based on exposures to both cleavage fragments and fibers, but were unable to distinguish between the two, (2) The most recent panel of experts to review asbestos risk assessment methods, the 2003 Peer Consultation Panel convened by EPA, concluded that "it is prudent at this time to conclude equivalent potency [of cleavage fragments and fibers] for cancer,"[22] (3) No well-designed animal or human epidemiological studies have been conducted to date to test the hypothesis that cleavage fragments with the same dimensions of a fiber are benign, or that the human body makes any distinction, and studies that purport to show that cleavage fragments are benign are questioned by many asbestos health experts,[23] (4) There are no routine air analytical methods, including those used by EPA, NIOSH, the Mine Safety and Health Administration (MSHA), the American Society for Testing and Materials (ASTM), and the ISO which differentiate between cleavage fragments and crystalline fibers.

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[22]USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page viii.

[23]Both Addison (Addison J, Davies LST. 1990. Analysis of amphibole asbestos in chrysotile and other minerals. Ann Occ Hyg, Apr;34(2):159-75) and members of the U.S. EPA 2003 Peer Consultation panel raised concerns about interpretation of the Davis study (Davis JM, McIntosh C, Miller BG, Niven K. 1991. Variations in the carcinogenicity of tremolite dust samples of differing morphology. Ann NY Acad Sci, Dec;643:473-90), which attempted to compare the toxicity of asbestos fibers and cleavage fragments. These concerns reflected the lack of peer review, use of intra peritoneal injection instead of inhalation exposure, significance of mesotheliomas caused by structures reported as cleavage fragments, purity of the cleavage fragment samples and issues related to fiber dimensions.

In terms of epidemiological data and health outcomes, the cleavage fragment argument is without merit. For the purposes of public health assessment and protection, EPA makes no distinction between fibers and cleavage fragments of comparable chemical composition, size, and shape.

There are no recognized analytical protocols, including those used by EPA, NIOSH, MSHA, ASTM, and ISO, which include criteria to differentiate between cleavage fragments and crystalline fibers. All these methods require that structures which meet their definition of the specific counting rules for an asbestos fiber be counted. The requirements are based on the fact that, in the words of an expert from the United States Geological Survey, "At a microscopic level, distinguishing between these forms on single [asbestos] particles, can be extremely difficult to impossible."[24] As noted above, R.J. Lee made a very similar claim with regard to cleavage fragments as the expert witness for W.R. Grace in the Libby, Montana, Superfund cost recovery litigation. The EPA analytical experts who reviewed the R.J. Lee Group's testing methodology related to the Libby site found that the R.J. Lee laboratory could not demonstrate any reliable criteria with which to distinguish, at the microscopic level, asbestos cleavage fragments from asbestos fibers of the same size, shape, and composition. The Ninth Circuit Court of Appeals recognized the competing scientific arguments but found that EPA's position was consistent with the record of evidence and accepted scientific principles.[25]

R.J. Lee Finding #5: "Applying the Latest Science and Definitional Techniques, the El Dorado Hills Study Shows no Significant Exposure to the Type of Amphibole Asbestos Fiber Connected To Health Risk."

The R. J. Lee Report claims that the latest science for measuring the risk posed by asbestos is the Berman-Crump Asbestos Risk Assessment Protocol ("Berman-Crump") which proposes that amphibole asbestos fibers which are more than 10 microns long and less than 0.5 microns wide (protocol fibers) are the most toxic. Of the 2,386 fibers which the R. J. Lee Report states the EPA laboratory identified, the R.J. Lee Report concludes that only 7 fibers meet the "Berman-Crump" definition. Therefore, the R.J. Lee Group maintains that EPA has overstated the risk from exposure to asbestos fibers in El Dorado Hills.

EPA Response

The "Berman-Crump" protocol that the R.J. Lee Report references is in fact a draft EPA method. EPA had the method reviewed by a peer consultation panel in 2003. The panel made a number of important recommendations that must be addressed before the method can be used for EPA risk assessments. A number of important revisions have been made

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[24]G.P. Meeker, USGS, (2002). Review of Expert Report of R.J. Lee.

[25]U.S. v. W.R. Grace, 429 F.3d at 1245.

to the draft method since 2003, but at this time the method has not been independently peer reviewed. It will not be adopted by EPA as a risk assessment tool unless and until it passes rigorous internal and external peer review.

The expert peer panel has recommended that the fiber size for the draft EPA risk assessment method be adjusted to include fibers greater than 5 microns in length and up to 1.5 microns in width.[26] The change is designed to account for lung deposition of fibers that results when fibers are inhaled through the mouth, and not filtered by the nasal passages. The broadening of the fiber definition to include inhalation by "mouth breathers" is especially relevant to the El Dorado Hills data. Our investigation measured personal asbestos exposures of individuals participating in sports activities, where physical exertion would likely increase breathing through the mouth. **The PCME fibers counted in the EPA air samples are actually consistent with the latest science of EPA, as reflected in the recommendations of the peer consultation panel.** In addition, the EPA peer consultation expert panel recommended that cleavage fragments be treated as any other asbestos fiber of the same morphology and chemical composition.[27]

EPA Region 9 focused on obtaining an accurate count of PCME structures, consistent with our risk assessment protocols and those of Cal/EPA and other health agencies. The counting rules which EPA set for the laboratory were designed to stop counting when a statistically-significant number of PCME fibers were detected. By concentrating on PCME structures, other fiber size classifications may not have been counted to statistical significance. This may have resulted in under counts of other fiber sizes (e.g. the "Berman Crump" protocol fibers referred to in the R. J. Lee Report). **EPA Region 9's study counted PCME structures so that the data could be directly compared to human health epidemiological studies.** These epidemiological studies form the basis for risk assessment models currently used by EPA, Cal/EPA and other federal agencies and international organizations.

R. J. Lee Report Peer Reviews

The R. J. Lee Report was reviewed by three individuals, although research of one of the individuals was extensively quoted in the report and therefore the independence of the reviewer is debatable. The three reviewers generally agree with the conclusions of the R. J. Lee Report regarding aluminum content, fiber chemistry, cleavage fragments, and extinction angles.

Both the R. J. Lee Report and one of the reviewers support use of the original "Berman-

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[26]USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page 5-5.

[27]Ibid, page 5-1.

Crump" protocol and calculate a "Berman-Crump" fiber air concentration of 0.0002 fibers/cubic centimeter, using the EPA fibers which they assert meet the "Berman-Crump" definition. The peer reviewer then compares that concentration with an ambient concentration of 0.0008 fibers/milliliter measured in New York City, and states that the "Berman-Crump" value in El Dorado Hills is extremely low. This comparison is flawed for at least two reasons. Significantly, the New York City numbers are based on fibers counted against a totally different size classification (essentially comparing apples to oranges), but **the reviewer also fails to recognize that a concentration of 0.0002 f/cc translates in the protocol to an increased cancer risk of 1 in 1,000 exposed individuals.** This number is disturbingly high and is outside the acceptable cancer risk ranges of EPA, Cal/EPA, and most other state and federal health agencies.

<u>Conclusions</u>

EPA Region 9 has carefully reviewed the R. J. Lee Report and believes that it makes largely unsupported and incorrect conclusions about the EPA Region 9 El Dorado Hills Naturally Occurring Asbestos Exposure Assessment. EPA Region 9 has asked the United States Geological Survey (USGS) to conduct an independent study of the El Dorado County area to address several mineralogical questions raised by the R. J. Lee Report. The USGS study will use sophisticated analytical techniques (such as electron probe micro analysis) to more completely characterize the naturally occurring asbestos in terms of mineral identification and particle morphology.

All of the EPA Region 9 work in El Dorado Hills was, and continues to be, consistent with the EPA's standard operating and quality control procedures for asbestos work throughout the country.

Erskine Environmental Consulting

Geologic Investigations   Hazardous Materials   Naturally Occurring Asbestos

TECHNICAL MEMORANDUM

September 23, 2019

Subject: Comments:
-DEP Comment Regarding Heavy Equipment Loadout
-Review of DEP Reanalysis OF Asbestos Test Results by TEM Methodology
Rockhill Quarry
East Rockhill Township
Bucks County, PA

This memorandum provides comments and recommendations regarding two documents that have been issued since EEC's review of RJ Lee's asbestos test results dated September 1, 2019:

1. Message from Mr. Stefanko of the Pennsylvania Department of Environmental Protection (DEP) regarding the off loading of heavy equipment on the Rockhill Quarry site (received by the Rockhill Environmental Protection Alliance (REPA) on September 18, 2019),

2. Reanalysis of selected soil and rock samples by EMSL Laboratories for DEP dated August 21, 2019.

These comments are supplementary to and augment comments provided in two previous memoranda:

1. Review of Qualitative Geologic Survey Sampling Plan, Rockhill Quarry, East Rockhill Township, Bucks County, PA: Erskine Environmental Consulting (EEC) dated June 6, 2019.

2. Review of Asbestos Test Results, Rockhill Quarry, East Rockhill Township, Bucks County, PA: Erskine Environmental Consulting (EEC) dated September 1, 2019.

These comments are intended to be a brief summary of findings. The basis for many of the findings and opinions have been discussed in detail within the two previous memoranda submitted by EEC, and the recipients of this memo are referred to those documents where additional explanation is needed.

1. **Document Number 1: Follow up message submitted to REPA by Mr. Stefanko of the DEP on September 18, 2019.**

The following is the comment by Mr. Stenfanko according to the email that was forwarded to EEC:

On September 12, 2019, DEP was informed that an oversized delivery had been made to the Rock Hill Quarry. Upon investigation, DEP learned that the equipment delivery to the site was *an excavator that is not currently needed for the turnpike project and is being stored at the quarry.*

DEP understands there are ongoing community concerns regarding the site and any activity that occurs. Due to the nature of the delivery and low speed of travel, it is unlikely there was any significant disturbance of asbestos. Moving or unloading this type of heavy equipment is common and done in a meticulous manner.

In order to alleviate concerns, moving forward, Hanson and/or RE Pierson will be required to notify and receive approval from DEP prior to moving equipment, either onto or from the site.

Comment No. 1-1: "*Due to the nature of the delivery and low speed of travel, it is unlikely there was any significant disturbance of asbestos".*

Reducing speeds on unpaved surfaces is a standard practice to reduce asbestos emissions, and speed limits are a standard best management practice to control dust. However, speed is not the only factor that contributes to uncontrolled dust. Larger vehicles produce a higher dust plume than smaller vehicles. Larger vehicles are heavier, and the depth of disturbance is greater, which impacts a higher volume of soil. There are a greater number of tires, and semi-trailer trucks that haul heavy equipment such as large excavators are often 18-wheelers, which produce more dust than standard vehicles with four tires. Due to the larger tire size, the surface area of each wheel that contacts the ground is greater, generating more dust than smaller wheels on standard vehicles. The area under the semi-trailer is greater, and the turbulence created under the semi-trailer is greater. Large trucks therefore produce significantly more dust than small vehicles at the same speed.

It should be recognized that asbestos is one of the few Federally-listed carcinogens, and it needs to be respected as such. The well-established connection between mesothelioma, asbestosis and lung cancer to asbestos, combined with significant public concern, has led to numerous laws, regulations and standards of practice related to asbestos disturbance. The OSHA asbestos standard in the construction industry is an excellent example where reliance on perception and visible observation is not allowed. On a site where asbestos in any concentration is disturbed, the employer must conduct an Initial Exposure Assessment (IEA) of each activity that disturbs asbestos. An IEA, which includes personal air monitoring, must be conducted before any determination regarding respiratory protection is made. Wet methods must be employed (in this case, the wetting of roads). Workers, including truck drivers, require documented awareness training. Also, OSHA requires that all feasible engineering controls be in place before a decision is made that respirators are not required, and this determination must be based on air monitoring data only.

Comment 1-2: "*Moving or unloading this type of heavy equipment is common and done in a meticulous manner".*

It is true that loading and unloading of heavy equipment is done in a meticulous manner. Heavy equipment is remarkably expensive, and even minor damage can bring high costs. However, minimizing dust generation is perhaps one of the least concerns to contractors. It should also be noted that in construction, time is money. There is a great financial incentive to drive to and on the site as fast as possible, and drive off as fast as possible. An asbestos dust mitigation plan (ADMP) that includes the wetting of roads and speed limits, asbestos awareness training and instruction regarding the elements of the ADMP, and oversight and enforcement is a fundamental requirement at asbestos sites. Training and decontamination procedures is paramount to prevent

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contractors from inadvertently bringing dust home and exposing family members to asbestos. It should be pointed out that Union organizations, who are very concerned with health and safety of workers, fully support adherence to asbestos regulations and standards.

Recommendations

An ADMP that specifies dust control measures, training and oversight should be prepared and implemented before any activity that disturbs soil in any amount occurs. All workers that enter the site should conduct work in accordance to regulations and standards for construction on asbestos sites. Please refer to discussions provided in the previous EEC documents for details.

2. Document Number 2: EMSL's Re-Analysis of Selected Samples by both Polarizing Light Microscopy (PLM) and Transmission Electron Microscopy (TEM)

The attached table summarizes the asbestos test results of the initial investigation and the recent reanalysis of selected samples.

