ASBESTOS-CONTAMINATED SOIL GUIDANCE DOCUMENT

Colorado Department of Public Health and Environment

Hazardous Materials and Waste Management Division
Colorado Department of Public Health and Environment

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1.0 INTRODUCTION

To address asbestos in soil, the Colorado Department of Public Health and Environment's Hazardous Materials and Waste Management Division (the Division) has established specific management requirements for asbestos-contaminated soil under Section 5.5 of the Regulations Pertaining to Solid Waste Disposal Sites and Facilities (6 CCR 1007-2), referred to herein as the Solid Waste Regulations. The applicability of these requirements is discussed in detail in Section 2 of this guidance document.

This guidance document is intended to provide direction to contractors, consultants and property owners and operators who are involved in soil disturbing activities in areas with known or suspected asbestos-contaminated soil, or where asbestos-contaminated soil is discovered. The guidance is meant to assist in compliance with the Solid Waste Regulations, and where applicable, Air Quality Control Commission Regulation No. 8, Part B (5 CCR 1001-10, Part B - Asbestos) referred to herein as Air Regulation No. 8, Part B. However, it is important that the reader be familiar with the regulations in order to understand the context of the information provided in this guidance. This guidance is not meant to modify or replace the promulgated regulations, which may undergo periodic revisions. In the event of a conflict between this guidance and promulgated regulations, the regulations govern.

Remediation of asbestos-contaminated soil is **not required** under Section 5.5 of the Solid Waste Regulations, but may be conducted in accordance with Section 5.5.5 of the Regulations. In addition remediation of asbestos-contaminated soil may be conducted under several corrective action mechanisms, as discussed below. If asbestos-contaminated soil is remediated under one of these mechanisms, the management requirements of Section 5.5 of the Solid Waste Regulations must be incorporated into the remediation plan. Asbestos-contaminated soil remediation projects are those where asbestos-contaminated soil is cleaned up to a specific concentration, or based on specific risk criteria, as defined in a remediation plan. Refer to the regulatory definitions of "management" and "remediation" provided in Section 3, for further guidance. Remediation of asbestos-contaminated soil is discussed further in Section 9 of this guidance document.

Voluntary Cleanup Program – Facilities may voluntarily choose to clean up their sites using the Voluntary Cleanup Program. Authority for the Voluntary Cleanup Program is derived from the Voluntary Cleanup and Redevelopment Act (the Act) (C.R.S. 25-16-301, et seq.) passed in 1994. The purpose of the Act is to "Provide for the protection of human health and the environment and to foster the transfer, redevelopment and reuse of facilities that had been previously contaminated with hazardous substances or petroleum products." Generally, the Voluntary Cleanup Program was intended for sites that were not covered by existing regulatory programs; however waste generated as part of a Voluntary Cleanup project must be managed in accordance with the Solid Waste Regulations and/or the Colorado Hazardous Waste Regulations (6 CCR 1007-3). Additional information regarding this program is available in the Division's "Voluntary Clean-up Roadmap, a How-To Guide" (October 2001, or most recent update).

Corrective Action Plan - Facilities may also voluntarily request to clean up their sites using a Corrective Action Plan, which is prepared and approved by the Division in accordance with Section 100.26 of the Colorado Hazardous Waste Regulations (6 CCR 1007-3). Only facilities subject to corrective action requirements under a permit are excluded from utilizing this process. This program includes a simple process whereby a facility subject to the hazardous waste regulations may initiate the corrective action process without seeking a permit or order. Additional information regarding this program is available in the Division's "RCRA Integrated Corrective Action Plan Guidance Document and Checklist" (January 2000, or most recent update).

Compliance Order on Consent – Cleanup of asbestos-contaminated soil may be conducted under an existing compliance order on consent, under the Colorado Hazardous Waste or Solid Regulations, in which the area of asbestos-contaminated soil may be considered a Solid Waste Management Unit (SWMU), an area of concern (AOC), or a solid waste disposal site. A compliance order on consent may also be used in cases where a) the remedial process is expected to require long-term commitments, b) the proposed cleanup activities necessitate the use of units requiring an order mechanism (e.g., Corrective Action Management Unit, Temporary Unit, or Staging Pile), or c) the proposed remedial activity requires the use of enforceable institutional controls. The facility and Division representatives would negotiate and agree upon the terms of the corrective action elements of the order before it is signed.

Unilateral Compliance Order – A unilateral compliance order, under the Colorado Hazardous Waste or Solid Waste Regulations, may be required in cases where a) there is a serious threat to human health that must be mitigated, b) the facility has demonstrated an unwillingness to perform the necessary actions in response to a serious threat to human health, or c) serious violations of the regulations have been identified by the Division. As the name implies, the Division prepares and issues this legal document with minimal to no input from the receiving facility.

Post-Closure Permits or Post-Closure Order – Cleanup of asbestos-contaminated soil may be conducted under an existing post-closure permit, or an equivalent mechanism such as a post-closure order. These mechanisms are required for permitted or interim status facility upon determining that all hazardous waste or hazardous constituents will not be removed from either the closing regulated unit or the surrounding environmental media. Under post-closure permits and orders, areas of asbestos-contaminated soil would be considered solid waste management units.

It should also be noted that sampling of asbestos-contaminated soil is not required under Section 5.5 of the Solid Waste Regulations; however, the information that can be gained from sampling may be beneficial for many projects. In addition, when conducting remediation under one of the mechanisms discussed above, sampling may be necessary to demonstrate that cleanup objectives have been met.

2.0 APPLICABILITY OF SOLID WASTE AND AIR REGULATIONS

2.1 Applicability

As specified in Section 5.5.1 of the Solid Waste Regulations, the following paragraphs detail when the Solid Waste Regulations apply to activities involving asbestos-contaminated soil, and when these activities are regulated under Air Regulation No. 8, Part B. This relationship is also illustrated in Figure 1. It is important to understand that there is nothing in the Solid Waste Regulations that requires an owner or operator to perform soil-disturbing activities, or to remediate asbestos contaminated soil. The regulations include specific requirements that apply *only if* asbestos-contaminated soil is disturbed or will be disturbed. The flow chart presented as Figure 2 illustrates the response sequence for unanticipated discoveries of asbestos-contaminated soil and planned asbestos-contaminated soil management activities subject to the requirements of the Solid Waste Regulations.

- The requirements of Section 5.5 of the Solid Waste Regulations apply to the owner or operator of any property with asbestos-contaminated soil at which soil-disturbing activities are occurring or planned for any area containing asbestos-contaminated soil. Section 5.5 does not apply to asbestos waste disposal areas that have a Certificate of Designation. The requirements of Section

FIGURE 1
DETERMINATION IF COVERED BY AIR POLLUTION'S REGULATION 8 OR THE SOLID WASTE REGULATIONS FLOW CHART

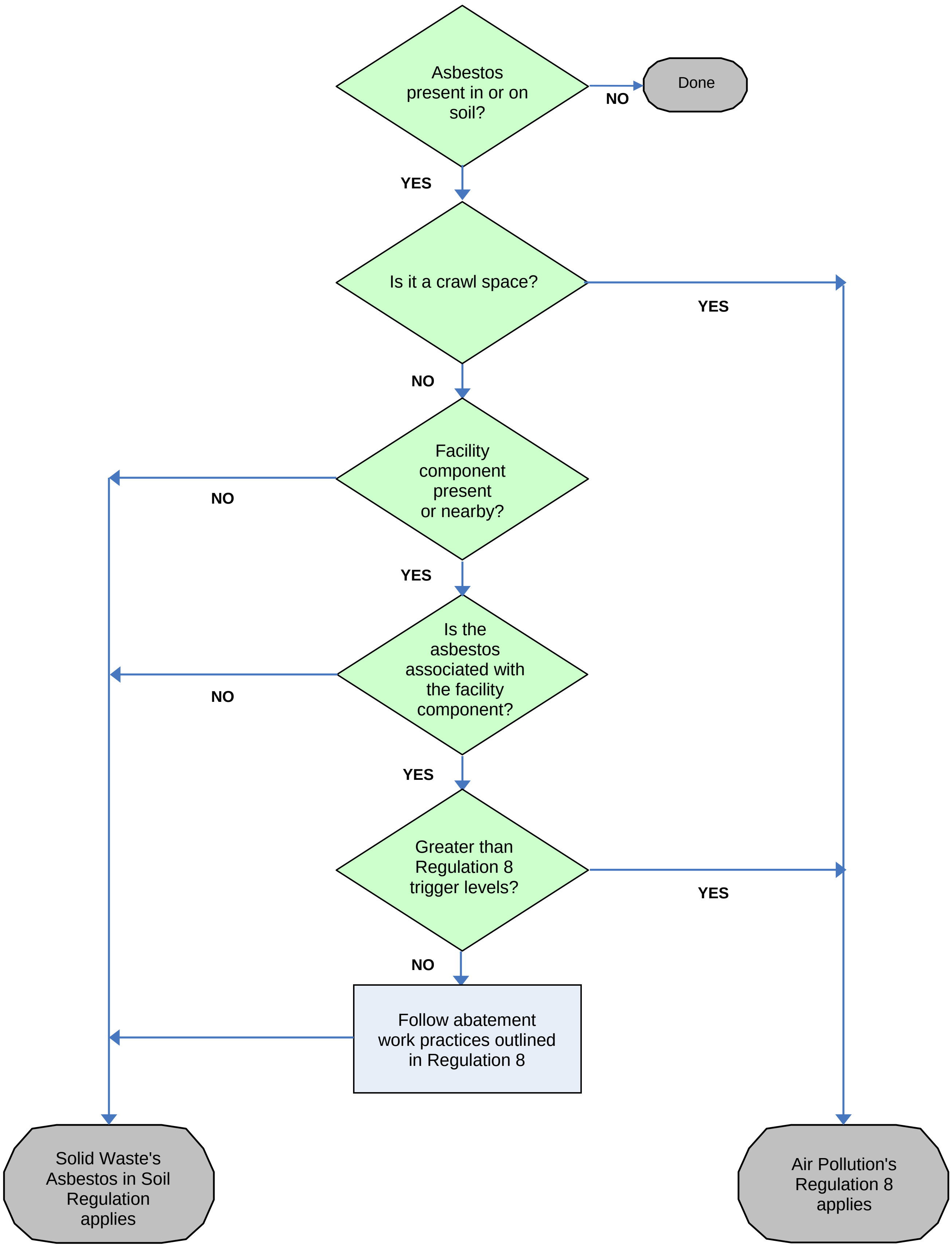
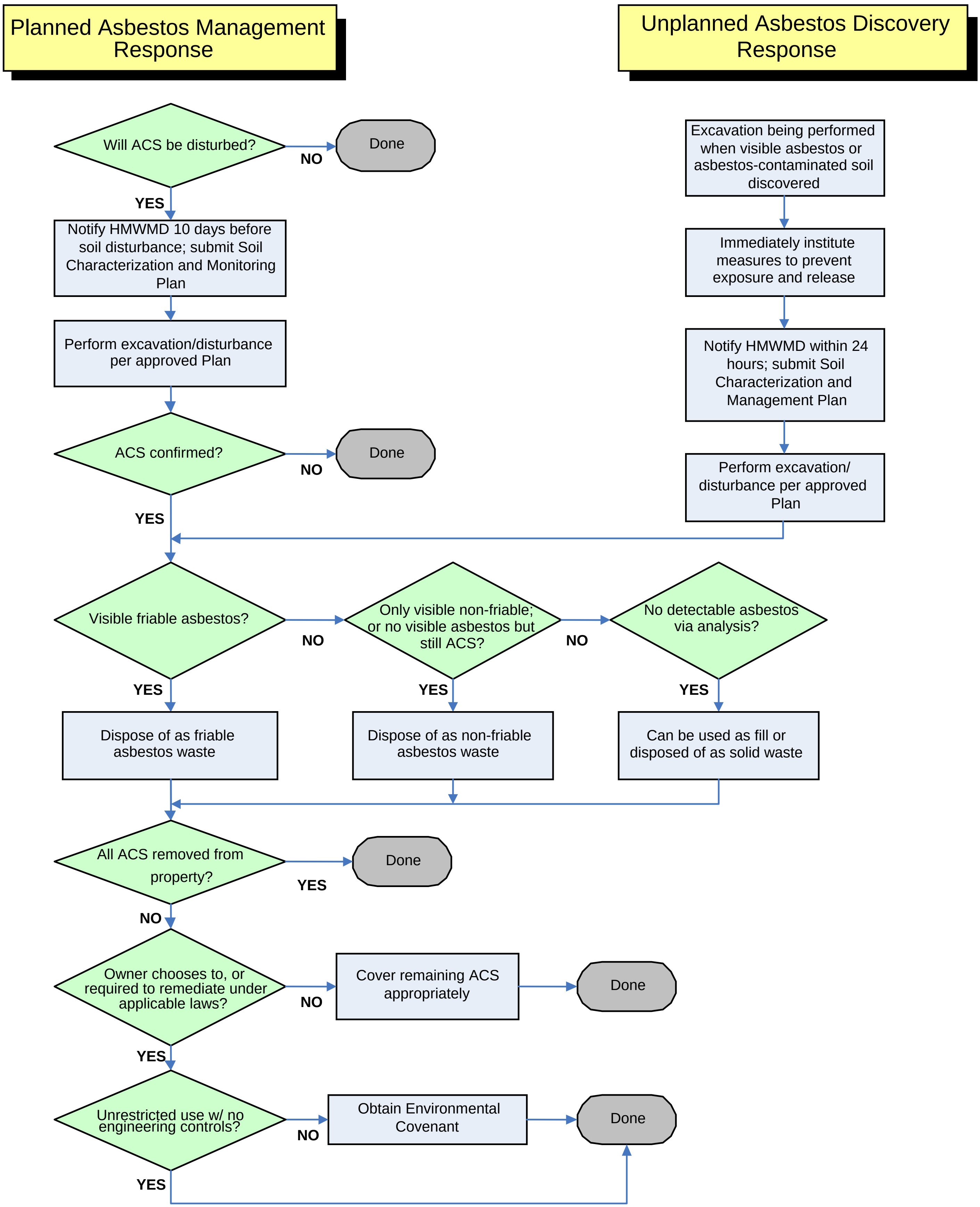


FIGURE 2
ASBESTOS-CONTAMINATED SOIL (ACS) RESPONSE FLOW CHART



- 5.5 are triggered when the owner or operator has reason to believe or suspect the presence of asbestos-contaminated soil at a site, (such as through confirmation by analysis of observed material that is suspected as containing asbestos), or has reason to believe or suspect that visible asbestos will be encountered. An owner or operator who has no reason to know of or suspect asbestos-contaminated soil at a site does not have a duty to sample or otherwise investigate for asbestos-contaminated soil prior to commencing excavation, or other soil disturbing activities, at the site.
- Removal of asbestos-containing material on a facility component that is located on or in soil that will be disturbed shall be conducted under Section 5.5 of the Solid Waste Regulations in accordance with work practices in Air Regulation No. 8, Part B, Section III.O, but is not subject to the permit requirements of Air Regulation No. 8, Part B as long as the total quantity of asbestos-containing material is below the following trigger levels:
    1) 260 linear feet on pipes,
    2) 160 square feet on other surfaces, or
    3) The volume equivalent of a 55-gallon drum.