On the left of the table are the test results of the initial RJ Lee report. On the right are the test results of the reanalysis by EMSL, with the PLM results highlighted in gray and the TEM results highlighted in yellow. In both cases, the results for asbestos, "non-asbestos", and total are broken out. Details regarding the methodology, limitations and advantages of each method, as well as a discussion regarding what each are measuring, is provided in detail within EEC's previous test review that is cited above. The following are some observations regarding the sample results. Again, details that support the observations may be found in the previous document that reviewed the RJ Lee results.

Comment 2-1: *The PLM results of the RJ Lee and EMSL analyses do not appear to be consistent.*

This inconsistency is not unexpected. As discussed in the previous review of the RJ Lee test results, the PLM method cannot detect fine particles, and the point counting protocol carries a high error. It was originally designed to quantify asbestos in building materials where large amounts of asbestos were applied. Naturally Occurring Asbestos (NOA) is much more complex and its properties are not equivalent to commercially exploitable asbestos. As was done at EMSL, it should be used as a first order analysis, followed by TEM.

Comment 2-2: *The EMSL TEM results do not appear to be consistent with either the EMSL or RJ Lee PLM results.*

This inconsistency is expected. The two methods measure two very different things. The PLM concentration is related to surface area percent where the TEM analysis is a measurement of concentration by weight. Both of the measurements provide information, but the TEM method is the only one that measures a true concentration. Please see comment 2-3 that suggests one additional reason for the inconsistency (inaccuracy). Details regarding this subject are provided in the review of the RJ Lee test results.

Comment 2-3: *The target analytical sensitivity (0.1% by weight) is too low to provide accurate and reproducible data, and the scanning method likely contributed to this error.*

The Analytical Sensitivity (AS) is not a limit of detection. It is defined as the concentration of a unit fiber that is detected within the area scanned during the analysis. For air samples, where fibers of different sizes are counted with equivalence, the AS should be one-tenth of the target concentration. For soil samples, where the weight of each fiber is dependent on size, the AS needs to be at least $1/100^{th}$ of the target concentration, and in many cases, $1/1000^{th}$ of the target concentration. Thus, the AS should have been 0.001% to 0.0001% by weight. The target AS of 0.1%, usually targeted because of analytical cost considerations, produces data with a high error and a result that is not reproducible. In samples where short fibers are predominant, as is likely the case with the Rockhill samples, the result tends to under estimate the asbestos concentration. There are methods, such as the phased magnification method, that can be employed to produce more accurate data with low cost impacts.

Comment 2-4: *The Analytical Sensitivity of 0.1% was incorrectly specified as a reporting limit, which under reported the concentration of asbestos in many samples.*

The Analytical Sensitivity is not a reporting limit, as used by EMSL. Traditionally, a report of "less than" (<) a value, in this case, <0.1%, is reported when no asbestos was detected. Where fibers were counted, and the concentration was less than 0.1%, EMSL reported "<0.1%" instead of the concentration that was calculated.

An example can be found in the first lab report by EMSL (attached) for the sample no. RH#33. Note that two asbestos fibers of tremolite and 17 asbestos fibers of actinolite were observed, however, the concentration of these fibers was reported as "<0.1%". Apparently, the concentration was below 0.1%, and rather than reporting the measured concentration, <0.1% was reported. This would normally mean that no asbestos was present, but it certainly is not the case. All concentrations are valid, even when below the AS. The result is an inappropriate and arbitrary under reporting of asbestos in several samples. These samples are identified by the comment regarding unreported fibers in the notes column of the attached table.

Comment 2-5: *Like RJ Lee, EMSL used a differential counting method that is not allowed by the test method and under-estimates the concentration of asbestos.*

As discussed in the EEC review of the sampling work plan and RJ Lee results, differential counting practices under report the concentration of asbestos are not allowed by the EPA test methods that were selected, not published for peer review, and accepted by neither EPA nor NIOSH (concentrations within the two categories are found on the attached table as "asbestos" and "non-asbestos" columns). There is no approved test method to differentiate fibers that were created by the parting of amphiboles that crystallized in the asbestiform habit from those produced by cleaving along planes of weakness (generally referred to as cleavage fragments). Thus, the methodology is proprietary, and likely not consistent between the laboratories that employ them. TEM analysis, in particular, cannot distinguish the two morphologies, so it is unclear how EMSL could possibly separate reported amphiboles into the two categories. Review of the laboratory bench sheets suggest that the average aspect ratio of fibers (length divided by width) was used as a differentiator, which has no utility in asbestos determinations, particularly when the test method dictates that all fibers with an aspect ratio of greater than 3:1 be counted.

The intent of the very few laboratories who employ these methods, and of clients that request them, is uncertain. In any case, the result is the under reporting of regulated asbestos as would be normally reported by the EPA test methods that were employed by both laboratories. The actual asbestos concentration, assuming that the data is reliable, is the sum of the asbestos and "non-asbestos" columns, labeled in the attached table as Total Asbestos. These concentrations should be regarded as the lower estimate of asbestos concentrations in the rocks and soil that were analyzed.

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Conclusions and Recommendations

Review of the EMSL test results indicate that the test methodologies, particularly the TEM results, are likely not reliable nor reproducible. In particular, the use of an in-house and unpublished method that attempts to differentiate fibers by morphology severely under reported the true asbestos concentrations, as would normally be reported by the test methods that were employed.

Regardless, one fact emerges from both the EMSL and RJ Lee analyses: Regulated actinolite and subordinate tremolite asbestos is present in the rocks underlying the Rockhill quarry site, and the concentrations are sufficiently high to produce a potential adverse health impact to workers at the site, residents near the site, and particularly children attending schools near the site. The site is considered an NOA site, and all relevant asbestos regulations and standards of practice apply when disturbing these materials.

The results support the recommendations that were documented in EEC's review of the asbestos testing work plan and review of the RJ Lee analyses. These include, but are not limited to the following (see the referenced documents for details):

- A work plan for the geologic investigation of the site needs to be prepared, reviewed and implemented to characterize the asbestos concentrations in each rock unit. The testing should be conducted by an experienced laboratory that follows strict protocols as required by EPA test methods, and not deviate by using differential counting methods.

- Following the asbestos investigation, soil or rock disturbance should not occur until an ADMP is prepared, reviewed, and approved by the DEP.

- Consider Activity-Based Sampling (ABS) prior to construction to measure asbestos emissions that may be anticipated during construction.

- Worker protection procedures should be implemented in compliance with the appropriate lead agencies regulations, presumably the Mine Safety and Health Administration (MSHA) or the Occupational Safety and Health Administration (OSHA).

- An air monitoring program that includes perimeter monitoring and monitoring of roads that are used by haul trucks through the Rockhill Township should be developed and implemented. Consider predictive air modeling that may assist in the design of the air monitoring program, and set risk-based thresholds to document exposures to residents and children at nearby schools.

- Consider using an alternative quarry located near the project site. This would eliminate the potential health risk caused by activities at the Rockhill Quarry.

Bradley G. Erskine, Ph.D., CEG
Erskine Environmental Consulting

Summary of Asbestos Testing
Original PLM Testing by R.J. Lee.

Sample ID	Asbestos	"Non-Asbestos" Fibers	Total Asbestos (EPA Criteria)
June 26 2019 lab sample May 30 2019			
#1 -CB-1 #1	0.2	0.1	0.3
#2 -CB-1 #3	ND	0.2	0.2
#3 -CB-2#4	ND	0.2	0.2
#4-CB-2#5	ND	0.1	0.1
#5 -CB-2 #6	0.1	0.3	0.4
#6 -CB-3 #7	ND	0.3	0.3
#7 -CB-3 #8	ND	0.2	0.2
#8 -CB-3 #9	ND	<0.1	0.05
#9- CB-4 #10	ND	<0.1	0.05
June 26 2019 lab sample June 3 2019			
1 - RH #1	ND	<0.1	0.05
2- RH#2	<0.1	0.5	0.505
3- RH#3	ND	<0.1	0.05
4-RH#4	ND	<0.1	0.05
5-RH#5	ND	<0.1	0.05
6-RH#6	ND	<0.1	0.05
7-RH#7	<0.1	<0.1	0.1
8-RH#8	ND	<0.1	0.05
9-RH#10	ND	<0.1	0.05
10-RH#11	<0.1	<0.1	0.1
11 -RH #12	<0.1	0.3	0.305
12 -RH #14	<0.1	0.5	0.505
13 -RH#18	ND	<0.1	0.05
June 27 2019 lab sample May 30 2019			
#1 - DB-1	0.1	0.2	0.3
#2 - DB-2	ND	ND	0
#3 - DB-3	ND	ND	0
#4 - DB-4	ND	ND	0
#1 - Hand Sample #1	ND	0.1	0.1
#2 - Hand Sample #2	ND	ND	0
#3 - Vein 7	0.1	0.4	0.5
June 27 2019 lab sample June 3 2019			
14 - RH #22	ND	<0.1	0.05
15 - RH #23	ND	<0.1	0.05
16 - RH #24	ND	ND	0
17 - RH #25	ND	<0.1	0.05
18 - RH #26	<0.1	ND	0.05
19 - RH #27	ND	ND	0
20 - RH #28	ND	ND	0
21 - RH #29	<0.1	0.2	0.205
22 - RH #30	ND	0.2	0.2
23 - RH #31	ND	0.2	0.2
24 - RH #32	ND	0.3	0.3
25 - RH #33	ND	0.8	0.8

Notes:
Asbestos= Concentrations reported as "asbestos" by the laboratory
Non-Asbestos Fibers= Concentrations reported as "non-asbestos fibers" by the laboratory
Total Asbestos= Concentrations calculated using EPA criteria.
ND= No fibers detected.
<0.1= Fibers detected but none fell on one of the 1,000 counting points.
Average Concentrations: The average concentrations were calculated using a value of 1/2 the limit of quantitation for trace concentrations (<0.1%) and zero for samples where no asbestos was detected.

Summary of Asbestos Testing
PLM and TEM Analyses by EMSL

Re-Analysis by PLM			Re-Analysis by TEM			
EMSL Reanalysis (PLM- Asestos)	EMSL Reanalysis (PLM- "Non-Asestos")	Total Asbestos (PLM- EPA Criteria)	EMSL Reanalysis (TEM-Asbestos)	EMSL Reanalysis (TEM-Non-Asbestos)	Total Asbestos (TEM- EPA Criteria)	NOTES
Reanalyses of Selected Samples by EMSL						
0.0	3.0	3.0	3.3	0.8	4.1	
0.0	5.0	5.0	0.5	<0.1	0.5	19 "non-asbestos" fibers were counted but not reported.
0.0	4.0	4.0	0.6	<0.1	0.6	11 "non-asbestos" fibers were counted but not reported.
0.0	5.0	5.0	0.2	<0.1	0.2	12 "non-asbestos" fibers were counted but not reported.
0.0	5.0	5.0	<0.1	0.2	0.2	
0.0	3.0	3.0	<0.1	<0.1	<0.1	one asbestos and one "non-asbestos" fibers were counted but not reported.
0.0	0.0	0.0	0.7	0.1	0.8	
0.0	3.0	3.0	0.6	0.2	0.8	
18.0	10.0	28.0	19.1	5.4	24.5	
0.0	3.0	3.0	0.05	<0.1	0.05	19 asbestos and 18 "non-asbestos" fibers were counted but not reported.

Notes:
Asbestos= Concentrations reported as "asbestos" by the laboratory
Non-Asbestos Fibers= Concentrations reported as "non-asbestos fibers" by the laboratory
Total Asbestos= Concentrations calculated using EPA criteria.
ND= No fibers detected.
<0.1= Fibers detected but none fell on one of the 1,000 counting points (PLM) or not detected within the scan area (TEM).
Total Asbestos Concentration: The average concentrations were calculated using a value of 0.5 where <0.1% asbestos was reported.

OrderID: 041922026

Asbestos Chain of Custody

EMSL Order Number *(Lab Use Only)*: 041922026

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LABORATORY • PRODUCTS • TRAINING

EMSL ANALYTICAL, INC.
5221 MILITIA HILL ROAD
PLYMOUTH MEETING, PA 19462
PHONE: (610) 828-3102
FAX: (610) 828-3122

Company Name: PA Dept. of Environmental Protection	**EMSL Customer ID:** PADP42
Street: 5 W. Laurel Blvd	**City:** Pottsville **State/Province:** PA
Zip/Postal Code: 17901 **Country:** US	**Telephone #:** 570-621-3118 **Fax #:** 570-621-3110
Report To (Name): Gary Latsha	**Please Provide Results:** ☐ Fax ☒ Email
Email Address: galatsha@pa.gov	**Purchase Order:**
Project Name/Number: Rockhill Quarry	**EMSL Project ID** *(Internal Use Only)*:
U.S. State Samples Taken: PA	**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:
☐

RECEIVED EMSL MANAHAWKIN, NJ 19 JUL 30 P 3:

☐ **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
RH # 33	rock		5/13/19 0830
DB -4	69.0' - core sample - rock		5/23/19 1248
HS # 2	bench zero trench - rock		5/15/19 1050
CB-3 # 8	core sample - rock		5/23/19 1203
CB-1 #1	core sample - rock		5/23/19 1123

Client Sample # (s): **Total # of Samples:** 10

Relinquished (Client): Amiee Bollinger **Date:** 7/30/19 **Time:** 0938

Received (Lab): [signature] **Date:** 7/30/19 **Time:** 9:38 AM

Comments/Special Instructions:
Disk milling on all samples - See attached quote sheet for methods

Rel. Toni Lucey
7-30-19 545

Page 1 of 2 pages

Rec: [signature] courier (10R4)
7/30/19 550

Controlled Document – Asbestos COC – R10 – 05/09/2016

OrderID: 041922026

Asbestos Chain of Custody

EMSL Order Number *(Lab Use Only)*: 041922026

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FAX: (610) 828-3122

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
CB-2 #5	core sample - rock		5/23/19 1147
CB-4 #10	core sample - rock		5/23/19 1211
CB-2 #4	core sample - rock		5/23/19 1139
RH HS -1	hand sample #1 rock		5/1/19 1400
RH Vein #7	rock sample		5/10/19 1300

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***Comments/Special Instructions:**

Page 2 of 2 pages

Controlled Document – Asbestos COC – R8 – 4/11/2012

OrderID: 041922026

EMSL ANALYTICAL, INC.

http://www.emsl.com
800-220-3675

EMSL ANALYTICAL, INC.
Confidential Pricing
PA Dept of Environmental Protection
Customer ID: PADP42
July 30, 2019

041922026

Locally Focused.....
.........Nationally Recognized

Attention:
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PA Dept of Environmental Protection
5 Laurel Blvd.
Pottsville, PA 17901
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galatsha@pa.gov

Contact:
Gary Perlmutter, Regional Account Manager
EMSL Analytical, Inc.
200 Route 130 North
Cinnaminson, NJ 08077
(856) 303-2530

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Asbestos Laboratory Services [1]

SOIL / ROCK / VERMICULITE METHODS	3 Hr	6 Hr	24 Hr	48 Hr	72 Hr	96 Hr	1 Wk	2 Wk
PLM by EPA/600/R-93/116 with Milling Prep Level A (400 Point Count, reporting limit to <0.25%)	$449.00	$321.00	$238.00	$197.00	$168.00	$138.00	$107.00	$77.50
* PLM by EPA/600/R-93/116 with Milling Prep Level B (1000 Point Count, reporting limit to <0.1%)	$544.00	$416.00	$290.00	$247.00	$215.00	$186.00	$155.00	$125.00
PLM by EPA/600/R-93/116 with Milling and Gravimetric Prep Level A (400 Point Count, reporting limit to <0.25%)	$461.00	$333.00	$250.00	$209.00	$179.00	$149.00	$119.00	$88.00
PLM by EPA/600/R-93/116 with Milling Prep and Gravimetric Prep Level B (1000 Point Count, reporting limit to <0.1%)	$557.00	$427.00	$301.00	$258.00	$227.00	$197.00	$167.00	$137.00
* TEM by EPA/600/R-93/116 with Milling Prep Level B (reporting limit to 0.1%)	N/A	N/A	$406.00	$351.00	$316.00	$281.00	$247.00	$212.00
TEM by EPA/600/R-93/116 with Milling and Gravimetric Prep Level B (reporting limit to 0.1%)	N/A	N/A	$418.00	$361.00	$328.00	$292.00	$258.00	$223.00
TEM by EPA/600/R-93/116 with Milling Prep Level C (reporting limit to 0 01%)	N/A	N/A	$455.00	$392.00	$351.00	$322.00	$287.00	$252.00
TEM by EPA/600/R-93/116 with Milling and Gravimetric Prep Level C (reporting limit to 0.01%)	N/A	N/A	$466.00	$402.00	$361.00	$333.00	$298.00	$264.00
PLM CARB 435 Level A (reporting limit to 0.25%)	$449.00	$321.00	$238.00	$197.00	$168.00	$138.00	$107 00	$77.50
PLM CARB 435 Level B (reporting limit to 0.1%)	$544.00	$415.00	$289.00	$246.00	$215.00	$185.00	$155.00	$125.00
TEM CARB 435 Level B (reporting limit to 0.1%)	N/A	N/A	$423.00	$365.00	$329.00	$292.00	$257.00	$219.00
TEM CARB 435 Level C (reporting limit to 0.01%) [2]	N/A	N/A	$474.00	$406.00	$365.00	$335.00	$298.00	$263.00
ASTM D7521 Asbestos in Soil PLM Quantitative with TEM Qualitative check	N/A	N/A	$284.00	$235.00	$205.00	$187.00	$145.00	$127.00
ASTM D7521 Asbestos in Soil TEM Quantitative [3]	N/A	N/A	$307.00	$268.00	$247.00	$239.00	$233.00	$225.00
PLM Qualitative (Asbestos Detect/Non Detect only)	$102.00	$68.50	$43.00	$35.00	$31.25	$28 90	$27.65	$26.45
TEM Qualitative via Filtration Prep Technique	N/A	Call	$142.00	$112.00	$90.50	$83.00	$75.50	$70.50
TEM Qualitative via Drop Mount Prep Technique	Call	Call	$107.00	$84.00	$67.00	$63.00	$56.50	$51.50
Fluidized Bed Asbestos Segregator (FBAS)-Level A	N/A	N/A	N/A	N/A	N/A	N/A	$566.00	$507.00
Fluidized Bed Asbestos Segregator (FBAS)-Level B	N/A	N/A	N/A	N/A	N/A	N/A	$624.00	$565.00
Fluidized Bed Asbestos Segregator (FBAS)-Level C	N/A	N/A	N/A	N/A	N/A	N/A	$739.00	$680.00
Fluidized Bed Asbestos Segregator (FBAS)-Level D	N/A	N/A	N/A	N/A	N/A	N/A	$1,213.00	$1,150.00
Superfund EPA 540-R-97-028 (Elutriator Method)	N/A	N/A	N/A	N/A	N/A	Call	$1,539.00	$1,358.00
Cincinnati Method EPA 600/R-04/004 PLM Only	N/A	N/A	N/A	N/A	$254.00	$232.00	$216.00	$181.00
Cincinnati Method EPA 600/R-04/004 TEM [3]	N/A	N/A	N/A	N/A	$181.00	$174.00	$169.00	$156.00
Jaw Crushing Prep	$368.00	$263.00	$184.00	$147.00	$105.00	$89.50	$79.00	$79.00
Milling Prep	$368.00	$263.00	$184.00	$147.00	$105.00	$89.50	$79.00	$79.00
Sample Homogenization (Turbula Mixer/Riffle Splitter)	$263.00	$158.00	$105.00	$79.00	$68.50	$61.00	$52.50	$36.75

All Test pricing is "Per Sample Unit Rates" which will apply to each item, discreet Sample and/or sub-component submitted for analysis. This unit price quote includes Customer Specific pricing which takes into account types of samples typically and/or routinely submitted, volume of workload expected, and client payment history and/or credit rating. Any/all work performed will be in accordance with EMSL Analytical, Inc. Terms and Conditions included herein. EMSL reserves the right to adjust pricing at our sole discretion based on (but not limited to) the customer's non-compliance with net 30 day payment terms, change in scope of work including but not limited to an amount/volume of work less then described at the time of the quote, and/or non-compliance with the EMSL terms and conditions included herein

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Customer PO:
Project ID:

Attn: *Gary Latsha*
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5 Laurel Blvd.
Pottsville, PA, 17901

Phone: (570) 274-2464
Fax: N/A
Collected: 05/13/2019
Received: 07/30/19 17:50

Project: **Rockhill Quarry**

Analyzed: 8/15/2019 - 8/21/2019

SUMMARY REPORT : TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Sample ID	*Minerals Present*	*Results*	*Structures*	*Reporting Limit*	*Asbestos Weight*	*Comments*
RH#33	*Tremolite, Non-asbestiform Tremolite, Actinolite, Non-asbestiform Actinolite, Pyroxene, Non-asbestiform Pyroxene*	Regulated Asbestos	19	0.1%	< 0.1%	*Pyx = Diopside*
041922026-0001 *Rock*		Other Minerals	20		< 0.1%	
		Total	**39**		**< 0.1%**	
		Undetermined	0		------------	
DB-4	*Actinolite, Non-asbestiform Actinolite*	Regulated Asbestos	1	0.1%	< 0.1%	
041922026-0002 *69.0'-Core Sample-Rock*		Other Minerals	1		< 0.1%	
		Total	**2**		**< 0.1%**	
		Undetermined	0		------------	
HS#2	*Non-asbestiform Actinolite, Actinolite*	Regulated Asbestos	52	0.1%	0.6%	
041922026-0003 *Bench Zero Trench-Rock*		Other Minerals	7		0.2%	
		Total	**59**		**0.8%**	
		Undetermined	0		------------	
CB-3#8	*Actinolite, Non-asbestiform Actinolite*	Regulated Asbestos	41	0.1%	0.2%	
041922026-0004 *Core Sample-Rock*		Other Minerals	12		< 0.1%	
		Total	**53**		**0.3%**	
		Undetermined	0		------------	
CB-1#1	*Non-asbestiform Actinolite, Actinolite, Non-asbestiform Pyroxene*	Regulated Asbestos	54	0.1%	3.3%	*Pyx = Diopside*
041922026-0005 *Core Sample-Rock*		Other Minerals	27		0.9%	
		Total	**81**		**4.2%**	
		Undetermined	0		------------	
CB-2#5	*Actinolite, Non-asbestiform Actinolite*	Regulated Asbestos	41	0.1%	0.6%	
041922026-0006 *Core Sample-Rock*		Other Minerals	11		< 0.1%	
		Total	**52**		**0.6%**	
		Undetermined	0		------------	
CB-4#10	*Actinolite, Non-asbestiform Actinolite*	Regulated Asbestos	23	0.1%	< 0.1%	
041922026-0007 *Core Sample-Rock*		Other Minerals	18		0.2%	
		Total	**41**		**0.2%**	
		Undetermined	0		------------	
CB-2#4	*Actinolite, Non-asbestiform Actinolite*	Regulated Asbestos	31	0.1%	0.5%	
041922026-0008 *Core Sample-Rock*		Other Minerals	19		< 0.1%	
		Total	**50**		**0.5%**	
		Undetermined	0		------------	

F Craig
Analyst

Approved Signatory

TEM CARB Spreadsheet Version: 7.4

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Project: **Rockhill Quarry**

Analyzed: 8/15/2019 - 8/21/2019

SUMMARY REPORT : TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Sample ID	*Minerals Present*	*Results*	*Structures*	*Reporting Limit*	*Asbestos Weight*	*Comments*
RH HS-1	*Non-asbestiform Actinolite, Actinolite*	Regulated Asbestos	21	0.1%	0.7%	
041922026-0009		Other Minerals	14		0.1%	
Hand Sample#1 Rock		**Total**	**35**		**0.8%**	
		Undetermined	0		---------------	
RH Vein#7	*Non-asbestiform Actinolite, Actinolite*	Regulated Asbestos	76	0.1%	19.1%	
041922026-0010		Other Minerals	27		5.4%	
Rock Sample		**Total**	**103**		**24.5%**	
		Undetermined	0		---------------	

F Craig
Analyst

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Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: **RH#33**
Reporting Limit : 0.1%
Sample Description: **Rock**

EMSL Sample Number: 041922026-0001
Sample Matrix: Bulk
Aspect ratio for fiber definition: 3:1
Area of collection filter (mm²): 1360
Minimum Length (µm): 0.5
Grid Opening Area (mm²): 0.0062
Gravimetric Reduction Ratio: 1.00
Grid Openings Analyzed: 10
Mass contributed by Largest fiber: 45%
Analyst: F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**19**	**< 0.1%**	**10.7**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	2	< 0.1%	8.8
Actinolite	17	< 0.1%	10.9
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**20**	**< 0.1%**	**6.5**
Non-asbestiform Actinolite	16	< 0.1%	6.7
Non-asbestiform Pyroxene	1	< 0.1%	3.1
Non-asbestiform Tremolite	2	< 0.1%	7.6
Pyroxene	1	< 0.1%	4.3
Undetermined Elongate Mineral	**None Detected**	**-**	

Pyx = Diopside

Laboratory Manager or Other Approved Signatory

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Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: DB-4 | **Reporting Limit : 0.1%**
Sample Description: 69.0'-Core Sample-Rock

EMSL Sample Number:	041922026-0002	Sample Matrix:	Bulk
Aspect ratio for fiber definition:	3:1	Area of collection filter (mm²):	1360
Minimum Length (µm):	0.5	Grid Opening Area (mm²):	0.0062
Gravimetric Reduction Ratio:	1.00	Grid Openings Analyzed:	10
Mass contributed by Largest fiber:	75%	Analyst:	F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**1**	**< 0.1%**	**6**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	1	< 0.1%	6
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**1**	**< 0.1%**	**6**
Non-asbestiform Actinolite	1	< 0.1%	6
Unknown Elongate Mineral	**None Detected**	**-**	

Laboratory Manager or Other Approved Signatory

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Received: 07/30/19 17:50

Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: HS#2 — **Reporting Limit :** 0.1%
Sample Decription: Bench Zero Trench-Rock

EMSL Sample Number: 041922026-0003
Aspect ratio for fiber definition: 3:1
Minimum Length (μm): 0.5
Gravimetric Reduction Ratio: 1.00
Mass contributed by Largest fiber: 56%