  Removal of asbestos-containing material on a facility component with asbestos quantities above the trigger levels is subject to the notification, permit, and abatement requirements of Air Regulation No. 8, Part B, and is therefore outside the scope of Section 5.5 of the Solid Waste Regulations, as provided in Section 5.5.2(B) of the regulations.
- Removal of pieces of asbestos-containing material that are not on a facility component and are located on or in soil that will be disturbed shall be conducted under Section 5.5 of the Solid Waste Regulations in accordance with work practices in Air Regulation No. 8 - Part B, Section III.O. The removal activities would not be subject to the permit requirements of Air Regulation No. 8, Part B.

2.2 Exemptions

In accordance with Section 5.5.2 of the Solid Waste Regulations, the following projects are exempt from the requirements of Section 5.5 of the Solid Waste Regulations, but may be subject to other sections of the Solid Waste Regulations or other regulatory programs:

- Non-friable Material Removed From Soil - In situations where the soil contains solely non-friable material containing asbestos that has not been rendered friable, the non-friable material can be removed from the soil and properly disposed of in accordance with Section 5.2 of the Solid Waste Regulations. The surrounding soil would not be considered to be asbestos-contaminated soil and therefore would not be subject to the requirements of Section 5.5 of the Solid Waste Regulations. The determination that a material is non-friable must be made by an asbestos Building Inspector who has been certified in accordance with Air Regulation No. 8, Part B and who has a minimum of six (6) months experience in asbestos-contaminated soil inspections (see Section 8.3 - Worker Training).
- Abatement of Facility Components Under Air Regulation No. 8, Part B - The requirements of Section 5.5 of the Solid Waste Regulations **do not** apply to asbestos abatement of facility components (including pipes, ducts and boilers) conducted in accordance with Air Regulation No. 8, Part B. However, disposal of asbestos must still comply with Sections 5.1 through 5.4 of the Solid Waste Regulations.
- Spill Response Conducted Under Regulation No. 8 - The requirements of Section 5.5 of the Solid Waste Regulations **do not** apply to spill response activities that are subject to the requirements of Air Regulation No. 8, Part B. As above, disposal of asbestos must still comply with Sections 5.1 through 5.4 of the Solid Waste Regulations.
- Ambient Occurrences of Asbestos - The requirements of Section 5.5 of the Solid Waste Regulations **do not** apply to ambient occurrences of asbestos that are not due to site-specific

activities. Ambient occurrences of asbestos may include, but are not limited to, naturally occurring asbestos or the distribution of asbestos from normal wear of automotive products. It should be noted that since sampling for asbestos fibers in soil is not required for asbestos management projects, and the fact that most sites will be identified based on visual identification of asbestos debris, identifying or distinguishing ambient or background concentrations of asbestos from site related asbestos would not typically be necessary. There may be instances where determining ambient/background concentrations may be helpful during a remediation project to support risk-based decisions. Guidance on determining background concentrations of asbestos is provided in Appendix B.

- De Minimis Projects - The requirements of Section 5.5 of the Solid Waste Regulations **do not** apply to projects involving excavations with a total volume of less than 1 cubic yard of soil using low-emission excavation methods such as hand held tools or light equipment. However, disposal of asbestos must still comply with Sections 5.1 through 5.4 of the Solid Waste Regulations.
- Projects by Homeowner - Projects conducted directly by a homeowner at their primary residence, including residential landscaping projects and other private residential soil-disturbing projects conducted after the primary dwelling is built, (e.g. planting trees, digging holes for fence posts, installing sign posts, gardening, other projects done by private individuals at their primary place of residence). This exemption does not apply to projects conducted by a person who resides at a residence that they do not own, or to projects conducted by a person who owns a property that is not their primary place of residence.

The exemption for asbestos abatement projects conducted under Air Regulation No. 8, Part B extends to asbestos debris that may come into contact with soil during demolition of structures with asbestos-containing materials and materials containing trace amounts of asbestos (including trace soil in crawlspaces, loose fill vermiculite, etc) that can legally remain during demolition and be disposed of as normal demolition debris. Any asbestos debris left behind after the completion of a demolition project and subsequent site cleanup would be subject to the requirements of Section 5.5 of the Solid Waste Regulations if disturbed in the future.

3.0 DEFINITIONS

The following terms are defined in Section 1.2 of the Solid Waste Regulations, and their use in this guidance document is intended to be consistent with their regulatory definitions. The definitions for friable and non-friable provided below are taken from Air Regulation No. 8, Part B.

“Adequately wet” means sufficiently mix or penetrate with liquid to completely prevent the release of particulate material and fibers into the ambient air. If visible emissions are observed coming from asbestos-contaminated soil or asbestos-containing material, then the material has not been adequately wetted. However, the absence of visible emissions is not sufficient evidence of being adequately wet.

Guidance on determining when a material is adequately wet can be found in EPA’s *Asbestos NESHAP Adequately Wet Guidance*, EPA 340/1-90-019 (December 1990).

"Asbestos" means the asbestiform varieties of serpentinite (chrysotile), riebeckit**e** (crocidolite), amosite (cummingtonite-grunerite), anthophyllite, and actinolite-tremolite.

“Asbestos-contaminated soil” means soil containing any amount of asbestos.

"Asbestos waste" means any asbestos-containing material whether it contains friable or non-friable asbestos, that is not intended for further use. This term includes but is not limited to asbestos mill tailings, asbestos from pollution control devices, and containers that contain asbestos.

"Asbestos-containing material" means any material that contains more than one percent (1%) asbestos by weight, area or volume.

"Asbestos waste disposal area" means an area approved for the disposal of asbestos waste at a solid waste facility, including, but not limited to, a trench or monofill.

“Emergency” means an unexpected situation or sudden occurrence of a serious and urgent nature that demands immediate action and that constitutes a threat to life or health, or that may cause major damage to property.

“Facility Component” for purposes of Section 5.5, means any part of a facility including equipment. For the purpose of this definition, “facility” means (as defined in Air Quality Control Commission Regulation No. 8 (5 CCR 1001-10, Part B):

> “any institutional, commercial, public, industrial, or residential structure, installation, or building (including any structure, installation, or building containing condominiums or individual dwelling units operated as a residential cooperative, but excluding: residential buildings having four or fewer dwelling units); any ship; and any active or inactive waste disposal site. For purposes of the definition, any building, structure, or installation that contains a loft used as a dwelling is not considered a residential structure, installation, or building. Any structure, installation or building that was previously subject to this subpart is not excluded, regardless of its current use or function.”

“Friable” means that the material, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure, and includes previously non-friable material after such previously non-friable material becomes damaged to the extent that when dry it may be crumbled, pulverized, or reduced to powder by hand pressure.

“Leak tight” means that solids, liquids, or gases cannot escape or spill out. It also means dust tight.

“Management” means the handling, storage, collection, transportation and disposal of solid waste.

“Mechanical” means operated or produced by mechanism or machine. This may include, but shall not be limited to, an excavator, backhoe, grader, tiller, auger, or hand shovel.

“Non-friable” means material which, when dry, may not be crumbled, pulverized, or reduced to powder by hand pressure.

“**Remediation”** or **“Remediate”** means a cleanup or removal to prevent or minimize the possible current or future release of hazardous substances to prevent an unacceptable threat to present or future public health, welfare or the environment.

“Site” or **“solid waste disposal site”** means the location for a facility chosen based upon geologic, hydrogeologic and operational considerations. For the purpose of Section 5.5 of the Solid Waste Regulations “site” means the area or areas where soil-disturbing activities are occurring or will occur.

“Soil-disturbing activities” means excavation, grading, tilling, or any other mechanical activity used to disturb the soil.

“Structurally rigid container” means a container capable of maintaining its shape when unsupported.

"Visible emissions" means any emissions which are visually detectable without the aid of instruments, coming from material containing asbestos, asbestos waste, asbestos-contaminated soil, or from handling and disposal of asbestos waste, material containing asbestos or asbestos-contaminated soil.

“Working day” means Monday through Friday and including holidays that fall on any of the days Monday through Friday.

The following definitions are terms that either do not have specific regulatory definitions, or the regulatory definitions have been modified or clarified for use in this guidance.

“Air Monitoring Specialist“ means a person who performs air monitoring referred to in this guidance and who is certified to perform air monitoring in accordance with Air Regulation No. 8, Part B.

“Asbestos Building Inspector” or **“Building Inspector”** means a person certified in accordance with Air Regulation No. 8, Part B, to perform asbestos inspection and sampling, and who has a minimum of six (6) months experience in asbestos-contaminated soil inspections.

“Asbestos Supervisor” means a person who has been certified as an asbestos Supervisor in accordance with Air Regulation No. 8, Part B.

“Asbestos Project Designer” or **“Project Designer”** means a person who has been certified as an asbestos Project Designer in accordance with Air Regulation No. 8, Part B.

4.0 HISTORICAL REVIEW TO DETERMINE THE POTENTIAL FOR ASBESTOS

4.1 Site Historical Review

Prior to disturbance of a soil area, it is recommended that an environmental professional with experience in conducting historical property use assessments review available historic site information to evaluate the potential to encounter asbestos. Depending on the past use of the property, it may be warranted to conduct a Phase I environmental site assessment following EPA’s *Standards and Practices for All Appropriate Inquiries* and ASTM E1527-05 *Standard Practice for Environmental Site Assessments: Phase 1 Environmental Site Assessment Process*. At a minimum, it is recommended that information regarding the following potential conditions be reviewed:

- **Historical** site use, including development of site buildings, structures and associated utility corridors on which there is a potential to encounter materials containing asbestos that are potentially within planned pathways of soil disturbance.
- **Past evidence** or information of historical land filling, dumping or grading of potential asbestos and asbestos waste materials.
- **The likelihood of an unexpected discovery** of building(s) and/or structure(s) with the potential of containing asbestos that may be within the pathway of planned soil disturbance.

In instances where the potential to encounter asbestos during excavation is already known, a historical review may not be necessary. Likewise, in situations involving the excavation of existing utility lines, where the presence or absence of asbestos can be readily confirmed, a historical review may not be warranted.

4.1.1 Historical Sources of Information

Historical documents and records may include, but are not limited to, the following sources and physical setting documents. It is recommended that document review be at ASTM recommended intervals (typically 5 years, 1 year at change of use or demolitions).

- Facility or site-owner records
- Site-specific foundation, water well and boring and drilling logs, and previous environmental subsurface investigation reports
- Aerial photographs
- Fire insurance maps
- City directories
- Chain of Title documents
- City inspection and land use records
- Municipal and county inspection, occupancy, construction and demolition permit records, and plan review drawings
- Fire response and emergency demolition records
- Federal, state and local agency environmental database records, including locally mapped areas of known landfill and construction waste disposal sites
- Utility corridor construction maps and plans
- USGS, State, and local geologic, and surface soils investigations and maps

It is recommended that historical documents and records reviewed cover a period of time as far back in history necessary to define the first use and development of property, and subsequent uses of the property including redevelopment of property for residential, agricultural, commercial, industrial, utility and governmental purposes. In addition to evaluating the various uses of the property, this review should include an evaluation of historic buildings or structures, and the demolition and disposal practices employed when these buildings or structures were removed. Lack of historical information available for review may necessitate an elevated awareness level for planning and protective measures.

Existing data regarding the current physical setting, including soil borings, trenching, ground penetrating radar (GPR) or other geophysical techniques, and industrial metal detectors may be reviewed by the environmental professional as an additional physical setting informational element to define actual soil conditions. These methodologies may assist in defining the nature of subsurface structure extent, subsurface buried material nature, and historic utility corridor and piping pathways.

In addition to historical documents, interviews with past and present site personnel may provide valuable information regarding past site usage, construction and demolition activities, and on-site disposal and abandonment practices.

4.1.2 Historic Conditions of Concern

High potential of encountering asbestos - A high potential of encountering asbestos will exist where historical information confirms the prior existence of building(s) and or associated structures and utility corridors that potentially contained asbestos and/or asbestos waste materials related to historic dumping, landfilling, or grading of potential asbestos waste materials. A high potential of encountering asbestos would be a “reason to believe or suspect that visible asbestos will be encountered” under Section 5.5.1 (A) of the Solid Waste Regulations, as discussed in Section 2.1 of this guidance.

Elevated potential of encountering asbestos - An elevated potential of encountering asbestos may exist but is not definitive, if there is information indicating a potential to encounter materials during subsurface activities, indications of past artificial fill use, or fill use of unknown origin. In addition, the lack of data available during the review process may result in an elevated potential to encounter asbestos. Depending on the information available, an elevated potential for encountering asbestos may be a "reason to suspect that visible asbestos will be encountered" under Section 5.5.1 (A) of the Solid Waste Regulation, and may be the basis for further inquiry or assessment.

Low potential of encountering asbestos - A low potential of encountering asbestos exists when physical setting and historic data indicate a minimal potential for past use and or development of the site, and no evidence of past dumping, filling or grading of the site. A low potential for encountering asbestos would *not* be a "reason to believe or suspect that visible asbestos will be encountered" under Section 5.5.1 (A) of the Solid Waste Regulations.

5.0 IMMEDIATE ACTIONS UPON UNANTICIPATED DISCOVERY OF SUSPECTED ASBESTOS-CONTAMINATED SOIL

This section, in conjunction with the following Section 6.0, describes the immediate and interim actions to be implemented when unanticipated contact with asbestos-contaminated soil, subject to Section 5.5 of the Solid Waste Regulations, occurs during active construction activities (refer to Sections 2.1 and 2.2 of this guidance for applicability of the Solid Waste Regulation). When suspect asbestos-contaminated soils or building debris are discovered during construction activities, the critical requirement is to avoid generating or being in direct contact with airborne soil, thereby limiting potential exposure to asbestos fibers. The following outlines procedures for minimizing the potential release of airborne asbestos when suspect asbestos material is discovered.

- Stop work immediately upon encountering material that is suspected of containing asbestos.
- Demarcate area suspected of containing asbestos with barrier tape, or other means, and provide site access control. Access can be prevented by means of fencing or security personnel.
- Disturb soil as little as possible to perform any initial characterization activities (as described in Section 7, "Site Characterization").
- Wet area immediately with water prior to performing any characterization activity that will disturb the material (visual inspection does not require wetting). Maintain wet conditions throughout site characterization activities. If leaving the site unattended, cover the disturbed soil with a layer of 6-mil polyethylene (poly), tarps, or spray with magnesium chloride solution in sufficient amounts to wet the soil to prevent drying and dust generation.
- A layer of 6-mil poly may be used to prevent cross contamination onto clean soils during initial characterization activity by placing the poly on the ground and then placing the contaminated soil directly on the poly.
- Generate no visible emissions (dust) during characterization activities.
- Contact an asbestos Building Inspector with a minimum of six (6) months experience conducting asbestos-contaminated soil inspections and certified in accordance with Air Regulation No. 8, Part B to collect samples of the suspect asbestos materials according to the procedures provided in Section 7 of this guidance. Samples must be analyzed by a National Voluntary Laboratory Accreditation Program (NVLAP) accredited Laboratory, administered by the National Institute of Standards and Technology (NIST), using the Polarized Light Microscopy (PLM) Method (Method – EPA/600/R-93/116) to determine if any asbestos fibers are present. Alternatively, suspect material may be assumed to contain asbestos, thus eliminating the need to conduct sampling and analysis.

- Assume clothing and equipment that has come into contact with the suspect asbestos is contaminated until/unless analytical results indicate the material does not contain any asbestos. Workers and equipment should be decontaminated on site and dirt and debris should not leave the immediate work area. Heavy equipment should be left on site after decontamination until analytical results are received. The following procedures can be modified as appropriate based on project scale and the potential level of exposure:

    - Decontaminate workers by removing any visible soil and dust with damp wipes or cloths, or by the use of a HEPA (high efficiency particulate air) filter equipped vacuum. Place wipes and cloths in a plastic bag and label as "Investigative waste", "date", and "company name/your name". If additional clothing is available, clothes should be changed and potentially contaminated clothes should be bagged separately from wipes and cloths (it may be possible to clean these clothes if it is determined that asbestos is present).
    - Decontaminate equipment by removal of gross soils and dust, then washing the equipment. Decontamination of equipment should be conducted by a certified asbestos worker wearing proper personal protective equipment (PPE). Materials used for decontamination should be bagged and labeled as above. Decontamination rinsate water should be collected and filtered to 5 microns prior to disposal off site, or prior to use for wetting of asbestos contaminated areas that will be removed (not allowed for worker decontamination water). If areas where decontamination water has been applied are not going to be excavated prior to drying, the surface must be covered or stabilized until excavation occurs to prevent the emissions of any asbestos fibers that were not removed during filtration. If disposal of decontamination water to the sanitary sewer is anticipated, rinsate water should be filtered to 5 microns, or in accordance with local requirements if such requirements are more stringent.
    - Based upon analytical results of suspect materials, if asbestos is present (or assumed to be present if sampling is not conducted), dispose of bags by double bagging and disposing of as asbestos waste in a properly permitted landfill. If analytical results indicate that no asbestos is present, bags can be disposed of as non-asbestos solid waste.

- Notify the Division as soon as possible, but no later than 24 hours after discovery of visible material containing asbestos in the soils or asbestos-contaminated soil, unless the activity is exempt under Section 5.5.2 of the Solid Waste Regulations (see Section 2.2 of this guidance). In accordance with the Solid Waste Regulations, the notification must, at a minimum, include:

    - property location.
    - general site description.
    - description of activities resulting in the discovery of asbestos-contaminated soil.
    - description of type and amount of material containing asbestos or asbestos-contaminated soil encountered.
    - description of any access and emission controls already implemented at the site.
    - property representative's name and phone number.
    - contact name and phone number for the party performing soil-disturbing activities.

  Verbal notification can be provided by calling the Division Customer Technical Assistance Line at (303) 692-3320. If after hours, leave a detailed message that includes the information listed above. Verbal notifications must be followed up by a written notification. Written notification can be submitted via facsimile to (303) 759-5355, via email to comments.hmwmd@state.co.us, or by any other means that will ensure that the notification is received by the Division within 24 hours. A sample notification form is provided in Appendix A.

- Submit a Soil Characterization and Management Plan, in accordance with Section 5.5.4(B) of the Solid Waste Regulations, to the Division for review and approval. The elements of a Soil Characterization and Management Plan are discussed in detail in Section 8, "Management of Asbestos-Contaminated Soil."

  To minimize potential delays, site owners and operators may proactively collaborate with the Division in advance of any soil-disturbing activities to jointly develop approved standard procedures that site owners and operators will implement as needed for all future applicable soil-disturbing activities. These standard operating procedures, once approved by the Division, satisfy the requirement for a Soil Characterization and Management Plan.

6.0 INTERIM ACTIONS TO PREVENT RELEASE OF AND/OR EXPOSURE TO ASBESTOS FIBERS

Upon confirmation of asbestos in soil, site characterization, as discussed in Section 7.0 of this guidance, may be necessary. Depending on the goals of the project and the nature of the asbestos material encountered, site characterization may be as simple as determining the extent of visible material and its friability, or may involve a more thorough investigation of the nature and extent of material present. Prior to and during the site characterization, and until final actions are taken in accordance with an approved Soil Characterization and Management Plan or approved standard procedures, the following interim actions should be implemented, as necessary, based on the nature and friability of material and the size and location of the project, to prevent release of and/or exposure to asbestos fibers.

- Maintain adequately wet conditions on the site until stabilized.
- Apply stabilizing agents to the soil as needed (note that some stabilizers like magnesium chloride will not work with water).
- Take measures, as necessary, to address asbestos-contaminated soil that may have been tracked to other areas by contaminated equipment. These measures could include stabilizing or covering these areas until they can be addressed under an approved Soil Characterization and Management Plan, or by conducting immediate spill response activities such as cleaning using wet methods and/or a HEPA equipped vacuum methods.
- Construct wind fences or other wind barriers as appropriate.
- Construct barriers around activity areas.
- Cover soil with 6-mil poly, or equivalent, or spray the soil with magnesium chloride or other stabilizer. Securely fasten poly sheeting to prevent removal by the wind.
- In addition to the 6-mil poly, an additional liner construction of reinforced polyethylene or a product similar in strength and durability can be applied to an adjacent soil surface to prevent cross contamination by truck or heavy equipment movement.
- Reduce traffic speeds for equipment, trucks and cars through adjacent exposed soil areas.
- Clothing and equipment that have come into contact with the asbestos-contaminated soils should be considered contaminated. Workers and equipment should be decontaminated on site, and dirt and debris should not leave the immediate work area. Decontaminate worker(s) by removing any visible soil and dust with damp wipes or cloths or by the use of a HEPA filter equipped vacuum. Place wipes, cloths and disposable personal protective equipment (PPE) in a plastic bag and label as "Asbestos Wastes", "date", and "company name/your name."
- Place equipment on a plastic barrier to collect decontamination water for filtering prior to disposal. Decontaminate equipment by removal of gross soils and dust, then wet wash equipment. Again, materials used for wiping should be bagged and labeled as stated above.
- Dispose of bagged decontamination waste materials as asbestos waste in a properly permitted landfill.

- Decontamination water should be filtered to 5 microns prior to disposal off site, or in accordance with local requirements if such requirements are more stringent, prior to disposal into a sanitary sewer.

7.0 SITE CHARACTERIZATION

Prior to commencing work in areas with known or suspected asbestos in soil, it is important to understand the nature and distribution of materials that may be encountered. This knowledge can aid in identifying areas where asbestos may be disturbed during excavation, allowing for the potential presence of asbestos to be considered in any plans for development. For instance, development can be planned in such a way that areas with asbestos are not disturbed. The plans could include pavement or open space over areas with asbestos in the subsurface, thus avoiding the need to disturb and manage asbestos-contaminated soil. Alternatively, areas with asbestos may be intentionally disturbed in order to remove asbestos and reduce potential future liability. Adequate characterization and planning up-front to properly manage asbestos-contaminated soil may reduce or eliminate project delays and reduce unforeseen costs.

As part of the site characterization process, the owner or operator of a site may decide to perform surface and/or subsurface sampling to confirm or deny the presence of asbestos and to define the extent of any asbestos-contaminated soil encountered. The investigation design and data quality objectives will be largely influenced by site-specific variables and project-specific goals. For example, an investigation to determine the extent of asbestos debris from a known feature, such as a former structure or a disposal area, may entail a less rigorous sampling program than would an investigation to determine the extent of a scattered debris field. Similarly, current or future property use considerations may influence the investigation design. For instance, small grid spacing and tight sample density might be appropriate in areas of future residential development, whereas larger grid spacing and lower sample density might be used in areas where subsurface soil will remain undisturbed. When designing a site characterization program and making decisions as to whether or not to collect samples, it is important to keep the following key questions in mind:

- what is the investigation intended to demonstrate?
- what is the current site model or hypothesis, and how will data be used to verify, disprove or modify the site model?
- how will data gathered be used to make management or remedial decisions?
- what confidence level in necessary to aide in decision-making?

Due to the wide range of variables that could influence investigation design and data quality objectives, this guidance focuses on investigation methodology rather than attempting to provide recommendations on investigation design parameters such as grid spacing or sample density. As part of the Soil Characterization and Management Plan review process, the Division will work with property owners/operators, and their contractors and consultants, to establish a characterization program that is capable of addressing site-specific factors and meeting project-specific goals.

It should be noted that sampling of asbestos-contaminated soil is not required under Section 5.5 of the Solid Waste Regulations. However, sampling may be required at remedial projects conducted under one of the other regulatory programs discussed in Section 1 of this guidance.

7.1 General Site Description

Prior to commencing any site characterization activities, it is recommended that a pre-work survey be conducted to assess existing site conditions. This survey should identify any hazards that may be present and that may affect the health and safety of those conducting characterization activities, such as working near overhead and underground utilities. All utilities should be field located prior to commencement of site activities. No drilling or excavation should begin without first notifying the Utility Notification Center of Colorado (UNCC) in accordance with the Colorado One Call Law (C.R.S. 9-1.5-101, et seq.).

7.2 Type(s) and Condition of Asbestos Material

There are several common scenarios in which asbestos-contaminated soil may be encountered at a site. These include redeveloping urban or otherwise previously developed areas, disturbing former disposal or demolition areas, upgrading utility systems, and disturbing areas where contaminated soil has been disposed. The types of asbestos materials that may be encountered include, but may not be limited to:

Sample List of Suspect Asbestos - Containing Materials

Cement Pipes	Elevator Brake Shoes
Cement Wallboard	HVAC Duct Insulation
Cement Siding	Boiler Insulation
Asphalt Floor Tile	Breaching Insulation
Vinyl Floor Tile	Ductwork Flexible Fabric Connections
Vinyl Sheet Flooring	Cooling Towers
Flooring Backing	Pipe Insulation (corrugated air-cell, block, etc.)
Construction Mastics (floor tile, carpet, ceiling tile, etc.)	Heating and Electrical Ducts
Acoustical Plaster	Electrical Panel Partitions
Decorative Plaster	Electrical Cloth
Textured Paints/Coatings	Electric Wiring Insulation
Ceiling Tiles and Lay-in Panels	Chalkboards
Spray-Applied Insulation	Roofing Shingles
Blown-in Insulation	Roofing Felt
Fireproofing Materials	Base Flashing
Taping Compounds (thermal)	Thermal Paper Products
Packing Materials (for wall/floor penetrations)	Fire Doors
High Temperature Gaskets	Caulking/Putties
Laboratory Hoods/Table Tops	Adhesives
Laboratory Gloves	Wallboard
Fire Blankets	Joint Compounds
Fire Curtains	Vinyl Wall Coverings
Elevator Equipment Panels	Spackling Compounds

It is important to observe the current condition of the materials encountered to determine whether they are friable or non-friable, and whether the friability of the material could be altered by planned site activities. Determinations regarding the type of asbestos material encountered and its friability must be made by an asbestos Building Inspector certified in accordance with Air Regulation No. 8, Part B who has at least six (6) months experience conducting asbestos-contaminated soil inspections.