Sample Matrix: Bulk
Area of collection filter (mm²): 1360
Grid Opening Area (mm²): 0.0062
Grid Openings Analyzed: 4
Analyst: F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**52**	**0.6%**	**20**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	52	0.6%	20
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**7**	**0.2%**	**14**
Non-asbestiform Actinolite	7	0.2%	14
Unknown Elongate Mineral	**None Detected**	**-**	

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Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: CB-3#8 — **Reporting Limit : 0.1%**
Sample Decription: Core Sample-Rock

EMSL Sample Number:	041922026-0004	Sample Matrix:	Bulk
Aspect ratio for fiber definition:	3:1	Area of collection filter (mm²):	1360
Minimum Length (µm):	0.5	Grid Opening Area (mm²):	0.0062
Gravimetric Reduction Ratio:	1.00	Grid Openings Analyzed:	5
Mass contributed by Largest fiber:	49%	Analyst:	F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**41**	**0.2%**	**15**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	41	0.2%	15
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**12**	**< 0.1%**	**11**
Non-asbestiform Actinolite	12	< 0.1%	11
Unknown Elongate Mineral	**None Detected**	**-**	

Laboratory Manager or Other Approved Signatory

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Collected: 05/13/2019
Received: 07/30/19 17:50

Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: CB-1#1 **Reporting Limit : 0.1%**
Sample Decription: Core Sample-Rock

EMSL Sample Number:	041922026-0005	Sample Matrix:	Bulk
Aspect ratio for fiber definition:	3:1	Area of collection filter (mm²):	1360
Minimum Length (µm):	0.5	Grid Opening Area (mm²):	0.0062
Gravimetric Reduction Ratio:	1.00	Grid Openings Analyzed:	4
Mass contributed by Largest fiber:	42%	Analyst:	F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**54**	**3.3%**	**27**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	54	3.3%	27
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**27**	**0.9%**	**11**
Non-asbestiform Actinolite	26	0.8%	11
Non-asbestiform Pyroxene	1	< 0.1%	7
Unknown Elongate Mineral	**None Detected**	**-**	

Pyx = Diopside

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Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: CB-2#5 **Reporting Limit :** 0.1%
Sample Decription: Core Sample-Rock

EMSL Sample Number:	041922026-0006	Sample Matrix:	Bulk
Aspect ratio for fiber definition:	3:1	Area of collection filter (mm²):	1360
Minimum Length (µm):	0.5	Grid Opening Area (mm²):	0.0062
Gravimetric Reduction Ratio:	1.00	Grid Openings Analyzed:	9
Mass contributed by Largest fiber:	71%	Analyst:	F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**41**	**0.6%**	**14**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	41	0.6%	14
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**11**	**< 0.1%**	**17**
Non-asbestiform Actinolite	11	< 0.1%	17
Unknown Elongate Mineral	**None Detected**	**-**	

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TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: CB-4#10 — **Reporting Limit : 0.1%**
Sample Decription: Core Sample-Rock

EMSL Sample Number:	041922026-0007	Sample Matrix:	Bulk
Aspect ratio for fiber definition:	3:1	Area of collection filter (mm²):	1360
Minimum Length (µm):	0.5	Grid Opening Area (mm²):	0.0062
Gravimetric Reduction Ratio:	1.00	Grid Openings Analyzed:	10
Mass contributed by Largest fiber:	23%	Analyst:	F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**23**	**< 0.1%**	**12**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	23	< 0.1%	12
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**18**	**0.2%**	**8**
Non-asbestiform Actinolite	18	0.2%	8
Unknown Elongate Mineral	**None Detected**	**-**	

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Phone: (570) 274-2464
Fax: N/A
Collected: 05/13/2019
Received: 07/30/19 17:50

Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: CB-2#4 | **Reporting Limit : 0.1%**

Sample Decription: Core Sample-Rock

EMSL Sample Number: 041922026-0008
Aspect ratio for fiber definition: 3:1
Minimum Length (µm): 0.5
Gravimetric Reduction Ratio: 1.00
Mass contributed by Largest fiber: 73%

Sample Matrix: Bulk
Area of collection filter (mm²): 1360
Grid Opening Area (mm²): 0.0062
Grid Openings Analyzed: 8
Analyst: F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**31**	**0.5%**	**15**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	31	0.5%	15
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**19**	**< 0.1%**	**8**
Non-asbestiform Actinolite	19	< 0.1%	8
Unknown Elongate Mineral	**None Detected**	**-**	

Laboratory Manager or Other Approved Signatory

EMSL Analytical, Inc.
200 Route 130 North, Cinnaminson, NJ 08077
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Fax: (856) 858-1292
Email: CinnAsblab@emsl.com

EMSL Order: 041922026
Customer ID: PADP42
Customer PO:
Project ID:

Attn: *Gary Latsha*
PA Dept of Environmental Protection
5 Laurel Blvd.
Pottsville, PA, 17901

Phone: (570) 274-2464
Fax: N/A
Collected: 05/13/2019
Received: 07/30/19 17:50

Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: RH HS-1
Reporting Limit : 0.1%
Sample Decription: Hand Sample#1 Rock

EMSL Sample Number: 041922026-0009
Sample Matrix: Bulk
Aspect ratio for fiber definition: 3:1
Area of collection filter (mm^2): 1360
Minimum Length (μm): 0.5
Grid Opening Area (mm^2): 0.0062
Gravimetric Reduction Ratio: 1.00
Grid Openings Analyzed: 10
Mass contributed by Largest fiber: 39%
Analyst: F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**21**	**0.7%**	**10**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	21	0.7%	10
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**14**	**0.1%**	**12**
Non-asbestiform Actinolite	14	0.1%	12
Unknown Elongate Mineral	**None Detected**	**-**	

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EMSL Order: 041922026
Customer ID: PADP42
Customer PO:
Project ID:

Attn: *Gary Latsha*
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5 Laurel Blvd.
Pottsville, PA, 17901

Phone: (570) 274-2464
Fax: N/A
Collected: 05/13/2019
Received: 07/30/19 17:50

Project: Rockhill Quarry

Analyzed: 08/15/2019

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Detailed Sample Report

Customer Sample Number: RH Vein#7 — **Reporting Limit : 0.1%**
Sample Decription: Rock Sample

EMSL Sample Number:	041922026-0010	Sample Matrix:	Bulk
Aspect ratio for fiber definition:	3:1	Area of collection filter (mm²):	1360
Minimum Length (µm):	0.5	Grid Opening Area (mm²):	0.0062
Gravimetric Reduction Ratio:	1.00	Grid Openings Analyzed:	3
Mass contributed by Largest fiber:	69%	Analyst:	F Craig

Mineral Type	Stuctures	Weight %	Average Aspect Ratio
Total Regulated Asbestos	**76**	**19.1%**	**28**
Chrysotile	None Detected	<0.1%	
Amosite	None Detected	<0.1%	
Crocidolite	None Detected	<0.1%	
Tremolite	None Detected	<0.1%	
Actinolite	76	19.1%	28
Anthophyllite	None Detected	<0.1%	
Total Other Elongate Mineral Types	**27**	**5.4%**	**19**
Non-asbestiform Actinolite	27	5.4%	19
Unknown Elongate Mineral	**None Detected**	**-**	

Laboratory Manager or Other Approved Signatory

Asbestos Analysis Of Bulk Materials using Polarized Light Microscopy With Point Counting

Special Instructions: Due Date 08/13/2019

Sample Number	**041922026-0001**	Analyst	wnguyen
Customer Sample No.	RH #33	Analysis Date	08/13/2019 09:34 AM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**3.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**97.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Fibrous (other)	3			Straight			Medium: 0.011-0.0!		

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Sample Number	**041922026-0002**	Analyst	wnguyen
Customer Sample No.	DB-4	Analysis Date	08/13/2019 09:57 AM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**3.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**97.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Fibrous (other)	3			Straight			Medium: 0.011-0.0!		

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Sample Number	**041922026-0003**	Analyst	wnguyen
Customer Sample No.	HS #2	Analysis Date	08/13/2019 10:16 AM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased/Crushed	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**3.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**97.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Fibrous (other)	3			Straight			Medium: 0.011-0.0!		

Asbestos Analysis Of Bulk Materials using Polarized Light Microscopy With Point Counting

Special Instructions: Due Date 08/13/2019

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Sample Number	**041922026-0004**	Analyst	wnguyen
Customer Sample No.	CB-3 #8	Analysis Date	08/13/2019 10:35 AM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**5.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**95.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Fibrous (other)	5			Straight			Medium: 0.011-0.0!		

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Sample Number	**041922026-0005**	Analyst	wnguyen
Customer Sample No.	CB-1 #1	Analysis Date	08/13/2019 11:23 AM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**3.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**97.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Fibrous (other)	3			Straight			Medium: 0.011-0.0!		

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Asbestos Analysis Of Bulk Materials using Polarized Light Microscopy With Point Counting

Special Instructions: Due Date 08/13/2019

Sample Number	**041922026-0006**	Analyst	wnguyen
Customer Sample No.	CB-2 #5	Analysis Date	08/13/2019 11:42 AM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**4.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**96.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Fibrous (other)	4			Straight			Medium: 0.011-0.0!		

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Sample Number	**041922026-0007**	Analyst	wnguyen
Customer Sample No.	CB-4 #10	Analysis Date	08/13/2019 12:00 PM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased/Crushed	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**5.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**95.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Fibrous (other)	5			Straight			Medium: 0.011-0.0!		

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Sample Number	**041922026-0008**	Analyst	wnguyen
Customer Sample No.	CB-2 #4	Analysis Date	08/13/2019 12:12 PM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**5.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**95.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Fibrous (other)	5			Straight			Medium: 0.011-0.0!		

Asbestos Analysis Of Bulk Materials using Polarized Light Microscopy With Point Counting

Special Instructions: Due Date 08/13/2019

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Sample Number	**041922026-0009**	Analyst	wnguyen
Customer Sample No.	RH HS-1	Analysis Date	08/13/2019 01:37 PM
Matrix	Bulk	Status	None Detected

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**0.0**
Treatment	Teased/Crushed/Dissolved	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**0.0**
Texture	Non-Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**100.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction

Comment:

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	100	0	0	0	0	0	0
	02	100	0	0	0	0	0	0
	03	100	0	0	0	0	0	0
	04	100	0	0	0	0	0	0
	05	100	0	0	0	0	0	0
	06	100	0	0	0	0	0	0
	07	100	0	0	0	0	0	0
	08	100	0	0	0	0	0	0
	09	100	0	0	0	0	0	0
	10	100	0	0	0	0	0	0

Sample Number	**041922026-0010**	Analyst	wnguyen
Customer Sample No.	RH Vein #7	Analysis Date	08/13/2019 01:47 PM
Matrix	Bulk	Status	Positive Result

Sample Colors	Gray	Homogeneity	Homogeneous	**% Asbestos**	**18.0**
Treatment	Teased	Stereo Asb. Est.		**% Non-Asb. Fibrous**	**10.0**
Texture	Fibrous	Temperature (C)	21.8	**% Non-fibrous**	**72.0**

Comments:

Material	Pct	R.I. Perpend.	R.I. Parallel	Morphology	Elongation	Pleochroism	Birefringence	Fiber Color	Extinction
Actinolite	18.0	1.621	1.638	Straight	+	No	Medium: 0.011-0.0!	Colorless	Oblique
Fibrous (other)	10			Straight			Medium: 0.011-0.0!		

Point counts:	SlideID	Non-asbestos	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
	01	79	0	0	0	0	0	21
	02	89	0	0	0	0	0	11
	03	85	0	0	0	0	0	15
	04	80	0	0	0	0	0	20
	05	75	0	0	0	0	0	25
	06	81	0	0	0	0	0	19
	07	84	0	0	0	0	0	16
	08	78	0	0	0	0	0	22
	09	91	0	0	0	0	0	9
	10	76	0	0	0	0	0	24

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Project ID:

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: RH#33
Laboratory Sample ID: 041922026-0001
Sample Description: Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
B1 : N5	Tremolite	5.4	0.49	F	1106	4.27E-03	11.0	Regulated
B1 : N5	Non-asbestiform Tremolite	2.4	0.25	F		4.94E-04	9.6	Other
B1 : N5	Actinolite	4.7	0.49	F		3.84E-03	9.6	Regulated
B1 : K3	Actinolite	4.9	0.25	F		1.04E-03	19.6	Regulated
B1 : K3	Actinolite	2.9	0.25	f	1108	6.16E-04	11.6	Regulated
B1 : K3	Non-asbestiform Actinolite	1.6	0.25	f		3.40E-04	6.4	Other
B1 : K3	Pyroxene	1.6	0.37	F		8.12E-04	4.3	Other
B1 : K3	Non-asbestiform Actinolite	1.6	0.12	F		7.83E-05	13.3	Other
B1 : K3	Non-asbestiform Actinolite	1.5	0.49	F		1.22E-03	3.1	Other
B1 : K3	Non-asbestiform Actinolite	2.4	0.25	F		5.10E-04	9.6	Other
B1 : K3	Actinolite	1.9	0.12	F		9.30E-05	15.8	Regulated
B1 : I5	Non-asbestiform Actinolite	1.2	0.12	F		5.88E-05	10.0	Other
B1 : I5	Non-asbestiform Tremolite	6.9	1.23	F		3.43E-02	5.6	Other
B1 : I5	Actinolite	1.5	0.25	F		3.19E-04	6.0	Regulated
B1 : I5	Non-asbestiform Actinolite	3.4	0.98	F		1.11E-02	3.5	Other
B1 : I5	Actinolite	2.9	0.25	F		6.16E-04	11.6	Regulated
B1 : F4	Actinolite	1.2	0.12	F		5.88E-05	10.0	Regulated
B1 : F4	Actinolite	1.6	0.25	F		3.40E-04	6.4	Regulated
B1 : F4	Non-asbestiform Actinolite	1.6	0.12	F		7.83E-05	13.3	Other
B1 : F4	Non-asbestiform Actinolite	2.8	0.37	F		1.30E-03	7.6	Other
B1 : C7	Actinolite	1.2	0.12	F		5.88E-05	10.0	Regulated
B1 : C7	Actinolite	1.5	0.12	F		7.34E-05	12.5	Regulated
B1 : C7	Non-asbestiform Actinolite	1.2	0.12	F		5.88E-05	10.0	Other
B2 : B6	Non-asbestiform Actinolite	2.2	0.49	F		1.80E-03	4.5	Other
B2 : B6	Actinolite	1.2	0.48	F		0.00E+00	2.5	Regulated
B2 : B6	Non-asbestiform Pyroxene	1.5	0.49	F		1.34E-03	3.1	Other

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Customer PO:
Project ID:

TEM EPA 600/R-93/116

Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: RH#33
Laboratory Sample ID: 041922026-0001
Sample Description: Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
B2 : E2	Actinolite	2.4	0.12	F		1.18E-04	20.0	Regulated
B2 : E2	Tremolite	2.4	0.37	F		1.08E-03	6.5	Regulated
B2 : E2	Non-asbestiform Actinolite	2.6	0.49	F		2.12E-03	5.3	Other
B2 : E2	Non-asbestiform Actinolite	2.4	0.49	F		1.96E-03	4.9	Other
B2 : H4	Actinolite	1.2	0.25	F		2.55E-04	4.8	Regulated
B2 : H4	Actinolite	1.5	0.37	F		6.98E-04	4.1	Regulated
B2 : L6	Actinolite	3.1	0.12	F		1.52E-04	25.8	Regulated
B2 : L6	Actinolite	1.5	0.25	F		3.19E-04	6.0	Regulated
B2 : L6	Actinolite	2.3	0.25	F		4.89E-04	9.2	Regulated
B2 : N5	Non-asbestiform Actinolite	1.9	0.49	F		1.55E-03	3.9	Other
B2 : N5	Non-asbestiform Actinolite	1.6	0.37	F		7.45E-04	4.3	Other
B2 : N5	Non-asbestiform Actinolite	1.5	0.49	F		1.22E-03	3.1	Other
B2 : N5	Non-asbestiform Actinolite	1.2	0.25	F		2.55E-04	4.8	Other

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: DB-4
Laboratory Sample ID: 041922026-0002
Sample Description: 69.0'-Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
C1 : N6	Actinolite	1.6	0.25	F		3.40E-04	6.4	Regulated
C1 : K4	No Structures Detected							
C1 : I2	No Structures Detected							
C1 : F7	No Structures Detected							
C1 : C5	No Structures Detected							
C2 : B6	No Structures Detected							
C2 : E3	No Structures Detected							
C2 : H5	No Structures Detected							
C2 : J2	Non-asbestiform Actinolite	2.2	0.37	F	1115	1.02E-03	5.9	Other
C2 : M4	No Structures Detected							

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: HS#2
Laboratory Sample ID: 041922026-0003
Sample Description: Bench Zero Trench-Rock

Grid ID	Mineral Type	Structure Length	Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
D4 : M4	Non-asbestiform Actinolite	8.1	0.49	F	1117	3.31E-02	16.5	Other
D4 : M4	Actinolite	1.5	0.12	F		3.68E-04	12.5	Regulated
D4 : M4	Actinolite	4.9	0.37	B		1.14E-02	13.2	Regulated
D4 : M4	Actinolite	2.7	0.12	F		6.62E-04	22.5	Regulated
D4 : M4	Actinolite	3.4	0.12	F		8.34E-04	28.3	Regulated
D4 : M4	Actinolite	1.5	0.12	F		3.68E-04	12.5	Regulated
D4 : M4	Actinolite	7.1	0.12	F		1.74E-03	59.2	Regulated
D4 : M4	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
D4 : M4	Non-asbestiform Actinolite	2.9	0.74	F		2.71E-02	3.9	Other
D4 : M4	Actinolite	5.4	0.12	F		1.32E-03	45.0	Regulated
D4 : M4	Actinolite	8.5	0.12	F		2.08E-03	70.8	Regulated
D4 : M4	Actinolite	3.2	0.25	F		3.41E-03	12.8	Regulated
D4 : M4	Actinolite	2.2	0.1	F		3.75E-04	22.0	Regulated
D4 : I6	Actinolite	5.1	0.49	F	1119	2.09E-02	10.4	Regulated
D4 : I6	Actinolite	2.6	0.12				21.7	Regulated
D4 : I6	Actinolite	2.9	0.12	F		7.11E-04	24.2	Regulated
D4 : I6	Actinolite	1.5	0.12	F		3.68E-04	12.5	Regulated
D4 : I6	Actinolite	0.8	0.12	F		1.96E-04	6.7	Regulated
D4 : I6	Non-asbestiform Actinolite	4.9	0.12	F		1.20E-03	40.8	Other
D4 : I6	Actinolite	1.2	0.37	F		2.80E-03	3.2	Regulated
D4 : I6	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
D4 : I6	Actinolite	1.5	0.12	F		3.68E-04	12.5	Regulated
D4 : I6	Actinolite	2.1	0.1	F		3.58E-04	21.0	Regulated
D4 : I6	Actinolite	5.4	0.12	F		1.32E-03	45.0	Regulated
D4 : I6	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
D4 : I6	Non-asbestiform Actinolite	5.9	0.74	F		5.50E-02	8.0	Other

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: HS#2
Laboratory Sample ID: 041922026-0003
Sample Description: Bench Zero Trench-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
D4 : I6	Actinolite	1.5	0.37	F		3.50E-03	4.1	Regulated
D4 : I6	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
D5 : F7	Actinolite	1.6	0.1	F		2.73E-04	16.0	Regulated
D5 : F7	Actinolite	1.2	0.1	F		2.04E-04	12.0	Regulated
D5 : F7	Actinolite	7.1	0.25	F		7.56E-03	28.4	Regulated
D5 : F7	Actinolite	3.6	0.25	F		3.83E-03	14.4	Regulated
D5 : F7	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
D5 : F7	Non-asbestiform Actinolite	5.1	0.37	F		1.19E-02	13.8	Other
DE5 : F7	Actinolite	1	0.12	F		2.45E-04	8.3	Regulated
D5 : F7	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
D5 : F7	Actinolite	4.3	0.74	F		4.01E-02	5.8	Regulated
D5 : F7	Actinolite	2.2	0.12	F		5.40E-04	18.3	Regulated
D5 : J8	Actinolite	2.2	0.12	F		5.40E-04	18.3	Regulated
D5 : J8	Non-asbestiform Actinolite	5.1	0.49	F		2.09E-02	10.4	Other
D5 : J8	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
D5 : J8	Actinolite	1	0.25	F		1.06E-03	4.0	Regulated
D5 : J8	Actinolite	9.1	1.72	B		4.59E-01	5.3	Regulated
D5 : J8	Actinolite	1.7	0.12	F		4.17E-04	14.2	Regulated
D5 : J8	Actinolite	5.1	0.12	F		1.25E-03	42.5	Regulated
D5 : J8	Actinolite	3.1	0.49	F		1.27E-02	6.3	Regulated
D5 : J8	Actinolite	4.3	0.25	F		4.58E-03	17.2	Regulated
D5 : J8	Actinolite	1.5	0.37	F		3.50E-03	4.1	Regulated
D5 : J8	Actinolite	6.1	0.12	F		1.50E-03	50.8	Regulated
D5 : J8	Actinolite	2.8	0.25	F		2.98E-03	11.2	Regulated
D5 : J8	Actinolite	7.3	0.25	F		7.77E-03	29.2	Regulated
D5 : J8	Actinolite	6.1	0.12	F		1.50E-03	50.8	Regulated

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: HS#2
Laboratory Sample ID: 041922026-0003
Sample Description: Bench Zero Trench-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
D5 : J8	Actinolite	4.9	0.12	F		1.20E-03	40.8	Regulated
D5 : J8	Actinolite	6.4	0.12	F		1.57E-03	53.3	Regulated
D5 : J8	Non-asbestiform Actinolite	5.4	0.74	F		5.04E-02	7.3	Other
D5 : J8	Actinolite	3.1	0.12	F		7.60E-04	25.8	Regulated
D5 : J8	Actinolite	2.9	0.49	F	1121	1.19E-02	5.9	Regulated
D5 : J8	Actinolite	2.9	0.12	F		7.11E-04	24.2	Regulated
D5 : J8	Actinolite	3.1	0.25	F		3.30E-03	12.4	Regulated

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: CB-3#8
Laboratory Sample ID: 041922026-0004
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
E1 : M6	Actinolite	2.4	0.49	F	1123	3.91E-03	4.9	Regulated
E1 : K4	Actinolite	2.2	0.25	F		9.34E-04	8.8	Regulated
E1 : K4	Non-asbestiform Actinolite	6.8	0.61	M		1.72E-02	11.1	Other
E1 : K4	Actinolite	1.2	0.12	F		1.17E-04	10.0	Regulated
E1 : K4	Actinolite	1.5	0.25	F		6.37E-04	6.0	Regulated
E1 : K4	Actinolite	1.2	0.25	F	1125	5.09E-04	4.8	Regulated
E1 : K4	Actinolite	7.5	0.12	F		7.34E-04	62.5	Regulated
E1 : K4	Actinolite	4.9	0.12	F		4.79E-04	40.8	Regulated
E1 : K4	Non-asbestiform Actinolite	1.5	0.25	F		6.37E-04	6.0	Other
E1 : K4	Actinolite	1.7	0.25	M		7.22E-04	6.8	Regulated
E1 : K4	Actinolite	4.6	0.12	F		4.50E-04	38.3	Regulated
E1 : K4	Actinolite	1.2	0.12	F		1.17E-04	10.0	Regulated
E1 : K4	Actinolite	1.2	0.12	F		1.17E-04	10.0	Regulated
E1 : K4	Actinolite	5.4	0.49	M		8.81E-03	11.0	Regulated
E1 : K4	Actinolite	5.4	0.12	F		5.28E-04	45.0	Regulated
E1 : I5	Non-asbestiform Actinolite	3.4	0.25	F		1.44E-03	13.6	Other
E1 : I5	Actinolite	0.8	0.12	F		7.83E-05	6.7	Regulated
E1 : I5	Actinolite	6.4	0.37	F		5.95E-03	17.3	Regulated
E1 : I5	Non-asbestiform Actinolite	4.1	0.49	F		6.69E-03	8.4	Other
E1 : I5	Actinolite	2.9	0.25	F		1.23E-03	11.6	Regulated
E1 : I5	Non-asbestiform Actinolite	7.8	0.49	F	1127	1.27E-02	15.9	Other
E1 : I5	Actinolite	1.5	0.12	M		1.47E-04	12.5	Regulated
E1 : I5	Non-asbestiform Actinolite	2.4	0.25	F		1.02E-03	9.6	Other
E1 : I5	Actinolite	2.9	0.49	F		4.73E-03	5.9	Regulated
E1 : I5	Actinolite	1.7	0.12	M		1.66E-04	14.2	Regulated
E1 : I5	Actinolite	2.2	0.25	F		9.34E-04	8.8	Regulated

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: CB-3#8
Laboratory Sample ID: 041922026-0004
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
E1 : I5	Actinolite	3.1	0.12	F		3.03E-04	25.8	Regulated
E1 : F7	Actinolite	2.6	0.25	F		1.10E-03	10.4	Regulated
E1 : F7	Actinolite	3.1	0.25	F		1.32E-03	12.4	Regulated
E1 : F7	Actinolite	2.8	0.12	F		2.74E-04	23.3	Regulated
E1 : F7	Actinolite	7.8	0.25	M		3.31E-03	31.2	Regulated
E1 : F7	Actinolite	2.6	0.49	F		4.24E-03	5.3	Regulated
E1 : F7	Non-asbestiform Actinolite	2.6	0.25	F		1.10E-03	10.4	Other
E1 : F7	Actinolite	6.2	1.72	B		1.25E-01	3.6	Regulated
E2 : G4	Actinolite	2.6	0.49	F		4.24E-03	5.3	Regulated
E2 : G4	Actinolite	1.5	0.12	F		1.47E-04	12.5	Regulated
E2 : G4	Actinolite	1.7	0.12	F		1.66E-04	14.2	Regulated
E2 : G4	Non-asbestiform Actinolite	9.3	0.49	F		1.52E-02	19.0	Other
E2 : G4	Non-asbestiform Actinolite	2.4	0.25	F		1.02E-03	9.6	Other
E2 : G4	Actinolite	3.2	0.74	F		1.19E-02	4.3	Regulated
E2 : G4	Actinolite	5.1	0.12	F		4.99E-04	42.5	Regulated
E2 : G4	Actinolite	2.2	0.25	F		9.34E-04	8.8	Regulated
E2 : G4	Non-asbestiform Actinolite	1.2	0.25	F		5.09E-04	4.8	Other
E2 : G4	Actinolite	1.2	0.12	F		1.17E-04	10.0	Regulated
E2 : G4	Non-asbestiform Actinolite	3.6	0.37	F		3.35E-03	9.7	Other
E2 : G4	Actinolite	4.3	0.12	F		4.21E-04	35.8	Regulated
E2 : G4	Actinolite	1.2	0.24	F		4.70E-04	5.0	Regulated
E2 : G4	Actinolite	2.5	0.25	F		1.06E-03	10.0	Regulated
E2 : G4	Non-asbestiform Actinolite	3.9	0.25	F		1.66E-03	15.6	Other
E2 : G4	Actinolite	2.4	0.25	F		1.02E-03	9.6	Regulated
E2 : G4	Actinolite	1.2	0.25	F		5.09E-04	4.8	Regulated
E2 : G4	Actinolite	3.4	0.25	F		1.44E-03	13.6	Regulated