7.3 Worker Training

As described in Section 8.3 of this guidance, the Solid Waste Regulations include minimum training requirements that apply to all persons performing soil-disturbing activities in areas with asbestos-contaminated soil. In addition to theses training requirements, it is suggested (and in some cases may be required by other regulations) that personnel overseeing, directing, inspecting and/or handling asbestos or asbestos-contaminated soil (including suspect asbestos) during characterization activities have the following:

- a current United States Environmental Protection Agency (EPA)/Asbestos Hazard Emergency Response Act (AHERA) 32-hour Worker, 40-hour Contactor/Supervisor, or 24-hour Building Inspector accreditation.
- a current EPA/AHERA 8-hour refresher course certification.
- current Colorado asbestos certification for the appropriate discipline.
- a current annual physical with medical release/respirator usage form and respirator fit test.
- all required certificates and licenses should be in accordance with the provisions set fourth in Air Regulation No. 8, Part B.

It is suggested that ancillary personnel not directly performing field work, such as quality assurance/quality control (QA/QC) oversight staff, management and owner project staff, attend an asbestos awareness class prior to visiting the site.

Upon initial discovery of any suspected asbestos, field personnel should immediately notify a supervisor or other person responsible for making project decisions. The supervisor, or other person with authority, should take actions necessary to ensure that the suspect material is not disturbed while waiting for the arrival of appropriately trained personnel (as discussed in Section 8.3), including an asbestos Building Inspector to evaluate the material encountered. Trained personnel should stake, flag, or otherwise demarcate suspect materials and notify key personnel such as the project manager, prime contractor, owner or other responsible entity regarding the location of the suspect materials and the necessary precautions to be taken. Crews working in the vicinity should be warned to avoid that area until directed otherwise. All personnel working on site should be advised and directed to not disturb areas where suspected or known asbestos material is present. Personnel driving onto the site to perform inspections or an oversight roll should be notified of suspect or known asbestos-containing material locations and directed to not drive over or otherwise disturb those areas. In addition, personnel accessing the site should take all necessary measures to minimize tracking of asbestos-contaminated soil. This may include wearing personal protective equipment, as appropriate, and implementing worker and equipment decontamination procedures.

7.4 Assessing the Presence and Extent of Asbestos

This procedure provides technical guidance and methods that can be used to identify and inspect both surface and subsurface soils when material containing asbestos is discovered during excavation projects. The purpose of this protocol is to allow the inspectors to perform investigations while avoiding any release of fugitive dust.

- Vehicles entering the area must avoid causing the release of fugitive dust. Vehicle operators should be observant and drive in a slow, cautious manner.
- Should the operators observe suspected asbestos materials, the operator must alter course as necessary in order to avoid direct contact.

- If drilling equipment is used, the point of operation must be misted to eliminate airborne emissions, especially during auger/drill extraction. The auger should be rinsed after it is removed from a soil boring.
- Prior to vehicles exiting the area, vehicle wheels should be decontaminated. Rinsate water should be collected and filtered to 5 microns prior to disposal off site, or prior to use for wetting of asbestos-contaminated areas that will be excavated at a later date. Surfaces where decontamination water has been applied must be covered or stabilized until excavation occurs to prevent the emissions of any asbestos fibers that were not removed during filtration. If disposal into a sanitary sewer is anticipated, the water should be filtered to 5 microns, or in accordance with local requirements if such requirements are more stringent.
- Personnel should take measures to minimize tracking asbestos-contaminated soil, including donning appropriate personal protective equipment, and implementing worker decontamination procedures.

The following materials may be needed during the course of discovery, inspection or remediation of soil containing asbestos:

- Appropriate field monitoring instruments (high and low flow pumps, personnel pumps, wind meters, magnifying lens or hand lens, phase contrast microscopy (PCM) microscopes (if trained personnel are onsite), etc)
- Camera
- Field log books
- Personal protective equipment (PPE) and cold weather gear as required.
- Tape measure and pin flags
- Garden trowel(s) and/or rakes
- Garden sprayers
- Marked 6-mil disposal bags, sample bags, generator labels, and manifests
- Suitable lab/sample reading area (if trained personnel are onsite)
- Surface soil sample field data sheets and chain-of-custody forms
- Diagrams and/or GPS equipment

7.4.1 Investigation Techniques

The following techniques can be employed during investigations to confirm or deny results of historical review. Emissions control measures should be employed during investigations where asbestos is suspected. In addition, personnel accessing the site should take all necessary measures to minimize tracking of asbestos-contaminated soil. This may include wearing personal protective equipment, as appropriate, and implementing worker and equipment decontamination procedures. It should be noted that sampling of asbestos-contaminated soil is not required under Section 5.5 of the Solid Waste Regulations. However, sampling may be required at remedial projects conducted under one of the other regulatory programs discussed in Section 1 of this guidance.

7.4.1.1 Surface Investigation Techniques

Visual inspections for surface occurrence of suspect asbestos material should be conducted by certified asbestos Building Inspectors, who have at least six (6) months experience conducting asbestos-contaminated soil inspections using the procedures provided below. The number and size of grids should be determined based on the size of the area to be investigated, any information available regarding potential presence and distribution of asbestos, and the manner in which it came to be located there. For example, if the material appears to have been disposed of in one location the grid size may be scaled relative to that disposal area; however, if the material appears to be randomly distributed, the grid size may need to be altered to reflect this random distribution, in order to be truly representative of the contamination.

- Conduct a shoulder-to-shoulder visual inspection of each grid. This can be done by multiple inspectors at an arms-length apart inspecting the surface together or a single inspector performing transverse inspections in two directions.
- Flag or demarcate location of any suspect asbestos material discovered in the grid. This may be done by using pin flags or paint, and may be logged into a GPS unit
- If sampling is conducted, care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the sample collection process.
- Collect a sample of suspect asbestos material following the sampling and analytical procedures in Section 7.5 below.
- If no visible suspect material is present, the inspector should note that observation on a site inspection form or field log.

7.4.1.2 Subsurface Investigation Techniques

Drilling methods can be used to assess subsurface occurrences of asbestos. If possible, drilling should be conducted using low emissions techniques such as hand augering or direct push methods. The number and location of borings should be determined based on the size of the site and any information available regarding potential presence and distribution of asbestos, and the manner in which it came to be located there. As discussed above, if the material appears to have been disposed of in one location, only a small number of borings may be needed to characterize the disposal area; however, if the material appears to be randomly distributed, a greater number of borings may be needed to reflect this random distribution in order to adequately characterize potential area(s) of contamination. The following procedure can be used to assess subsurface asbestos:

- It is recommended that auger holes be drilled to a depth that will penetrate native (undisturbed) soil by at least six (6) inches (to verify identification of native material), or to the anticipated depth of a planned excavation. Native soil can be identified based on geotechnical information (i.e., whether soil is consolidated or unconsolidated) and best professional judgment. However, because the identification of native soil is often difficult, this identification should be made by a person who is experienced in performing lithologic evaluations and is familiar with local lithology.
- Care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the inspection and sampling process.
- All soil cores should be visually inspected to identify the presence of visible suspect asbestos material. The presence or absence of suspect asbestos should be noted on the soil sampling field log. Any suspect asbestos material present should be sampled and analyzed in accordance with the procedures in Section 7.5 below.
- The presence of asbestos fibers in soil can be assessed by collecting composite soil samples from each soil boring. Composite samples should be made up of five (5) to ten (10) aliquots per soil boring. Soil samples should be collected and analyzed in accordance with the procedures in Section 7.5 below.
- Soil cuttings containing asbestos-contaminated soil should be containerized and disposed of in accordance with the disposal requirements discussed in Section 8.9.4 of this guidance.

Potholing or trenching can be used to visually assess the presence of suspect asbestos material and to facilitate sample collection. Care should be taken to ensure that soil and any suspect asbestos material are adequately wetted to prevent visible emissions during investigation and sampling activities. Sample collection should be conducted as discussed in Section 7.5.1.2 of this guidance. The following process can be used when conducting potholing or trenching.

- Establish a grid pattern for investigational pits (“potholes”) or trenches to assess the area of future soil-disturbing activities or remediation. Conduct a subsurface visual investigation for suspect debris, by digging potholes or trenches at each investigation location. Dig potholes or trenches to a depth of future excavation, or to a depth where there is a high degree of confidence that “native” or “undisturbed” soil is encountered. Flag, photograph and sample any material suspected of containing asbestos or assume material contains asbestos.
- Continue potholing or trenching incrementally in an outward direction from the last piece of debris found, until no suspect debris is noted in any of the pits. Once the outer boundary of the debris field is established, additional potholes or trenches may be required to confirm the extent of debris.
- If soil piles derived from trenching or potholes suspected of containing asbestos are stored on site, they should be covered with 6-mil plastic or sprayed with as stabilizer such as magnesium chloride.
- If soils derived from trenching or potholes suspected of containing asbestos are temporarily returned to the excavation, they must be covered or stabilized to prevent emissions, and they must later be removed and disposed of in accordance with the disposal requirements of Section 5.5.7 of the Solid Waste Regulations, as discussed in Section 8.9.4 of this guidance.
- If no suspect materials are encountered during potholing or trenching, or if analysis of suspect materials confirms that they do not contain asbestos, the soil may be used as backfill. This assumes that there is no “reason to know” of asbestos fibers in soil based on site history and an absence of visible asbestos material (refer to Section 2.0 of this guidance regarding applicability of the Section 5.5 of the Solid Waste Regulations).

Ground Penetrating Radar (GPR), Electromagnetic (EM) or other geophysical techniques may be useful tools to detect different soil conductivities or the presence of buried objects, which may suggest previous earthmoving activities or disposal and abnormal fill areas.

7.5 Sampling and Analysis

The sampling and analytical procedures presented in this section are based on techniques that have been used to characterize asbestos in soil at various sites throughout Colorado. As additional projects emerge, and experience at sites with asbestos-contaminated soil increases, these sampling and analytical techniques may be refined or modified. In general, sampling and analysis methods should meet data quality objectives and address the heterogeneous nature of contamination

7.5.1 Sampling Procedures

7.5.1.1 Sampling Suspect Asbestos Material

The following procedures are recommended for the collection of samples of suspect asbestos material identified during surface or subsurface sampling:

- Samples of suspect asbestos material shall be placed in appropriate sample containers such as sample bags or jars.
- Care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the sampling process.

- A field sampling form or log book entry should be maintained for each sample. The form or log book entry should contain the location, date and time of each sample, a description of the type of and friability of any suspect material encountered and any observations made during sample collection.
- Proper chain-of-custody protocols should be followed for all samples collected.

7.5.1.2 Surface Soil Sampling

The following procedures can be used for the collection of surface soil samples:

- Using the grids established for visual inspections (discussed above), collect five (5) to ten (10) random aliquots of surface soil per grid. The actual number of aliquots may vary depending on the size of the area and other site conditions. Depending on the source and distribution of asbestos, and the results of the visual inspections, sampling of all grids may not be warranted.
- Sample aliquots should be collected using a scooping device (stainless steel spoon or equivalent), and transferred to a composite sample container.
- When all aliquots have been collected, the composite sample container should be sealed and labeled with a sample number unique to the grid from which the sample was collected. The sample should be homogenized by the laboratory prior to analysis.
- A field sampling form or log book entry should be maintained for each sample. The form or log book entry should contain the location, date and time of each sample, a description of the type of and friability of any suspect material encountered, and any observations made during sample collection.
- Proper chain-of-custody protocols should be followed for all samples collected.

7.5.1.3 Subsurface Soil Sampling – Potholes, Trenches, Drilling/Soil Borings

The following procedures can be used for the collection of subsurface soil samples from potholes, trenches or soil borings:

- Collect a composite sample made up of five (5) to ten (10) aliquots representative of the pothole, trench or soil boring. The actual number of aliquots may vary depending on the depth of sampling, the depth at which asbestos is anticipated to be encountered, and the conditions observed. In addition, it may be warranted to collect separate samples from various strata, with aliquots collected from individual strata, to better characterize observed conditions.
- Care should be taken to ensure that suspect asbestos material is adequately wetted to prevent visible emissions during the sampling process.
- Sample aliquots should be collected using a scooping device (stainless steel spoon or equivalent), and transferred to a composite sample container.
- When all aliquots have been collected, the composite sample container should be sealed and labeled with a sample number unique to the boring from which the sample was collected. The sample should be homogenized by the laboratory prior to analysis.
- A field sampling form or log book entry should be maintained for each sample. The form or log book entry should contain the location, date and time of each sample, a description of the type of and friability of any suspect material encountered, and any observations made during sample collection.
- Proper chain-of-custody protocols should be followed for all samples collected.