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Analytical Worksheet Report

Customer Sample Number: CB-3#8
Laboratory Sample ID: 041922026-0004
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
E2 : G4	Actinolite	1.9	0.25	F		8.07E-04	7.6	Regulated

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: CB-1#1
Laboratory Sample ID: 041922026-0005
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
F4 : M6	Non-asbestiform Actinolite	5.9	0.49	F	1132	2.41E-02	12.0	Other
F4 : M6	Actinolite	2.2	0.12	F		5.39E-04	18.3	Regulated
F4 : M6	Non-asbestiform Actinolite	2.3	0.49	F		9.39E-03	4.7	Other
F4 : M6	Actinolite	2.2	0.25	F		2.34E-03	8.8	Regulated
F4 : M6	Non-asbestiform Actinolite	3.6	0.49	F		1.47E-02	7.3	Other
F4 : M6	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
F4 : M6	Actinolite	3.4	0.25	F		3.61E-03	13.6	Regulated
F4 : M6	Non-asbestiform Actinolite	4.9	0.25	F		5.21E-03	19.6	Other
F4 : M6	Actinolite	5.9	0.12	F		1.44E-03	49.2	Regulated
F4 : M6	Actinolite	0.8	0.12	F		1.96E-04	6.7	Regulated
F4 : M6	Actinolite	1.9	0.12	F		4.65E-04	15.8	Regulated
F4 : M6	Actinolite	4.9	0.12	F		1.20E-03	40.8	Regulated
F4 : M6	Actinolite	1.7	0.12	F		4.16E-04	14.2	Regulated
F4 : M6	Actinolite	14.1	0.12	F		3.45E-03	117.5	Regulated
F4 : M6	Non-asbestiform Actinolite	3.4	0.25	F		3.61E-03	13.6	Other
F4 : M6	Non-asbestiform Actinolite	1.5	0.37	F		3.49E-03	4.1	Other
F4 : M6	Non-asbestiform Actinolite	12.2	0.49	F		4.98E-02	24.9	Other
F4 : F4	Actinolite	7.7	0.37	F	1134	1.79E-02	20.8	Regulated
F4 : F4	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
F4 : F4	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
F4 : F4	Actinolite	8.1	0.25	F		8.61E-03	32.4	Regulated
F4 : F4	Non-asbestiform Actinolite	1.5	0.25	F		1.59E-03	6.0	Other
F4 : F4	Non-asbestiform Actinolite	3.6	0.49	F		1.47E-02	7.3	Other
F4 : F4	Actinolite	1.2	0.12	F		2.94E-04	10.0	Regulated
F4 : F4	Actinolite	2.6	0.25	F		2.76E-03	10.4	Regulated
F4 : F4	Actinolite	1	0.25	F		1.06E-03	4.0	Regulated

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Analytical Worksheet Report

Customer Sample Number: CB-1#1
Laboratory Sample ID: 041922026-0005
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
F4 : F4	Actinolite	14.1	0.86	B		1.77E-01	16.4	Regulated
F4 : F4	Non-asbestiform Actinolite	5.1	0.25	F		5.42E-03	20.4	Other
F4 : F4	Non-asbestiform Actinolite	12.6	0.74	F		1.17E-01	17.0	Other
F4 : F4	Non-asbestiform Actinolite	3.4	0.25	F		3.61E-03	13.6	Other
F4 : F4	Actinolite	9.2	0.37	F		2.14E-02	24.9	Regulated
F4 : F4	Actinolite	4.3	0.25	F		4.57E-03	17.2	Regulated
F4 : F4	Non-asbestiform Actinolite	2.9	0.25	F		3.08E-03	11.6	Other
F4 : F4	Actinolite	7.9	0.12	F		1.93E-03	65.8	Regulated
F4 : F4	Actinolite	1.2	0.25	F		1.28E-03	4.8	Regulated
F5 : E5	Actinolite	1.7	0.25	F		1.81E-03	6.8	Regulated
F5 : E5	Non-asbestiform Actinolite	1.5	0.25	F		1.59E-03	6.0	Other
F5 : E5	Actinolite	7.1	1.23	B		1.83E-01	5.8	Regulated
F5 : E5	Non-asbestiform Actinolite	1.2	0.25	F		1.28E-03	4.8	Other
F5 : E5	Actinolite	3.4	0.61	F		2.15E-02	5.6	Regulated
F5 : E5	Actinolite	7.8	0.86	F		9.81E-02	9.1	Regulated
F5 : E5	Non-asbestiform Actinolite	3.4	0.74	F		3.17E-02	4.6	Other
F5 : E5	Actinolite	1.5	0.12	F		3.67E-04	12.5	Regulated
F5 : E5	Actinolite	3.6	0.12	F		8.81E-04	30.0	Regulated
F5 : E5	Actinolite	6.6	0.12	F		1.62E-03	55.0	Regulated
F5 : E5	Actinolite	4.6	0.25	F		4.89E-03	18.4	Regulated
F5 : E5	Actinolite	11.2	0.49	F		4.57E-02	22.9	Regulated
F5 : E5	Actinolite	3.4	0.1	F		5.78E-04	34.0	Regulated
F5 : E5	Actinolite	1.2	0.25	F		1.28E-03	4.8	Regulated
F5 : E5	Actinolite	1.5	0.49	F		6.12E-03	3.1	Regulated
F5 : E5	Actinolite	12.2	0.12	F		2.99E-03	101.7	Regulated
F5 : E5	Actinolite	7.5	0.12	F		1.84E-03	62.5	Regulated

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Analytical Worksheet Report

Customer Sample Number: CB-1#1
Laboratory Sample ID: 041922026-0005
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
F5 : E5	Non-asbestiform Actinolite	3.6	0.37	F		8.38E-03	9.7	Other
F5 : E5	Actinolite	1.7	0.12	F		4.16E-04	14.2	Regulated
F5 : E5	Non-asbestiform Actinolite	9.2	0.49	F		3.76E-02	18.8	Other
F5 : E5	Actinolite	6.1	0.98	F		9.96E-02	6.2	Regulated
F5 : K7	Non-asbestiform Actinolite	4.6	0.49	F		1.88E-02	9.4	Other
F5 : K7	Actinolite	2.6	0.49	F		1.06E-02	5.3	Regulated
F5 : K7	Actinolite	17.1	0.12	F		4.19E-03	142.5	Regulated
F5 : K7	Actinolite	12.2	0.12	F		2.99E-03	101.7	Regulated
F5 : K7	Actinolite	5.4	0.37	F		1.26E-02	14.6	Regulated
F5 : K7	Non-asbestiform Actinolite	2.4	0.37	F		5.59E-03	6.5	Other
F5 : K7	Non-asbestiform Actinolite	3.1	0.25	F		3.29E-03	12.4	Other
F5 : K7	Actinolite	13.4	0.1	F		2.28E-03	134.0	Regulated
F5 : K7	Actinolite	6.8	0.98	B		1.11E-01	6.9	Regulated
F5 : K7	Actinolite	3.1	0.49	F		1.27E-02	6.3	Regulated
F5 : K7	Actinolite	1.9	0.12	F		4.65E-04	15.8	Regulated
F5 : K7	Non-asbestiform Pyroxene	5.9	0.86	F	1138	8.09E-02	6.9	Other
F5 : K7	Actinolite	3.4	0.49	F		1.39E-02	6.9	Regulated
F5 : K7	Non-asbestiform Actinolite	7.9	1.23	F		2.03E-01	6.4	Other
F5 : K7	Actinolite	14.8	0.49	F		6.04E-02	30.2	Regulated
F5 : K7	Non-asbestiform Actinolite	17.1	0.74	F		1.59E-01	23.1	Other
F5 : K7	Non-asbestiform Actinolite	2.4	0.25	F		2.55E-03	9.6	Other
F5 : K7	Actinolite	8.5	1.72	F		4.27E-01	4.9	Regulated
F5 : K7	Non-asbestiform Actinolite	2.9	0.74	F		2.70E-02	3.9	Other
F5 : K7	Actinolite	3.6	0.25	F		3.83E-03	14.4	Regulated
F5 : K7	Actinolite	21.9	2.18	B		1.77E+00	10.0	Regulated
F5 : K7	Actinolite	8.3	0.98	B		1.36E-01	8.5	Regulated

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: CB-1#1
Laboratory Sample ID: 041922026-0005
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
F5 : K7	Actinolite	4.9	0.12	F		1.20E-03	40.8	Regulated
F5 : K7	Non-asbestiform Actinolite	5.4	0.61	F		3.42E-02	8.9	Other
F5 : K7	Actinolite	1.7	0.25	F		1.81E-03	6.8	Regulated

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: CB-2#5
Laboratory Sample ID: 041922026-0006
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
G1 : N6	Actinolite	7.3	0.49	F	1142	6.61E-03	14.9	Regulated
G1 : N6	Actinolite	6.4	0.49	F		5.79E-03	13.1	Regulated
G1 : N6	Actinolite	1.2	0.12	F		6.51E-05	10.0	Regulated
G1 : N6	Non-asbestiform Actinolite	2.5	0.49	F		2.26E-03	5.1	Other
G1 : N6	Actinolite	3.6	0.37	F		1.86E-03	9.7	Regulated
G1 : N6	Actinolite	7.1	0.25	M		1.67E-03	28.4	Regulated
G1 : N6	Actinolite	5.4	0.25	M		1.27E-03	21.6	Regulated
G1 : N6	Actinolite	4.9	0.98	B		1.77E-02	5.0	Regulated
G1 : K4	Non-asbestiform Actinolite	2.1	0.49	F		1.90E-03	4.3	Other
G1 : K4	Actinolite	3.6	0.49	F		3.26E-03	7.3	Regulated
G1 : K4	Actinolite	2.3	0.25	F		5.42E-04	9.2	Regulated
G1 : K4	Actinolite	1.2	0.25	F		2.83E-04	4.8	Regulated
G1 : K4	Actinolite	4.6	0.98	F		1.67E-02	4.7	Regulated
G1 : I5	Actinolite	7.5	1.23	F		4.28E-02	6.1	Regulated
G1 : I5	Actinolite	4.6	0.12	F		2.50E-04	38.3	Regulated
G1 : I5	Actinolite	2.1	0.25	F		4.95E-04	8.4	Regulated
G1 : I5	Actinolite	1.7	0.25	F		4.01E-04	6.8	Regulated
G1 : G7	Non-asbestiform Actinolite	1.7	0.61	F		0.00E+00	2.8	Other
G1 : G7	Actinolite	4.3	0.12	F		2.33E-04	35.8	Regulated
G1 : G7	Non-asbestiform Actinolite	12.5	0.25	F		2.95E-03	50.0	Other
G1 : D4	Actinolite	2.6	0.25	F		6.13E-04	10.4	Regulated
GF1 : D4	Actinolite	1.5	0.12	F		8.14E-05	12.5	Regulated
G1 : D4	Non-asbestiform Actinolite	2.7	0.74	F		5.57E-03	3.6	Other
G1 : D4	Actinolite	2.9	0.25	F		6.83E-04	11.6	Regulated
G3 : C6	Non-asbestiform Actinolite	2.6	0.49	F		2.35E-03	5.3	Other
G3 : C6	Actinolite	3.1	0.12	F		1.68E-04	25.8	Regulated

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Customer Sample Number: CB-2#5
Laboratory Sample ID: 041922026-0006
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
G3 : C6	Actinolite	2.6	0.25	F		6.13E-04	10.4	Regulated
G3 : C6	Actinolite	1.2	0.25	F		2.83E-04	4.8	Regulated
G3 : E5	Non-asbestiform Actinolite	17.2	0.25	F		4.05E-03	68.8	Other
G3 : E5	Actinolite	6.8	0.98	F		2.46E-02	6.9	Regulated
G3 : E5	Actinolite	2.6	0.12	F		1.41E-04	21.7	Regulated
G3 : E5	Actinolite	3.4	0.25	F		8.01E-04	13.6	Regulated
G3 : E5	Actinolite	1.7	0.25	F		4.01E-04	6.8	Regulated
G3 : E5	Non-asbestiform Actinolite	3.6	0.49	F		3.26E-03	7.3	Other
G3 : E5	Actinolite	5.1	0.25	F		1.20E-03	20.4	Regulated
G3 : E5	Actinolite	3.1	0.25	F		7.30E-04	12.4	Regulated
G3 : E5	Actinolite	6.6	0.25	F		1.56E-03	26.4	Regulated
G3 : H4	Non-asbestiform Actinolite	8.3	0.49	f	1144	7.51E-03	16.9	Other
G3 : H4	Actinolite	1.5	0.12	F		8.14E-05	12.5	Regulated
G3 : H4	Actinolite	4.9	0.49	F		4.44E-03	10.0	Regulated
G3 : H4	Actinolite	17.5	2.52	B		4.19E-01	6.9	Regulated
G3 : H4	Non-asbestiform Actinolite	2.6	0.25	F		6.13E-04	10.4	Other
G3 : H4	Actinolite	1.2	0.25	F		2.83E-04	4.8	Regulated
G3 : H4	Actinolite	3.9	0.12	F		2.12E-04	32.5	Regulated
G3 : H4	Non-asbestiform Actinolite	3.4	0.49	F		3.08E-03	6.9	Other
G3 : H4	Actinolite	1.2	0.12	F		6.51E-05	10.0	Regulated
G3 : H4	Actinolite	1.5	0.12	F		8.14E-05	12.5	Regulated
G3 : H4	Actinolite	3.1	0.25	F		7.30E-04	12.4	Regulated
G3 : L5	Actinolite	2.4	0.1	F		9.05E-05	24.0	Regulated
G3 : L5	Actinolite	1.2	0.12	F		6.51E-05	10.0	Regulated
G3 : L5	Actinolite	3.1	0.25	F		7.30E-04	12.4	Regulated
G3 : L5	Actinolite	1.7	0.25	M		4.01E-04	6.8	Regulated

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Analytical Worksheet Report

Customer Sample Number: CB-2#5
Laboratory Sample ID: 041922026-0006
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: CB-4#10
Laboratory Sample ID: 041922026-0007
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
H2 : N6								
H2 : N6								
H2 : N6	Actinolite	8.3	0.49	F	1146	6.78E-03	16.9	Regulated
H2 : N6	Actinolite	1.2	0.25	F		2.55E-04	4.8	Regulated
H2 : N6	Actinolite	2.6	0.61	F		3.29E-03	4.3	Regulated
H2 : N6	Non-asbestiform Actinolite	4.5	0.98	F		1.47E-02	4.6	Other
H2 : N6	Actinolite	7.5	0.98	F		2.45E-02	7.7	Regulated
H2 : L4	Non-asbestiform Actinolite	1.7	0.25	F		3.61E-04	6.8	Other
H2 : L4	Non-asbestiform Actinolite	3.6	0.74	F		6.70E-03	4.9	Other
H2 : L4	Non-asbestiform Actinolite	5.5	0.86	F		1.38E-02	6.4	Other
H2 : L4	Actinolite	1.2	0.25	F		2.55E-04	4.8	Regulated
H2 : L4	Non-asbestiform Actinolite	7.1	1.47	F		5.22E-02	4.8	Other
H2 : J7	Non-asbestiform Actinolite	10.2	0.74	F	1148	1.90E-02	13.8	Other
H2 : J7	Actinolite	2.4	0.12	F		1.18E-04	20.0	Regulated
H2 : J7	Actinolite	1.7	0.49	F		1.39E-03	3.5	Regulated
H2 : G4	Actinolite	2.2	0.25	F		4.68E-04	8.8	Regulated
H2 : G4	Non-asbestiform Actinolite	1.5	0.12	F		7.34E-05	12.5	Other
H2 : D5	Non-asbestiform Actinolite	1.7	0.49	F		1.39E-03	3.5	Other
H2 : D5	Actinolite	1.7	0.49	F		1.39E-03	3.5	Regulated
H2 : D5	Non-asbestiform Actinolite	3.6	0.49	F		2.94E-03	7.3	Other
H3 : C7	Actinolite	2.9	0.61	F		3.67E-03	4.8	Regulated
H3 : C7	Actinolite	4.9	0.12	M		2.40E-04	40.8	Regulated
H3 : C7	Non-asbestiform Actinolite	12.2	0.74	F		2.27E-02	16.5	Other
H3 : F8	Actinolite	3.1	0.25	F		6.59E-04	12.4	Regulated
H3 : F8	Non-asbestiform Actinolite	1.5	0.37	F		6.98E-04	4.1	Other
H3 : F8	Non-asbestiform Actinolite	2.5	0.49	F		2.04E-03	5.1	Other

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Analytical Worksheet Report

Customer Sample Number: CB-4#10
Laboratory Sample ID: 041922026-0007
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
H3 : I6	Non-asbestiform Actinolite	3.9	0.74	F		7.26E-03	5.3	Other
H3 : I6	Actinolite	1.5	0.25	F		3.19E-04	6.0	Regulated
H3 : L10	Non-asbestiform Actinolite	7.5	0.49	F		6.12E-03	15.3	Other
H3 : L10	Actinolite	5.1	0.49	F		4.16E-03	10.4	Regulated
H3 : L10	Actinolite	2.4	0.49	F		1.96E-03	4.9	Regulated
H3 : L10	Actinolite	2.6	0.12	F		1.27E-04	21.7	Regulated
H3 : L10	Actinolite	2.9	0.49	F		2.37E-03	5.9	Regulated
H3 : L10	Non-asbestiform Actinolite	1.5	0.25	F		3.19E-04	6.0	Other
H3 : L10	Actinolite	5.4	0.1	F		1.84E-04	54.0	Regulated
H3 : L10	Actinolite	1.2	0.25	F		2.55E-04	4.8	Regulated
H3 : L10	Non-asbestiform Actinolite	2.9	0.61	F		3.67E-03	4.8	Other
H3 : L10	Actinolite	2.4	0.25	M		5.10E-04	9.6	Regulated
H3 : N8	Actinolite	1.7	0.25	F		3.61E-04	6.8	Regulated
H3 : N8	Actinolite	7.1	0.98	F		2.32E-02	7.2	Regulated
H3 : N8	Non-asbestiform Actinolite	1.5	0.12	F		7.34E-05	12.5	Other
H3 : N8	Non-asbestiform Actinolite	2.7	0.25	F		5.74E-04	10.8	Other
H3 : N8	Actinolite	1.2	0.12	F		5.88E-05	10.0	Regulated

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Analytical Worksheet Report

Customer Sample Number: CB-2#4
Laboratory Sample ID: 041922026-0008
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
I4 : N5	Actinolite	4.7	0.49	F	1150	9.61E-03	9.6	Regulated
I4 : N5	Actinolite	3.4	0.61	F		1.08E-02	5.6	Regulated
I4 : N5	Non-asbestiform Actinolite	1.7	0.37	F		1.98E-03	4.6	Other
I4 : N5	Non-asbestiform Actinolite	2.9	0.25	F		1.54E-03	11.6	Other
I4 : N5	Non-asbestiform Actinolite	2.4	0.49	F		4.91E-03	4.9	Other
I4 : N5	Actinolite	10.2	0.25	F		5.43E-03	40.8	Regulated
I4 : N5	Actinolite	1.9	0.12	F		2.33E-04	15.8	Regulated
I4 : N5	Actinolite	2.2	0.49	F		4.50E-03	4.5	Regulated
I4 : J3	Actinolite	1.5	0.12	F		1.84E-04	12.5	Regulated
I4 : J3	Actinolite	7.8	2.43	B		3.92E-01	3.2	Regulated
I4 : J3	Non-asbestiform Actinolite	3.6	0.25	F		1.92E-03	14.4	Other
I4 : J3	Actinolite	1.2	0.1	F		1.02E-04	12.0	Regulated
I4 : J3	Actinolite	3.9	0.37	F		4.55E-03	10.5	Regulated
I4 : J3	Non-asbestiform Actinolite	1.7	0.49	F		3.48E-03	3.5	Other
I4 : J3	Actinolite	5.4	0.49	F		1.10E-02	11.0	Regulated
I4 : J3	Non-asbestiform Actinolite	3.2	0.74	F		1.49E-02	4.3	Other
I4 : J3	Non-asbestiform Actinolite	1.7	0.37	F		1.98E-03	4.6	Other
I4 : J3	Actinolite	1.2	0.12	F		1.47E-04	10.0	Regulated
I4 : G5	Actinolite	2.6	0.25	F		1.38E-03	10.4	Regulated
I4 : G5	Actinolite	1.7	0.12	F		2.08E-04	14.2	Regulated
I4 : G5	Non-asbestiform Actinolite	1.5	0.25	F		7.98E-04	6.0	Other
I4 : G5	Non-asbestiform Actinolite	4.9	0.49	F	1152	1.00E-02	10.0	Other
I4 : G5	Actinolite	2.6	0.12	F		3.19E-04	21.7	Regulated
I4 : G5	Non-asbestiform Actinolite	2.4	0.25	F		1.28E-03	9.6	Other
I4 : G5	Actinolite	2.6	0.1	F		2.21E-04	26.0	Regulated
I4 : G5	Non-asbestiform Actinolite	1.5	0.25	F		7.98E-04	6.0	Other

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Analytical Worksheet Report

Customer Sample Number: CB-2#4
Laboratory Sample ID: 041922026-0008
Sample Description: Core Sample-Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
I5 : C6	Non-asbestiform Actinolite	1.7	0.49	F		3.48E-03	3.5	Other
I5 : C6	Non-asbestiform Actinolite	1.2	0.25	F		6.39E-04	4.8	Other
I5 : F5	Actinolite	1.2	0.25	F		6.39E-04	4.8	Regulated
I5 : F5	Actinolite	6.9	0.12	F		8.46E-04	57.5	Regulated
I5 : F5	Actinolite	4.1	0.25	F		2.18E-03	16.4	Regulated
I5 : F5	Actinolite	1.5	0.12	F		1.84E-04	12.5	Regulated
I5 : F5	Non-asbestiform Actinolite	3.1	0.25	F		1.65E-03	12.4	Other
I5 : F5	Non-asbestiform Actinolite	1.5	0.25	F		7.98E-04	6.0	Other
I5 : H12	Actinolite	1.2	0.25	F		6.39E-04	4.8	Regulated
I5 : H12	Actinolite	2.4	0.12	F		2.94E-04	20.0	Regulated
I5 : H12	Non-asbestiform Actinolite	2.7	0.25	F		1.44E-03	10.8	Other
I6 : M4	Non-asbestiform Actinolite	2.6	0.12	F		3.19E-04	21.7	Other
I6 : M4	Actinolite	1.5	0.12	F		1.84E-04	12.5	Regulated
I6 : M4	Actinolite	5.5	0.49	B		1.12E-02	11.2	Regulated
I6 : M4	Actinolite	3.4	0.25	F		1.81E-03	13.6	Regulated
I6 : M4	Actinolite	2.9	0.25	F		1.54E-03	11.6	Regulated
I6 : H2	Actinolite	2.2	0.12	F		2.70E-04	18.3	Regulated
I6 : H2	Actinolite	1.2	0.12	F		1.47E-04	10.0	Regulated
I6 : H2	Non-asbestiform Actinolite	3.1	0.49	F		6.34E-03	6.3	Other
I6 : H2	Actinolite	4.6	0.12	F		5.64E-04	38.3	Regulated
I6 : H2	Actinolite	1.2	0.12	F		1.47E-04	10.0	Regulated
I6 : H2	Actinolite	2.1	0.12	F		2.58E-04	17.5	Regulated
I6 : H2	Non-asbestiform Actinolite	7.1	0.49	F		1.45E-02	14.5	Other
I6 : H2	Actinolite	0.9	0.12	F		1.10E-04	7.5	Regulated

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Analytical Worksheet Report

Customer Sample Number: RH HS-1
Laboratory Sample ID: 041922026-0009
Sample Description: Hand Sample#1 Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
J2 : L4	Non-asbestiform Actinolite	3.2	0.61	F	1158	4.05E-03	5.2	Other
J2 : L4	Actinolite	2.6	0.49	F		2.12E-03	5.3	Regulated
J2 : L4	Actinolite	8.5	1.76	F		8.95E-02	4.8	Regulated
J2 : I6	Non-asbestiform Actinolite	5.6	0.25	F		1.19E-03	22.4	Other
J2 : I6	Non-asbestiform Actinolite	1.2	0.25	F		2.55E-04	4.8	Other
J2 : I6	Non-asbestiform Actinolite	4.5	0.49	F		3.67E-03	9.2	Other
J2 : I6	Actinolite	2.9	0.12	F		1.42E-04	24.2	Regulated
J2 : G4	Actinolite	7.5	0.49	F	1160	6.12E-03	15.3	Regulated
J2 : G4	Non-asbestiform Actinolite	1.7	0.49	F		1.39E-03	3.5	Other
J2 : G4	Non-asbestiform Actinolite	14.3	1.23	F		7.36E-02	11.6	Other
J2 : G4	Actinolite	15.1	2.43	F		3.03E-01	6.2	Regulated
J2 : E5	Actinolite	2.2	0.12	F		1.08E-04	18.3	Regulated
J2 : E5	Non-asbestiform Actinolite	1.2	0.12	F		5.88E-05	10.0	Other
J2 : E5	Actinolite	1.5	0.25	F		3.19E-04	6.0	Regulated
J2 : E5	Actinolite	1.5	0.25	F		3.19E-04	6.0	Regulated
J2 : B6	Non-asbestiform Actinolite	11.9	0.25	F		2.53E-03	47.6	Other
J2 : B6	Non-asbestiform Actinolite	3.6	0.74	F	1162	6.70E-03	4.9	Other
J2 : B6	Actinolite	2.4	0.25	F		5.10E-04	9.6	Regulated
J3 : C5	Actinolite	1.2	0.12	F		5.88E-05	10.0	Regulated
J3 : C5	Actinolite	1.7	0.25	F		3.61E-04	6.8	Regulated
J3 : C5	Non-asbestiform Actinolite	5.3	0.86	F		1.33E-02	6.2	Other
J3 : C5	Actinolite	1.5	0.37	F		6.98E-04	4.1	Regulated
J3 : C5	Actinolite	1.2	0.12	F		5.88E-05	10.0	Regulated
J3 : F4	Non-asbestiform Actinolite	1.2	0.25	F		2.55E-04	4.8	Other
J3 : F4	Actinolite	1.7	0.25	F		3.61E-04	6.8	Regulated
J3 : F4	Actinolite	1.2	0.12	F		5.88E-05	10.0	Regulated