7.5.2 Analytical Procedures

Suspect Material - Samples of suspect asbestos-containing material should be analyzed by an (National Voluntary Laboratory Accreditation Program) NVLAP-accredited Laboratory by polarized light microscopy (PLM) methodology (Method – EPA/600/R-93/116), or equivalent method, to determine if any asbestos fibers are present. Alternatively, samples of suspect asbestos material may be qualitatively analyzed by an National Voluntary Laboratory Accreditation Program (NVLAP) accredited Laboratory by transmission electron microscopy (TEM) methodology, or an equivalent method, to determine if any asbestos fibers are present.

Soil Samples - Soil samples should be analyzed by polarized light microscopy for bulk asbestos samples. The samples should be homogenized by the laboratory prior to sample analysis. Samples can also be qualitatively analyzed by transmission electron microscopy to confirm the presence or absence of asbestos. It is recommended that confirmation using transmission electron microscopy analysis, if conducted, be done on a representative number of samples.

A more detailed discussion of the analytical methods that can be used to detect asbestos is provided in Appendix C, Attachment-1 of this guidance.

7.6 Determining Ambient Concentrations of Asbestos

Generally the Division assumes asbestos in soils is caused by site-specific activities. In certain unusual situations, it may be helpful to determine the ambient, or background, concentration of asbestos in soil that is not the result of site-specific activities. Assessment of background concentrations may depend on several variables including factors inherent in site-specific geology and soils, site history, potential asbestos sources, sampling design, and data analysis. All of these factors should be considered during the development of a plan to quantify ambient levels of asbestos in soil. Some general guidance on determining representative site-specific background concentrations of asbestos in soil is provided in Appendix B of this guidance. It is recommended that all sampling plans to determine the presence and concentration of background asbestos be presented to, and approved by, the Division prior to their implementation.

8.0 MANAGEMENT OF ASBESTOS-CONTAMINATED SOILS

This Section 8 is intended to guide the actions of owners, operators, contractors and consultants when asbestos-contaminated soils are being disturbed. Asbestos-contaminated soil “management” projects are those where soil may be handled, stored, collected, transported and/or disposed of as asbestos-contaminated soil as part of a larger project. Refer to the regulatory definitions of management and remediation provided in Section 3 for further guidance.

The Division must be notified at least 10-working days prior to any planned soil-disturbing activity in an area that is known to have, or has the potential to have, material suspected of containing asbestos. In accordance with the Solid Waste Regulations, the notification must, at a minimum, include:

- Property location.
- General site description.
- A Soil Characterization and Management Plan in accordance with Section 5.5.4 of the Solid Waste Regulations, or implement standard procedures that have been pre-approved by the Division.
- Property representative’s name and phone number.

- Contact name and phone number for the party performing soil-disturbing activities.

Written notification can be submitted via facsimile to (303) 759-5355, via email to comments.hmwmd@state.co.us, or by any other means that will ensure that the notification is received by the Division at least 10-working days prior to planned soil-disturbing activities. A sample notification form is provided in Appendix A of this guidance.

Soil Characterization and Management Plans and standard operating procedures submitted to the Division pursuant to Section 5.5.4(B) of the Solid Waste Regulations should be consistent with the following recommended work practices, unless alternate work practices are appropriate and approved by the Division.

8.1 General Site Description

In addition to site characterization activities conducted in accordance with Section 7 of this guidance, and prior to commencement of any site operations, it is recommended that a pre-work survey be conducted to assess existing site conditions. This survey should identify any hazards that may be present and that may affect the health and safety of persons at the site. For example, the survey should:

- determine safe access and movement within work areas, walkways and passageways;
- identify archeological interests, if any;
- identify and assess the risks of working near overhead and/or underground high voltage or telephone lines, if any;
- establish sufficient overhead clearance for power and/or telephone lines, if any;
- assess the risks of working near other overhead and underground utilities; and
- determine the location of sanitary facilities and drinking water sources for project personnel.

All utilities should be field-located prior to commencement of site activities. No excavation should begin without first notifying the Utility Notification Center of Colorado (UNCC) in accordance with the Colorado One Call Law (C.R.S. 9-1.5-101, et seq.).

The owner, operator or asbestos contractor may have other work plans applicable to the site which onsite personnel should be aware of. Ancillary plans could include, for example, stormwater plans, communication plans, transportation plans, and site health and safety plans. The asbestos contractor, consultant and other onsite personnel should be familiar with ancillary site plans and should comply with them where applicable.

Special consideration should be given to evaluate other challenges presented by site conditions. For example, wetlands and areas of historical, archaeological and cultural resources should be identified, as may be required by local, State, or federal regulations, prior to commencement of site activities and protected throughout the project. Adverse impacts may be avoided by the use of stormwater control devices or other specific protection measures. Site visitors and workers should be prevented from trespassing on, removing or otherwise disturbing areas of special consideration.

8.2 Nature and Extent of Asbestos Material(s)

Management of asbestos-contaminated soil does not require a complete delineation of the type or extent of contamination, either in an area where soil disturbance is planned or on a property in general. However, prior to commencement of soil disturbing activities, it may be beneficial to have an asbestos Building Inspector, who has at least six (6) months experience conducting asbestos-contaminated soil inspections, identify the nature and extent of asbestos material present in the area of planned disturbance so that it may be handled in accordance with a Division-approved plan.

Additionally, the asbestos Building Inspector should identify areas of potential or known asbestos-contaminated soil in areas surrounding or near the planned work area in order to prevent unintended disturbance. Visible surface contamination should be managed in all cases so as to eliminate the pathway of exposure to uncontrolled asbestos-contaminated soil. Areas of suspect or known contamination should be clearly marked with indicators such as paint and/or flags. Methods for assessing the nature and extent of asbestos debris and asbestos-contaminated soil are discussed in Section 7 of this guidance.

Once the areas of potential or known contamination have been identified, the asbestos Building Inspector should ascertain the friability of asbestos material present. A mixture of both friable and non-friable asbestos in soil shall be managed in the manner prescribed for friable asbestos. Sampling for purposes of waste characterization, if necessary, should be conducted in a manner consistent with sampling procedures presented in Section 7.

8.3 Worker Training

Personnel overseeing, directing, inspecting and/or handling asbestos and asbestos-contaminated soil (including suspect asbestos) must have, at a minimum and as appropriate to the activity, the following training and experience as set forth in the Solid Waste Regulations:

- Individuals performing soil-disturbing activities at sites where asbestos-contaminated soil may be encountered are required to complete an on-the-job asbestos-contaminated soil awareness training. The training must provide information necessary to perform their duties in a way that ensures compliance with the requirements of Section 5.5 of the Solid Waste Regulations. The training must be conducted by an Asbestos Supervisor, Building Inspector or Project Designer, certified in accordance with Air Regulation No. 8, Part B, and who has a minimum of six (6) months experience in asbestos-contaminated soil management.
- Individuals performing soil-disturbing activities in an area with asbestos waste or asbestos-contaminated soil are required to complete an asbestos awareness training in accordance with the 2005 OSHA (Occupational Safety and Health Administration) standards set forth at 29 CFR 1926.1101(k)(9)(vii). In addition, the individual is required to complete asbestos-contaminated soil training that provides information necessary to perform their duties in a way that ensures compliance with the requirements of Section 5.5 of the Solid Waste Regulations. The training must be conducted by an Asbestos Supervisor, Building Inspector or Project Designer, certified in accordance with Air Regulation No. 8, Part B, and who has a minimum of six (6) months experience in asbestos-contaminated soil management. This training requirement applies to equipment operators but is not required for drivers of trucks carrying contaminated material for disposal to approved landfills. However, it is recommended that drivers complete an on-the-job asbestos-contaminated soil awareness training.
- Individuals performing inspection and identification of asbestos in soil must have a current asbestos Building Inspector certification in accordance with Air Regulation No. 8, Part B, and must have a minimum of six (6) months experience conducting asbestos-contaminated soil inspections.
- Individuals preparing and signing Soil Characterization and Management Plans must have a current Asbestos Project Designer certification in accordance with Air Regulation No. 8, Part B.
- Individuals performing air monitoring must have a current Air Monitoring Specialist certification in accordance with Air Regulation No. 8, Part B.

In addition, individuals with the potential for exposure to asbestos fibers should be trained in the proper usage of personnel protective equipment and have a current annual physical with a medical release/respirator usage form.

It should be noted that the requirements for six (6) months of asbestos-contaminated soil experience for trainers and inspectors can be satisfied by documenting total time worked on projects involving asbestos in soil, including asbestos projects in crawl spaces and utility trenches.

8.4 Mobilization

Mobilization is the actual movement and assignment of personnel and equipment onto the site to establish a presence for project implementation and includes those activities associated with establishing administrative facilities. The extent and nature of mobilization activities should be commensurate with the project scope and site specific conditions. Following is a sample list of activities which may be conducted as part of the mobilization effort where appropriate:

- establish office and storage trailers,
- establish personal hygiene and decontamination stations,
- establish roadway and traffic controls,
- establish parking and walkways, and
- establish pedestrian communications.

Following is a sample list of equipment and materials that may be mobilized, depending on the site specific conditions and needs:

- site transportation pick-up trucks;
- tool storage box;
- water truck, tanks and vessels;
- excavation machinery;
- load-out stations;
- fencing and windscreen.

8.4.1 Site-Specific Training

As part of the mobilization, all personnel, including supervisors, should receive site-specific training. The training should cover the provisions of the Soil Characterization and Management Plan or the Division-approved standard operating procedures. This training should also include, at a minimum, the following:

- background of asbestos; including health effects,
- recognition of debris in soil that may contain asbestos,
- controls and notifications to be followed when debris that may contain asbestos is identified,
- the nature of operations that could result in exposure to asbestos,
- spill prevention and contamination reduction techniques,
- proper use, handling and disposal of personal protective equipment (PPE),
- best management practices for the establishment of work zones and stormwater control,
- engineering controls and other measures to prevent contact with contaminants,
- personnel decontamination,
- emergency procedures, and
- equipment decontamination.

8.4.2 Site Preparation

Consistent with Section 8.1, site personnel should review and maintain utility locations and markers; develop and delineate work zones, haul routes, excavation areas; and identify direct loading areas so as to minimize the physical impact on the site. Haul routes should be reviewed for conformance with any existing transportation plan and should be compared to site conditions to avoid unnecessary disturbances of asbestos-contaminated soil.

8.4.3 Safety Meetings

Daily safety meetings should be conducted prior to the start of each work day. These meetings should focus primarily on the safe completion of the work plan for the day, as well as safe work practices and contingencies associated with the scheduled tasks. Other topics may be discussed as deemed appropriate by site health and safety personnel. New work or different site conditions should be discussed in individual crew or specific crew meetings. At a minimum, it is recommended that daily safety meetings include and confirm the following:

- delineation of the removal grid system and depth,
- establishment of work zones,
- utility identification,
- haul routes and site access,
- equipment mobilization,
- dust and particulate emissions control,
- water source and weather proofing, and
- fencing and wind break barriers as required.

8.4.4 Spill Response Plan

A spill response plan should be developed to provide a systematic and controlled response to an asbestos-contaminated soil spill that could adversely impact human health or the environment. The plan should not only include response actions for spills that occur onsite, but should also include response actions for spills that occur during transportation to the landfill. The spill response plan should be implemented in addition to the other protective measures described in this Section 8. Refer to Section 6 for additional information concerning “Interim Actions to Prevent Release of and/or Exposure to Asbestos Fibers.”

8.5 Planned Soil-Disturbing Activities

8.5.1 Horizontal and Vertical Extent of Excavation

During an asbestos-contaminated soil management project, only that soil which will be disturbed during the course of the project must be removed and properly disposed of in accordance with 6 CCR 1007-2, Section 5.5. There is no requirement that the complete extent of asbestos contamination be identified nor removed.

As a result, some asbestos-contaminated soil management projects will result in asbestos-contaminated soil being left in place. Leaving undisturbed asbestos-contaminated soil in place is acceptable as long as there is no demonstrated exposure pathway. For example, if asbestos is visible in the sidewall of an excavation but the lateral extent of the excavation is complete, it is acceptable to cover the asbestos with a 6-mil poly tarp during site work. However, where known or suspected asbestos-contaminated soil is being left in place, it is recommended that a written record, with a surveyed or GPS diagram, be made which identifies the areas of known or potential contamination. An environmental covenant, as discussed in Section 10.0 of this guidance, is one tool that may be used to document the presence of asbestos-contaminated soil.

Following the removal of asbestos-contaminated soil, appropriate controls should be implemented consistent with this Section 8 to prevent the disturbance of asbestos-contaminated soil remaining in the excavation area but not identified for removal. These areas should be covered with a tarp, as described above, or continuously wetted in order to protect on-site personnel and prevent disturbance and emissions. When appropriate and as determined by the asbestos consultant or qualified site personnel, personnel entering the excavation area should wear appropriate personal protective equipment. Air monitoring should be conducted in accordance with Section 8.7 and all efforts should be made to prevent the disturbance of remaining asbestos-contaminated soil.

8.5.2 Soil Removal Techniques

Soil removal activities should be conducted in a manner that minimizes soil handling in order to minimize emissions. Emissions are most likely to occur at the point of excavation, when pushing or moving soils around and at the dumping point (where a large surface area of soil is exposed), with the latter two activities presenting the greatest chance for emissions. Therefore, the staging of soil should be avoided whenever practicable (e.g., excavate the soil and load it directly into the truck), and dumping of soil should be done in a careful and controlled manner with misting to control emissions.

It should be noted that misting is not designed or meant to "adequately wet" the soil, but provide a "water curtain" around the soil to contain possible emissions. Adequate wetting of soil should have already occurred before commencing soil disturbance. The key to wetting is to conduct good pre-excavation wetting, such as injection wetting, and letting the water soak into the soil. Evenly moist soil throughout will provide the most efficient use of water and the greatest emissions control, with minimal hassle and cross-contamination potential. In contrast, drenching the dirt with a fire hose may result in using large amounts of water with very little emission control benefit.

Project specific soil removal techniques should be detailed in the Soil Characterization and Management Plan. Though each site will present somewhat unique circumstances, in most cases the removal of asbestos-contaminated soil should be generally consistent with the protocols described below.

Approximately twenty-four hours in advance of soil disturbing activities, the work area should be adequately wetted to prevent any visible dust emissions that may be generated during mobilization and site setup. In order to prepare the work area, amended water (water to which surfactant chemicals have been added) may be applied using a root watering wand or other mechanism to allow sufficient penetration of water into the soil. Injection wetting is preferred over surface wetting to ensure the most even distribution of water. Surface wetting has the potential to create areas of ponding and mud pits if not carefully conducted, resulting in difficult working conditions and increased potential for cross-contamination If surface wetting is conducted, it should be done in such a manner as to prevent generation of dust, run-off or splattering. During actual soil disturbing activities, water should be applied to the site of the disturbance as appropriate to suppress any visible emissions. Adequate dust control protocols should be maintained throughout the course of the removal project. It is generally recommended that removal of asbestos-contaminated soil be done with heavy equipment to minimize dust emissions at the point of removal.

Utilizing equipment appropriate to the site conditions (i.e. excavator, mini excavator, backhoe, etc.), soil excavation should proceed within the designated work area. Excavation equipment should be fitted with a spray bar or equivalent system to provide an emissions barrier during the removal process. Additional hand wetting may be accomplished as long as no dust, run-off or splattering results. It is recommended that a dedicated misting station be used at the dump point, which encloses the entire bucket and surface area of soil being dumped. Use of garden hoses may not be adequate to cover the entire area. The dump point is probably the most critical emissions point. Therefore, misting at this point is very important.

Excavation of asbestos-contaminated soil must not overreach the bounds of wetting. Excavation should be conducted in lifts small enough to ensure that disturbed soil remains adequately wet. Over reaching is one of the biggest problems encountered during asbestos-contaminated soil removal, and can be avoided by adequately pre-wetting the site before commencing soil disturbance.

Generally, removal of asbestos-contaminated soil should begin at one edge of the work area and proceed across to the opposite edge of the planned excavation. Removal should be conducted in a direction to prevent the spread of contamination. Uncontaminated soil in the swing radius of heavy equipment should be covered with poly to prevent contamination during removal activities. The bucket of the excavator should only be filled to 2/3 its normal capacity to minimize the chance of spillage.

At all times, an asbestos Building Inspector and Air Monitoring Specialist, certified in accordance with Air Regulation No. 8, Part B, should monitor the work area under active removal. Should any area under active removal prove too large for adequate stabilization of asbestos-contaminated soil, the work area should be reduced. All asbestos-contaminated soil that is not being actively removed should be adequately stabilized in order to prevent the spread of contamination.

If at any time visible emissions are observed, all removal activities should immediately cease until such time as the work practices are altered so as to prevent further visible emissions. Occurrences of visible emissions should be recorded in the site record.

Each excavation should be monitored and visually inspected by the asbestos Building Inspector and contractor or qualified site personnel during removal activities. If subsurface anomalies are encountered (such as unexpected debris or materials), all work should stop and the owner/client should be notified. Work should then proceed only when directed by the site safety officer in conjunction with other qualified site personnel.

Air monitoring should be conducted in accordance with Section 8.7 during asbestos-contaminated soil removal activities. Air samples should be collected to ensure personnel protection as well as measure the adequacy of engineering and environmental controls employed in the work areas.

8.5.2.1 Excavation Equipment and Placement of the Excavator

Equipment to be used for removal of asbestos contaminated soil will vary depending on the site-specific conditions. Equipment appropriate to topography, soil type and other field conditions should be used. Before leaving the work area, all excavation equipment should be decontaminated in accordance with Section 8.8.7.

Site access controls should be established for each individual and primary work area in accordance with the procedures described in this Section 8. These controls should allow for the incorporation of a contamination reduction zone to be utilized for the dry decontamination of heavy equipment (buckets, tires and tracks) between work areas if needed.

Every attempt should be made to keep the excavation equipment on clean or non-contaminated soil. In the event the excavator must be placed onto asbestos-contaminated soil, the following or equivalent engineering controls should be implemented to avoid contamination:

- place a suitable impermeable lining (e.g., plastic) over contaminated soils,
- import rocks, recycled asphalt road material or clean soil, etc., and place on the liner over the impacted area,
- use an alternate (rubber tired) excavator,
- utilize barriers (plywood, plastic, railroad ties) on impacted soils taking care to decontaminate such barriers before reuse in other areas.

At the completion of the project, all contaminated lining and fill materials must be decontaminated or disposed of as asbestos waste material. Equipment should be decontaminated as described in 8.8.7 of this guidance.

8.5.2.2 Direction to Prevent Spread of Contamination

The excavation protocols should include control for any asbestos-contaminated soil, which might fall from excavation equipment. Asbestos-contaminated soil falling within the work area should fall only on the contaminated portion of the work area or should be removed by the equipment operator prior to completion of the remaining work area. Asbestos-contaminated soil falling onto the plastic-lined load station should be cleaned and added to the truckload prior to the truck moving off the plastic, or cleaned after the truck leaves the plastic and added to the next truckload. The excavator and load station should be moved as required to complete multiple work areas.

When feasible, excavated asbestos-contaminated soil should be directly loaded into the beds of properly lined trucks that will haul the soil for disposal. Refer to Section 8.9 for further information on accepted waste handling and disposal practices. A plastic-lined load-out station should be created close to the edge of each work area. Trucks that will transport asbestos-contaminated soil to an approved disposal facility should be directed onto the load-out station.

8.5.2.2 Stormwater Management

Stormwater should be managed in accordance with the Water Quality Control Commission's stormwater regulations (5 CCR 1002-61), which include specific stormwater permitting and management requirements for construction sites. The Water Quality Control Division should be contacted to determine the specific requirements for each project.

8.6 Site Access Control

Every attempt should be made to prevent unauthorized site access. One means of preventing access is the installation of portable fence panels to enclose work areas and posting appropriate warning signs in visible locations. Key site personnel should be responsible for limiting access to the work site and only authorized personnel should be allowed on site in accordance with the project health and safety plan. All personnel should sign in and out as they enter and leave designated work areas.

8.7 Air Monitoring

During the removal of asbestos-contaminated soil, the Air Monitoring Specialist should collect air samples to assist in determining the adequacy of engineering and environmental controls employed at the site. In addition, personal air monitoring should be performed in accordance with OSHA requirements.

Air samples should be collected inside each work area. It is suggested that either a minimum of four static air samples be collected per day inside each regulated work area, samplers be placed on personnel or equipment in the work area, or both. The goal is to collect information regarding worst-case emissions by collecting samples as close to the area of soil disturbance as possible. Static air samples should cover all four points of the compass and should be located as close as possible to the point of excavation and loading activities. In all cases the sample points must be located to capture the worst-case emissions during that particular activity. The sample locations should not be fixed, and should be changed as necessary to keep pace with the point of excavation and loading. Additional "floating" samples may be needed to monitor worst-case emissions as prevailing wind direction shifts.

Personnel air monitoring samples may also be used as point of operation work area samples, and may be used in conjunction with, or in place of, perimeter samples. For instance, in the event that ambient air samplers cannot be placed within close proximity to the work area, personnel air monitoring samples will provide a more representative look at conditions in the work area. It is suggested that at least 25% of workers, with no fewer than two workers, wear personnel sampling cassettes. It should be noted that this "personnel" sampling is different, and in addition to, personal monitoring mandated by OSHA.

Air samples can be collected on transmission electron microscopy (TEM) or on phase contrast microscopy (PCM) 25 mm cassettes, and submitted for appropriate analysis. Samples for transmission electron microscopy analysis should be submitted to a NVLAP (National Voluntary Laboratory Accreditation Program) accredited laboratory (administered by the national Institute of Standards and Technology (NIST)), and samples for phase contrast microscopy analysis should be submitted to a laboratory showing successful participation in the American Industrial Hygiene Association (AIHA) Proficiency Analytical Testing (PAT) Program. Although analysis using phase contrast microscopy is commonly performed during asbestos abatement projects, transmission electron microscopy analysis is generally preferred for asbestos-contaminated soil projects since transmission electron microscopy analysis specifically detects asbestos fibers, thus aiding in decisions regarding the adequacy of work practices and engineering controls. If samples are submitted for phase contrast microscopy analysis, it is recommended that at least two samples (one sample for the highest phase contrast microscopy result and one randomly selected among the remaining samples) be analyzed by transmission electron microscopy each day that active asbestos-contaminated soil removal activities are being conducted. The results of transmission electron microscopy sampling will be used to assess the adequacy of work practices and engineering controls to determine if adjustments are necessary. If the work practices and engineering controls are deemed adequate by the Air Monitoring Specialist and the Division, the number of daily transmission electron microscopy samples may be reduced; however, the frequency of transmission electron microscopy samples should be increased, if at any time, subsequent phase contrast microscopy air samples indicate an increase in emissions.

All samples collected should be delivered to the laboratory at the end of the workday using appropriate chain-of-custody procedures. Phase contrast microscopy verbal results should be made available to the Air Monitoring Specialist and onsite personnel before work begins the following day. Transmission electron microscopy verbal results should be made available within 24 hours of receipt of samples by the laboratory. Hard copy results should be on site within 24 hours of verbal communication, or as soon as practicable.

Notification of Positive Transmission Electron Microscopy (TEM) Results - if an air sample contains any concentration of airborne asbestos fibers after transmission electron microscopy analysis of personal and work area samples, the Division should be notified immediately via one of the methods provided in Section 5 of this guidance. Work practices and engineering controls should be modified to reduce emissions. If subsequent air monitoring results indicate that work practices and engineering controls are still not adequate, soil removal activities should cease and a control plan be developed and submitted to the Division. Soil removal should not continue until the Division provides authorization to proceed.

8.8 Dust Control/Emissions Control Measures

Dust generated during removal activities presents a potential impact to air quality. Soils contaminated with asbestos present an even greater threat and pose a risk to human health and the environment. Accordingly, dust suppression and emissions controls are critical elements of asbestos-contaminated soil removal activities. The types of emissions controls used are job specific and dependent upon the type of asbestos, the amount of contamination, the integrity of the asbestos material and the type of soil being disturbed. For example, amosite asbestos that has separated from its structural matrix will cause substantial emissions that cannot be controlled with the wetting techniques discussed below, mainly because amosite is resistant to water absorption and the fibers that have separated from the matrix are no longer bound in a material. Similarly, relatively high concentrations of chrysotile asbestos fibers in loose soil that have lost adhesion to a matrix will cause emissions that cannot be effectively controlled by standard wetting techniques. In cases such as these, the use of containment structures may be the only way to effectively control emissions. Containment structures are discussed further in Section 8.8.5 of this guidance.

Whenever potentially contaminated soil and debris are being disturbed, the asbestos contractor or qualified site personnel and Air Monitoring Specialist should be on site at all times that asbestos contaminated soil is removed to ensure that no visible emissions are generated at any time during soil-disturbing activities. An Air Monitoring Specialist or asbestos Building Inspector should be on site at all times to monitor the moisture of the asbestos-contaminated soil being removed and to ensure that it is adequately wet. If visible emissions are observed during the removal process, work practices should be reviewed and modified by the asbestos contractor or qualified site personnel and Air Monitoring Specialist.

At no time should vehicle traffic be allowed on surfaces where the surface samples have shown positive test results or where visible asbestos is present. In addition to restricted access for vehicles, all other vehicle access should be limited to surfaces with a reinforced, tear-resistant polyethylene sheeting or equivalent liner. This excludes equipment that is to remain off road throughout the project. The off-road equipment may travel on soils that do not have surface contamination and have been saturated for the control of visible emissions.

To prevent the possible cross contamination of clean surfaces, 6-mil polyethylene sheeting should be placed over clean surfaces in the vicinity of the work area. In addition, reinforced tear-resistant polyethylene sheeting or equivalent liners should be applied to surfaces where truck traffic will be moving from the work area onto non-surface contaminated soils.

Potential dust emissions from stockpiled soils should be mitigated by the application of water or stabilizing agents (such as magnesium chloride), and/or by covering with tarps or other appropriate cover material.

8.8.1 Soil Wetting or Stabilizing

A continuous water supply (i.e., water truck, water tanks, fire hydrant and fire hose, etc.) should be available at all times during removal activities. The water truck or water hose should be capable of applying water or a water mist directly to the ground surface to minimize dust and prevent emissions.

A misting system localized to the work area should be installed prior to removal activities. The water misting system should be constructed out of PVC piping or equivalent materials that will generate a low energized mist of water droplets large enough to minimize drift but fine enough to control any fiber emissions generated from the work area without over-saturation of the soil. There are two types of misting systems that can be utilized; one type is mounted around the immediate excavation area and one type is mounted on the equipment. Ground mounted misting systems are very effective on small excavations. Equipment mounted misting systems are typically not as effective as ground mounted systems; however, they are generally used on large excavation projects because the use of ground mounted misters is usually not practical for work in large areas. In addition, if improperly designed, ground mounted misters can cause a buildup of water. However, if fine misters are used with a wind fence, ground mounted misters work much better than equipment mounted misters.