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: RH HS-1
Laboratory Sample ID: 041922026-0009
Sample Description: Hand Sample#1 Rock

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
J3 : F4	Actinolite	10.7	2.68	F		2.61E-01	4.0	Regulated
J3 : H6	Non-asbestiform Actinolite	2.2	0.37	F		1.02E-03	5.9	Other
J3 : H6	Actinolite	1.5	0.12	F		7.34E-05	12.5	Regulated
J3 : K3	Non-asbestiform Actinolite	8.7	0.49	F		7.10E-03	17.8	Other
J3 : K3	Actinolite	4.9	0.12	F		2.40E-04	40.8	Regulated
J3 : K3	Non-asbestiform Actinolite	1.2	0.12	F		5.88E-05	10.0	Other
J3 : M7	Actinolite	2.4	0.49	F		1.96E-03	4.9	Regulated
J3 : M7	Actinolite	1.5	0.25	F		3.19E-04	6.0	Regulated
J3 : M7	Actinolite	1.5	0.25	F		3.19E-04	6.0	Regulated

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Analysis of Bulk Material Utilizing Analytical Electron Microscopy (Section 2.5.5.2) with Milling Prep

Analytical Worksheet Report

Customer Sample Number: RH Vein#7
Laboratory Sample ID: 041922026-0010
Sample Description: Rock Sample

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
J4 : M2	Non-asbestiform Actinolite	4.7	0.74	F	1165	2.92E-01	6.4	Other
J4 : M2	Actinolite	2.4	0.12	F		3.92E-03	20.0	Regulated
J4 : M2	Actinolite	1.5	0.12	F		2.45E-03	12.5	Regulated
J4 : M2	Non-asbestiform Actinolite	1.2	0.12	F		1.96E-03	10.0	Other
J4 : M2	Actinolite	1.2	0.12	F		1.96E-03	10.0	Regulated
J4 : M2	Actinolite	7.1	0.25	F		5.03E-02	28.4	Regulated
J4 : M2	Non-asbestiform Actinolite	1.7	0.12	F		2.77E-03	14.2	Other
J4 : M2	Actinolite	10.4	0.12	F		1.70E-02	86.7	Regulated
J4 : M2	Actinolite	9.5	0.12	F		1.55E-02	79.2	Regulated
J4 : M2	Actinolite	3.4	0.12	F		5.55E-03	28.3	Regulated
J4 : M2	Actinolite	0.8	0.12	F		1.31E-03	6.7	Regulated
J4 : M2	Non-asbestiform Actinolite	3.6	0.49	F	1167	9.80E-02	7.3	Other
J4 : M2	Actinolite	3.2	0.25	F		2.27E-02	12.8	Regulated
J4 : M2	Actinolite	3.6	0.1	F		4.08E-03	36.0	Regulated
J4 : M2	Actinolite	1.2	0.1	F		1.36E-03	12.0	Regulated
J4 : M2	Actinolite	1.2	0.25	F		8.50E-03	4.8	Regulated
J4 : M2	Actinolite	5.6	0.25	F		3.97E-02	22.4	Regulated
J4 : M2	Non-asbestiform Actinolite	10.2	0.74	F		6.33E-01	13.8	Other
J4 : M2	Non-asbestiform Actinolite	1.5	0.49	F		4.08E-02	3.1	Other
J4 : M2	Actinolite	3.1	0.1	F		3.51E-03	31.0	Regulated
J4 : M2	Actinolite	10.2	0.1	F		1.16E-02	102.0	Regulated
J4 : M2	Actinolite	2.9	0.12	F		4.73E-03	24.2	Regulated
J4 : M2	Actinolite	2.3	0.12	F		3.75E-03	19.2	Regulated
J4 : M2	Actinolite	1.2	0.37	F		1.86E-02	3.2	Regulated
J4 : M2	Actinolite	4.7	0.25	F		3.33E-02	18.8	Regulated
J4 : M2	Actinolite	7.6	0.25	F		5.38E-02	30.4	Regulated

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Analytical Worksheet Report

Customer Sample Number: RH Vein#7
Laboratory Sample ID: 041922026-0010
Sample Description: Rock Sample

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
J4 : M2	Actinolite	6.4	0.12	F		1.04E-02	53.3	Regulated
J4 : M2	Non-asbestiform Actinolite	3.4	0.49	F		9.25E-02	6.9	Other
J4 : M2	Actinolite	3.2	0.25	F		2.27E-02	12.8	Regulated
J4 : M2	Actinolite	1.2	0.12	F		1.96E-03	10.0	Regulated
J4 :	Actinolite	1.5	0.12	F		2.45E-03	12.5	Regulated
J4 : M2	Actinolite	4.9	0.98	F		5.33E-01	5.0	Regulated
J4 : M2	Actinolite	2.9	0.49	F		7.89E-02	5.9	Regulated
J4 : M2	Actinolite	4.7	0.49	F	1169	1.28E-01	9.6	Regulated
J4 : M2	Actinolite	2.7	0.12	F		4.41E-03	22.5	Regulated
J4 : M2	Actinolite	1.2	0.12	F		1.96E-03	10.0	Regulated
J4 : M2	Actinolite	3.6	0.37	F		5.59E-02	9.7	Regulated
J4 : M2	Actinolite	5.5	0.25	F		3.90E-02	22.0	Regulated
J4 : M2	Actinolite	4.9	0.1	F		5.55E-03	49.0	Regulated
J4 : M2	Actinolite	3.4	0.1	F		3.85E-03	34.0	Regulated
J4 : M2	Actinolite	9.9	0.25	F		7.01E-02	39.6	Regulated
J4 : M2	Non-asbestiform Actinolite	3.6	0.25	F		2.55E-02	14.4	Other
J4 : M2	Actinolite	17.4	2.92	B		1.68E+01	6.0	Regulated
J4 : M2	Actinolite	10.4	0.25	F		7.37E-02	41.6	Regulated
J4 : M2	Actinolite	24.7	0.25	F		1.75E-01	98.8	Regulated
J4 : M2	Actinolite	1.2	0.12	F		1.96E-03	10.0	Regulated
J4 : M2	Actinolite	14.8	0.37	F		2.30E-01	40.0	Regulated
J4 : M2	Actinolite	10.5	0.12	F		1.71E-02	87.5	Regulated
J4 : M2	Actinolite	3.6	0.25	F		2.55E-02	14.4	Regulated
J4 : M2	Actinolite	3.4	0.12	F		5.55E-03	28.3	Regulated
J4 : M2	Non-asbestiform Actinolite	4.1	0.25	F		2.90E-02	16.4	Other
J4 : M2	Actinolite	2.9	0.12	F		4.73E-03	24.2	Regulated

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Analytical Worksheet Report

Customer Sample Number: RH Vein#7
Laboratory Sample ID: 041922026-0010
Sample Description: Rock Sample

Grid ID	Mineral Type	Structure Length	Structure Width	Structure Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
J4 : M2	Actinolite	2.2	0.12	F		3.59E-03	18.3	Regulated
J6 : I3	Actinolite	7.6	0.25	F		5.38E-02	30.4	Regulated
J6 : I3	Actinolite	1.2	0.1	F		1.36E-03	12.0	Regulated
J6 : I3	Non-asbestiform Actinolite	1.2	0.25	F		8.50E-03	4.8	Other
J6 : I3	Actinolite	1.2	0.1	F		1.36E-03	12.0	Regulated
J6 : I3	Actinolite	8.3	0.12	F		1.35E-02	69.2	Regulated
J6 : I3	Actinolite	1.7	0.25	F		1.20E-02	6.8	Regulated
J6 : I3	Non-asbestiform Actinolite	3.7	0.49	F		1.01E-01	7.6	Other
J6 : I3	Actinolite	1.9	0.12	F		3.10E-03	15.8	Regulated
J6 : I3	Non-asbestiform Actinolite	1.2	0.12	F		1.96E-03	10.0	Other
J6 : I3	Non-asbestiform Actinolite	1.5	0.25	F		1.06E-02	6.0	Other
J6 : I3	Actinolite	1.2	0.1	F		1.36E-03	12.0	Regulated
J6 : I3	Non-asbestiform Actinolite	7.3	0.37	F		1.13E-01	19.7	Other
J6 : I3	Actinolite	1.2	0.12	F		1.96E-03	10.0	Regulated
J6 : I3	Non-asbestiform Actinolite	7.8	0.49	F		2.12E-01	15.9	Other
J6 : I3	Actinolite	1.7	0.49	F		4.63E-02	3.5	Regulated
J6 : I3	Actinolite	6.4	0.12	F		1.04E-02	53.3	Regulated
J6 : I3	Actinolite	2.5	0.12	F		4.08E-03	20.8	Regulated
J6 : I3	Actinolite	6.4	0.25	F		4.53E-02	25.6	Regulated
J6 : I3	Non-asbestiform Actinolite	6.6	0.25	F		4.68E-02	26.4	Other
J6 : I3	Non-asbestiform Actinolite	1.5	0.12	F		2.45E-03	12.5	Other
J6 : I3	Non-asbestiform Actinolite	2.2	0.49	F		5.99E-02	4.5	Other
J6 : I3	Non-asbestiform Actinolite	13.1	0.12	F		2.14E-02	109.2	Other
J6 : I3	Actinolite	5.4	0.12	F		8.81E-03	45.0	Regulated
J6 : I3	Non-asbestiform Actinolite	19.9	0.25	F		1.41E-01	79.6	Other
J6 : I3	Actinolite	2.9	0.12	F		4.73E-03	24.2	Regulated

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Analytical Worksheet Report

Customer Sample Number: RH Vein#7
Laboratory Sample ID: 041922026-0010
Sample Description: Rock Sample

Grid ID	Mineral Type	Structure Length	Structure Width	Type	Photo ID Number	Mass (%)	Aspect Ratio	Mineral Class
J6 : I3	Actinolite	1.5	0.25	F		1.06E-02	6.0	Regulated
J6 : I3	Actinolite	2.2	0.1	F		2.49E-03	22.0	Regulated
J6 : I3	Actinolite	8.8	0.12	F		1.44E-02	73.3	Regulated
J6J : I3	Non-asbestiform Actinolite	8.1	0.25	F		5.74E-02	32.4	Other
J6 : I3	Non-asbestiform Actinolite	16.1	0.25	F		1.14E-01	64.4	Other
J6 : I3	Actinolite	12.6	0.12	F		2.06E-02	105.0	Regulated
J6 : I3	Actinolite	9.2	0.25	F		6.52E-02	36.8	Regulated
J6 : I3	Actinolite	2.6	0.25	F		1.84E-02	10.4	Regulated
J6 : I3	Non-asbestiform Actinolite	2.9	0.74	F	1172	1.80E-01	3.9	Other
J6 : I3	Non-asbestiform Actinolite	1.5	0.25	F		1.06E-02	6.0	Other
J6 : I3	Actinolite	4.7	0.12	F		7.67E-03	39.2	Regulated
J6 : I3	Actinolite	2.9	0.12	F		4.73E-03	24.2	Regulated
J6 : I3	Non-asbestiform Actinolite	9.3	1.72	F		3.12E+00	5.4	Other
J6 : I3	Actinolite	1.9	0.37	F		2.95E-02	5.1	Regulated
J6 : I3	Actinolite	1.7	0.12	F		2.77E-03	14.2	Regulated
J6 : I3	Actinolite	2.9	0.25	F		2.05E-02	11.6	Regulated
J6 : I3	Actinolite	2.9	0.1	F		3.29E-03	29.0	Regulated
J6 : I3	Actinolite	8.3	0.1	F		9.41E-03	83.0	Regulated
J6 : I3	Actinolite	1.5	0.12	F		2.45E-03	12.5	Regulated
J6 : I3	Actinolite	1.2	0.12	F		1.96E-03	10.0	Regulated
J6 : I3	Actinolite	8.5	0.25	F		6.02E-02	34.0	Regulated
J6 : I3	Non-asbestiform Actinolite	0.8	0.12	F		1.31E-03	6.7	Other
J6 : I3	Non-asbestiform Actinolite	1.2	0.25	F		8.50E-03	4.8	Other
J6 : I3	Actinolite	1.2	0.1	F		1.36E-03	12.0	Regulated
J6 : I3	Actinolite	0.6	0.12	F		9.79E-04	5.0	Regulated