It is recommended that prior to commencing any removal activities, a root watering system be used to saturate soils beneath the surface and the surface soil should be sprayed with amended water (water to which surfactant chemicals have been added) to suppress any dust migration or visible emissions within the work area. Sufficient time should be allowed for the amended water to penetrate the surface prior to the commencement of work. The root watering system should be utilized initially at least 24 hours in advance of the commencement of work and repeated as necessary to ensure adequate saturation of soil prior to removal activities.

During the removal process, all areas of impact should be kept adequately wet. Wetting may be accomplished with amended water, such as a 50:50 mixture of polyoxyethylene ester and polyoxyethylene ether, or the equivalent, in a 0.16 percent solution (1 ounce to 5 gallons) of water. The amended water should be applied at low pressure in order to prevent dust generation or splattering.

Soil should have water or amended water applied at the point of contact. The excavator or other removal equipment should handle the material wet and direct load the soil into a tractor trailer or other appropriate waste container. The trailer or other waste container should contain a leak tight container constructed out of 6-mil polyethylene sheeting. In addition to the point of impact wetting, additional wetting should occur within the trailer or waste container itself to provide additional emissions control at the point of loading.

8.8.2 Wind Break Barriers

Wind break barriers should be constructed prior to commencement of removal activities. Wind break barriers should be constructed out of materials appropriate to site conditions. For example, temporary chain link fencing at a level of approximately 6 feet in height with fence screen installed and fitted to each panel may be used to assist in controlling any potential migration of dust and debris throughout the removal process. All wind speed measurements should be taken inside any wind break barriers and in locations in close proximity to, and representative of, the work area in which the soil is being handled. This would include both the point of removal and the dumping point since the potential for emissions is greatest in these two areas.

8.8.3 High Wind Work Stoppage

Shutdown conditions – Soil removal/disturbance operations should immediately and temporarily cease when one or more of the following four conditions have been met:

- any wind gust reaches or exceeds 20 miles per hour as determined by hand-held instruments;
- sustained wind speeds reach or exceed 12 miles per hour averaged over a period of 10 minutes;
- winds produce visible emissions or create movement of dust or debris in or near the removal/disturbance area or loading area; or
- winds impact the ability of engineering controls to work as designed.

During wind-related work shutdowns, other work activities not involving soil removal or disturbance (e.g. lining dumpsters) may continue.

Startup conditions – Soil removal/disturbance operations may resume after all of the following four conditions have been met:

- all wind gust readings drop below 20 miles per hour for a period of 20 minutes as determined by hand-held instruments;
- sustained wind speeds are below 12 miles per hour averaged over a period of 20 minutes;
- winds are no longer producing visible emissions or creating movement of dust or debris in or near the removal/disturbance area; and
- winds are not impacting the ability of engineering controls to work as designed.

8.8.4 Covers

Exposed clean surfaces within the work area should be protected with 6-mil polyethylene sheeting or an equivalent cover to eliminate the potential for contamination during removal of soil within the work area.

Exposed asbestos-contaminated soil should be covered or otherwise stabilized during high wind work stoppages, and other periods when active removal/disturbance is not occurring.

8.8.5 Containment Structures

In some cases, construction of containment structures will be appropriate in order to eliminate the potential release of asbestos dust emissions to adjacent facilities/locations and in order to protect human health and the environment.

When greatly diffuse contamination is encountered, or relatively high concentrations of asbestos are present in the soil (e.g., soil with high asbestos content and no visible asbestos debris), or when the soil matrix is loose (i.e., the soil does not bind well to the asbestos and, therefore, does not help control emissions), it may be necessary to construct a containment system over the work area. Similarly, amosite asbestos that has separated from its structural matrix will cause substantial emissions that cannot be controlled with standard wetting techniques due to the fact that amosite is resistant to water absorption.

Containment systems can range from pre-engineered tent structures that are relatively large and easy to erect, to basic site built tents made with reinforced polyethylene sheeting mounted on site fabricated structures. Containment barriers must be placed under negative pressure with HEPA filtered fan units to further prevent emissions. Containment systems provide the greatest emission control and facilitate faster excavation through minimizing interruption in production from high wind events, poor weather conditions, unfavorable soil absorption rates (e.g., wetting becomes less critical because of the other engineering), etc. The most difficult problem with a containment system is the decontamination of the waste trucks. This problem is not technically insurmountable, but if not designed properly can substantially lower the cost-benefit on the containment system. Even if not necessarily required by law, it is recommended that exterior containment systems be designed and installed by licensed asbestos abatement contractors (as they have expertise in designing and maintaining exterior containment systems).

Containment structures may be necessary under Regulation No. 8, Part B, if the work involves buried pipes that are covered in asbestos-containing materials with quantities in excess of the trigger levels; which are 260 linear feet on pipes, 160 square feet on other surfaces, or a volume equivalent of a 55-gallon drum. In such circumstances, it may be preferable to establish a containment structure prior to excavation of buried pipes since it is very common to find that pipes have been disturbed in the past, resulting in loose asbestos and asbestos-contaminated soil.

8.8.6 External Critical Barriers for Nearby Structures

In some cases, construction of external critical barriers may be necessary for the protection of structures or people located near the work area.

When the abatement area is close to other structures, and within the potential airshed of those structures (such as occupied structures within 50’ of the work area), the owners of the structures should be advised of the potential hazards and the abatement contractor should offer to seal openings to the adjacent structure(s) to prevent fiber migration into the structure(s). The “airshed” can be thought of as an area in which air mixes freely; that is, pollution generated at any point within an airshed will be more or less equally distributed throughout. Practical determination of the airshed could be made through using smoke generators to determine characteristic airflow patterns. Any windows, doors, vents or other openings that are within the airshed are considered “critical openings.” The so-called “critical barriers” that seal these openings usually consist of 6-mil polyethylene sheeting, sometimes reinforced sheeting, which is secured with spray glue, tape and sometimes staples or furring strips.

Vents that cannot be sealed, such as furnace combustion vents in homes, should be ducted out of the air shed using flex ducting. Vents with “tight-sealing” flappers, such as certain types of household dryer vents, need not be covered.

8.8.7 Equipment Decontamination

All excavation equipment should be thoroughly cleaned before being mobilized to the work area. Cleaning procedures should be conducted in such a manner as to ensure that all residual soil and contaminants are removed and other hazards are not present. Equipment should also be inspected for leaking fluids in order to prevent introducing other contaminants to the site. Leaking equipment should not be allowed on site.

Once the removal process is complete, decontamination of the equipment should occur within a waste container when possible. The equipment that was in contact with the contaminated material should be thoroughly cleaned using water (or amended water) and rags. The water and rags should be containerized and the container then sealed for transportation and disposal. The final decontamination of equipment should occur within a catch basin constructed out of 10 mil polyethylene sheeting and at least 12 inches deep for the purposes of collection and filtration of the water generated during the decontamination process. Decontamination water should be filtered to 5 microns prior to collection for offsite disposal or being discharged into a contaminated soil loaded truck. Alternatively, the filtered decontamination water can be used for wetting of asbestos-contaminated areas that will be removed. If areas where decontamination water has been applied are not to be excavated prior to drying, the surface must be covered or stabilized until excavation occurs to prevent the emissions of any fibers that were not removed during filtration. Disposal of decontamination water into the sanitary sewer may be allowed after filtration to 5 microns, or to local requirements if such requirements are more stringent.

All vehicles and other equipment that were used in the intrusive removal activities should receive a thorough and invasive cleaning, as described above, prior to being removed from the site. Each vehicle and piece of equipment should receive a documented inspection by an asbestos Building Inspector prior to its demobilization.

8.8.8 Worker Decontamination

A fully functioning decontamination unit or trailer should be utilized at each site. The decontamination unit should be located within 100 feet of the property and as near the removal area as practical. The decontamination unit should consist of 3 chambers, should have fully operational hot and cold running water, adjustable at the shower tap, and a functioning water filtration unit that will filter the waste water down to 5 microns prior to being drummed for offsite disposal, or discharged into contaminated soil loaded truck. If disposal into the sanitary sewer is anticipated, water should be filtered to 5 microns, or to local requirements if such requirements are more stringent.

Workers should wear a clean outer protective suit as they exit from the work area to the decontamination area. Workers should either wear double suits and remove the exterior suit or don a second, clean suit over the single suit within the work area prior to moving into the decontamination unit. The decontamination unit should be utilized by the workers each time they exit the work area. Workers may not wear street clothes under suits.

8.9 Waste Handling

8.9.1 Loading

Removal of asbestos-contaminated soil should be conducted utilizing a direct load system when possible. Asbestos-contaminated soil should be removed wet and transported directly from the contaminated work area to a waste container that contains a minimum 6-mil polyethylene sheeting, leak tight disposal bag. Soil that contains visible friable asbestos must be loaded into a waste container that contains at least two 6-mil polyethylene sheeting, leak tight disposal bags, in accordance with the disposal requirements for friable asbestos waste (Section 5.3.5(A) of the Solid Waste Regulations). Once each dump has been executed within the disposal container, the excavator should return the bucket to a closed position prior to returning to the specific area undergoing removal activities.

While the excavation equipment operator is loading the disposal container, the walls of the container should act as the wind break barrier until the load is wrapped and ready for disposal. During the process of loading the container, the excavation equipment operator should lower the bucket as close as possible to the interior of the container before dumping, and dump the load slowly to allow adequate misting. The loading site should be equipped with a dedicated misting station on the opposite side of the disposal container (opposite the loading point). This misting station must be provided with enough water pressure and personnel to ensure that the entire surface area of the dump is shrouded in the mist. The most effective misting system is a prefabricated misting bar that can be quickly hooked on the edge of the disposal container and water turned on with a single valve (the bar is almost as long as the container so that mist/spray covers the entire container). If personnel are used to mist the loads manually, they should be positioned on a scaffold system that runs the length of the disposal container. The number of personnel and hoses is dictated by the ability to mist the entire surface area of the dump.

Throughout the entire loading process, water or amended water should be applied to suppress any visible emissions that might occur. The swing radius of the excavator should have a 6-mil polyethylene liner over the clean surface to control cross contamination as material is transferred. In addition, the excavation bucket should not be filled to more than 2/3 its normal capacity so as to minimize spillage. Once the trailer or container has been loaded to a safe level for transportation, it should be sealed within the 6-mil polyethylene sheeting container and transported for disposal. Each vehicle should receive a documented inspection by an asbestos Building Inspector prior to it leaving the site. This should include an inspection of the tailgate to ensure that is securely latched and chained to prevent it from opening during transportation.

8.9.2 Packaging

Containers or trucks should be lined with a minimum of one 6-mil thick pre-formed polyethylene liner (do not use roll poly). In accordance with the disposal requirements for friable asbestos waste (Section 5.3.5(A) of the Solid Waste Regulations), at least two 6-mil polyethylene liners must be used for soil that contains visible friable asbestos. Polyethylene liners should be designed and sized for the container to be used and should be folded over the sides of trailers or containers to protect against contamination during loading and to facilitate decontamination. After loading, both liners should be sealed separately. The liners must be sealed in a manner that ensures that they remain leak-tight during transportation and disposal operations.

Containers of friable asbestos waste, or asbestos-contaminated soil with visible friable asbestos, must be labeled in accordance with the requirements of Section 5.3.5 of the Solid Waste Regulations using one of the following legends in type at least 5 inches tall:

(1)	CAUTION CONTAINS ASBESTOS AVOID OPENING OR BREAKING CONTAINER BREATHING ASBESTOS IS HAZARDOUS TO YOUR HEALTH
(2)	DANGER CONTAINS ASBESTOS FIBERS AVOID CREATING DUST CANCER AND LUNG DISEASE HAZARD

In addition, Department of Transportation (DOT) asbestos placards should be placed on all four vertical sides of the container or vehicle being used.

Containers of non-friable asbestos waste, asbestos-contaminated soil with visible non-friable asbestos, and asbestos-contaminated soil with no visible asbestos should be labeled noting “Asbestos, Danger” and the name of the generator, and placed on top of sealed liner. DOT asbestos placards should be placed on all four vertical sides of the container or vehicle being used.

8.9.3 Transportation

It is recommended that the asbestos contractor, or other qualified site personnel, direct the schedule of transportation of asbestos-contaminated soil. When loaded, each truck should be assigned a manifest to serve as the shipping document for that particular load. Asbestos-contaminated soil must be transported and disposed of in a leak tight container in accordance with the disposal requirements discussed in the following section. Documentation stating that the soil originating from the site shall not be used a daily cover or sold as clean fill must accompany each load of asbestos-contaminated soil removed from the site.

8.9.4 Disposal

Disposal of asbestos-contaminated soil must be conducted in accordance with the following requirements, in accordance with Section 5.5.7 of the Solid Waste Regulations:

- Asbestos-contaminated soils containing visible friable asbestos shall be disposed of in a leak tight container as friable asbestos waste in accordance with the requirements of Section 5.3 of the Solid Waste Regulations.
- Asbestos-contaminated soil containing only visible non-friable asbestos that has not been rendered friable shall be disposed of as non-friable asbestos in accordance with Section 5.2 of the Solid Waste Regulations.
- Asbestos-contaminated soils containing no visible asbestos shall be disposed of in a manner similar to non-friable asbestos waste, as described in Section 5.2 of the Solid Waste Regulations.
- Soils that are not asbestos-contaminated, based on analysis showing no detectable amounts of asbestos, may be replaced into the disturbed area as needed, used as fill, or disposed of as solid waste.

Section 5.7 of the Solid Waste Regulation also requires that documentation stating that the asbestos-contaminated soil originating from the site shall not be used as daily cover or sold as clean fill accompany each load of asbestos-contaminated soil removed from the site.

8.10 Clearance

Asbestos-contaminated soil management projects do not require final clearance sampling. However, the asbestos consultant or qualified site personnel should conduct a final visual inspection of the area of asbestos-contaminated soil removal to determine what, if any, controls must be instituted to allow future activity in the excavation area. For example, if asbestos remains in the sidewalls of an excavation, a determination should be made by the asbestos consultant (usually an Air Monitoring Specialist or an asbestos Building Inspector) or the asbestos contactor as to whether personnel entering the excavation must wear personal protective equipment (PPE), air monitoring must be conducted or temporary or permanent liners should be installed over asbestos-contaminated-soil left in place. Due to the wet nature of the removal process, adequate drying time should be allowed before a final visual inspection is conducted. In some cases, it may be beneficial to conduct a pre-final visual inspection while the area is moist, as it may be easier to see some forms of asbestos when they are still wet (this is not true with some types of asbestos-containing materials, such as aircell or transite). However, final visual inspections may only be conducted when soil is dry.

8.10.1 Backfilling Excavation

The excavation should be backfilled only after final visual inspection by the asbestos consultant or qualified site personnel to allow for the implementation of appropriate controls. Backfilled soil should be protected with adequate cover if additional removal activities are to occur in other areas of the site.

8.10.2 Designation of Cleared Work Areas

New flagging or other means of visual communication should be utilized to show that a particular work area has been excavated and work is complete. Completed work areas may be utilized as haul routes or for other site access provided appropriate controls are instituted to prevent contamination of these areas.

8.11 Demobilization

After the project has been determined complete, the misting system, wind break barriers and other fencing can be removed and the decontamination trailer/unit can be de-mobilized.

Waste containers should be removed from the site and taken to an approved landfill for disposal immediately upon completion. Any remaining protective barriers should then be removed from the site.

8.12 Close-out Report

The contractor, consultant or qualified site personnel should maintain complete documentation of the project. It is recommended that a project close-out report be prepared and, at a minimum, include the following:

- property description and description of area(s) with asbestos-contaminated soil;
- description of soil disturbing activities;
- description of all field operations or daily logs;
- containment logs (where appropriate);
- air monitoring logs and analytical results;
- description/results of all asbestos sampling events, including sample locations;
- analytical results;
- disposal summaries and manifests;
- maps showing excavation profiles;
- maps showing the location of any asbestos left in place (where appropriate);
- description of any engineering or institutional controls for any asbestos left in place;
- photographs showing pre- and post-removal conditions; and
- worker certifications.

Project close-out reports for asbestos-contaminated soil management projects are not required to be submitted to the Division. In addition, submittal of project close-out reports is not required for remediation projects conducted under Section 5.5.5 of the Solid Waste Regulations, but may be necessary if the owner/operator wants the Division to make a determination regarding the adequacy of a remediation project. Submittal of project close-out reports for asbestos-contaminated soil remediation projects may be required for projects conducted under one of the corrective action mechanisms discussed in Section 1 of this guidance.

9.0 REMEDIATION OF ASBESTOS-CONTAMINATED SOIL

This Section 9 is intended to guide the actions of owners/operators, contractors and consultants when asbestos-contaminated soil is being totally or partially remediated pursuant to a Division approved plan under Section 5.5.5 of the Solid Waste Regulations or other remedial program as discussed in Section 1 of this guidance. Asbestos-contaminated soil "remediation" projects are those where the owner/operator, intends to remediate asbestos-contaminated soil to a specific concentration, or based on specific risk criteria (referred to herein as "remediation objectives") as defined in the remediation plan. Refer to the regulatory definitions of "management" and "remediation" provided in Section 3 for further guidance.

Unless indicated otherwise below, all provisions of Section 8 "Management of Asbestos Contaminated Soils" should be considered and incorporated where appropriate in any Soil Characterization and Management Plan submitted to the Division pursuant to Section 5.5.5 of the Solid Waste Regulations.

9.1 Risk Assessment and Site Characterization

The property owner may wish to conduct a site-specific risk assessment to evaluate potential risks of exposure to asbestos-contaminated soil left in place. The risk assessment should consider future uses of the property and whether any engineering or institutional controls are needed to manage future risk of exposure. A detailed discussion of the risk of exposure to asbestos, and issues that should be considered when conducting a site-specific risk assessment, is provided in Appendix C – Overview of Asbestos Toxicology and Risk Assessment.

9.2 Clearance Sampling and Inspection

After asbestos-contaminated soil has been excavated to the appropriate depth as established by the consultant or qualified site personnel, the work area should be confirmed clean through visual inspection, and if appropriate, post-excavation sampling. If visual inspection or sampling demonstrates the site has not been remediated to remediation objectives, additional excavation should be performed. Final visual inspections should be conducted after remediated areas have been allowed to dry. Final clearance sampling, if conducted, can take place before the area is dry; however, collecting final clearance samples prior to confirming the area is visually clean may be premature.

Only a certified asbestos Building Inspector with a minimum of 6 months experience in asbestos-contaminated soil abatement may clear an asbestos-contaminated soil remediation project. In order to avoid potential conflicts of interest, it is recommended that the certified asbestos Building Inspector be an employee of the independent asbestos consultant hired to oversee the remediation project and not an employee of the contractor performing the remediation.

9.2.1 Visual Inspection

As removal activities progress, visual inspections should be performed to ensure that all visible asbestos-contaminated soil has been removed from the work area. Inspections by the asbestos Building Inspector should be performed for each work area remediated on a daily basis, typically at the end of the each work day, but may be conducted more frequently. If visible contamination will be allowed to remain over-night, the area should be stabilized with an appropriate cover so as to prevent disturbance of the material and visible emissions.

Final visual inspection should be conducted upon completion of remediation activities. Due to the wet nature of the remediation process, adequate drying time should be allowed before a final visual inspection is conducted (see section 9.2 immediately above).

The final visual inspection should consist of at least 2 passes over the entire area with one pass in one direction (e.g., East-West) and the subsequent pass going perpendicular to the first pass (e.g., North-South). The inspector should use invasive inspection techniques, such as periodically raking or digging through the surface and closely inspecting the disturbed area. Detailed close examination and sifting of the soil in multiple, 10' x 10' test grids scattered throughout the area is also recommended in addition to the passes described above. Final visual inspections must be conducted with adequate lighting; early morning or late afternoon inspections should generally be avoided because of shading. It is important to note that a final visual inspection of soil, while a valuable and important tool for determining project completion, may not be very reliable even when conscientiously performed. Hence, there is no substitute for a good soil characterization and project design for over excavating contaminated soils (i.e., knowing where the native soil horizon is and excavating well past this horizon to ensure complete removal). It is also important to employ good soil abatement practices and institute positive controls against cross-contamination.

The presence of any visible asbestos-contaminated soil will not pass final visual inspection. If visible asbestos-contaminated soil is observed, the area should be adequately wetted and additional excavation should be conducted (unless the remediation plan provides for asbestos to be left in place). A subsequent visual inspection should be conducted after each additional excavation event until the area passes. Generally, because of the inherent limitations associated with visual inspections, if one piece of debris is found it is likely that more debris is present, but hidden from view.

In the event that not all asbestos-contaminated soil will be remediated, the contractor or applicable site personnel, under direction from the asbestos Building Inspector and/or Air Monitoring Specialist, should proceed in accordance with a Division approved plan for clearance of the work area.

9.2.2 Soil Sampling

Once a certified asbestos Building Inspector has determined that the remediation has passed visual inspection, the following protocol can be followed, in addition to sampling procedures presented in Section 7.0 of this guidance, for collection of clearance bulk samples from the excavation.

a. After the desired depth is attained in each work area, collect one composite, made up of five (5) to ten (10) aliquots, from exposed excavation floor and each exposed sidewall. The actual number of aliquots may vary based on the size of the area and other observed conditions.
b. Submit composite samples to an National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory for asbestos polarized light microscopy analysis.
c. Review results to determine whether depth and extent of excavation are adequate or if over-excavation is required.
d. If depth of excavation is not adequate (based on analytical results of floor screening samples), then excavate an additional 6 inches and collect another composite floor sample as directed in (a) above.
e. If extent of excavation is not adequate (based on analytical results of sidewall screening samples), then remove an additional 6 inches from appropriate sidewall(s) and collect additional sidewall sample(s) as directed in (a) above.
f. Repeat removal and sampling cycle until results are below remediation objectives.

The excavation should be backfilled only after final visual inspection and final clearance sampling, if appropriate, demonstrate that asbestos-contaminated soil has been remediated in accordance with the Division-approved remediation plan and Soil Characterization and Management Plan. Backfilled soil should be protected with adequate covers if additional removal activities are to occur on the site.

Sampling may not always be necessary to verify completion of remedial activities. Examples may include excavation of a disposal or fill area where the boundaries of waste or fill are known or can be identified based on the presence of native (undisturbed) material or other change in condition indicative of non-impacted soil.

9.3 Close-out Report

Project personnel should maintain complete documentation of the project. A project close-out report should be prepared, as described in Section 8.12 of this guidance. The submittal of project close-out reports is not required for remediation projects conducted under Section 5.5.5 of the Solid Waste Regulations, but may be necessary if the owner/operator wants the Division to make a determination regarding the adequacy of a remediation project. Submittal of project close-out reports for asbestos-contaminated soil remediation projects may be required for projects conducted under one of the corrective action mechanisms discussed in Section 1 of this guidance.

10.0 ENVIRONMENTAL COVENANTS

In certain circumstances as discussed below, an environmental covenant may be required when asbestos-contaminated soil is left in place after the completion of a remediation project. An environmental covenant would not be required in situations where asbestos-contaminated soil is only being managed during a soil-disturbing activity. For example, an environmental covenant would not be required when asbestos-contaminated soil is disturbed for underground utility work, maintenance or construction where soil disturbance is conducted in the course of such projects. In cases where a covenant is not required, and asbestos-contaminated soil will be left in place, the property owner may choose to place a covenant on the property. The covenant may be helpful in limiting potential future liability for residual asbestos-contaminated soil by ensuring that the asbestos-contaminated soil is fully disclosed, not inadvertently disturbed, and that any engineering controls are maintained.

In accordance with § 25-15-320, C.R.S, environmental covenants are required for environmental cleanup decisions made on or after July 1, 2001 that would result in either residual contamination at levels that have been determined to be safe for one or more specific uses, but not all uses; or that include the incorporation of an engineered feature or structure that requires monitoring, maintenance or operation, or that will not function as intended if it is disturbed. The law applies to cleanup decisions made under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. § 9601; the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. § 6901 (including the corrective action authorities, emergency order authorities, and citizen suit provisions of that Act); the Uranium Mill Tailings Radiation Control Act of 1978, 42 U.S.C. § 7901; the Colorado Hazardous Waste Act, § 25-15-101, C.R.S.; the Colorado Radiation Control Act, § 25-11-101, C.R.S.; and the Colorado Solid Waste Disposal Sites and Facilities Act, § 30-20-100.5 C.R.S. It also applies to closure of hazardous waste management units under the Colorado Hazardous Waste Act and of solid waste disposal sites under the Colorado Solid Waste Disposal Sites and Facilities Act. Environmental covenants are not required for remediation projects conducted under the Colorado Voluntary Cleanup and Redevelopment Act, § 25-16-301, C.R.S.; however, a property owner may choose to place a covenant on the property.

For sites with asbestos-contaminated soil, an environmental covenant is required whenever the Division makes a final remedial decision as part of an "environmental remediation project" that results in residual asbestos-contaminated soil that does not allow for unrestricted use, or that incorporates an engineered feature that requires monitoring, maintenance, or operation. "Environmental remediation projects," as defined in the statute, include any remediation of environmental contamination that is conducted under the authority of one of the laws listed above, including the Solid Wastes Disposal Sites and Facilities Act.

As an example, if an asbestos-contaminated soil remediation project includes an engineered structure, such as a cap, to isolate residual asbestos-contaminated soil, land use restrictions, such as prohibitions on drilling, excavating, and irrigating may be necessary to prevent damage to the cap. Or, it may be necessary to perform maintenance on the cap periodically to prevent it from eroding. An environmental covenant would be required to document and enforce the use restrictions necessary to maintain the integrity of the cap.

Similarly, decisions regarding the extent of asbestos-contaminated soil remediation may be based on a site-specific assessment of the risk posed by remaining asbestos. The nature and amount of exposure to contamination is a factor in determining risk. In turn, land use may influence exposure to contamination. Asbestos-contaminated soil may pose little risk if it is covered by an asphalt parking lot. The same soil could pose a significant risk if it were used for a garden or in a yard where children play. If cleanup decisions are based on an assumption that the future land use will be a parking lot, and the land use changes to residential, the original cleanup may not be protective for the new use. An environmental covenant would allow the Division to enforce the land-use restriction against subsequent landowners to ensure the cleanup remains protective.

APPENDIX A

Notification Forms

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
Asbestos Contaminated Soil Notification Form

24 HOUR NOTIFICATION OF UNPLANNED ASBESTOS DISCOVERY

For 24-hour notification of the unplanned discovery of asbestos-contaminated soil, a completed a copy of this form should be faxed to 303-759-5355 Attn: Solid Waste Unit Leader, or emailed to comments.hmwmd@state.co.us . If the Hazardous Materials and Waste Management Division has not pre-approved standard operating procedures that will be implemented, you must then submit a **Soil Characterization and Management Plan** to the Division for approval. If the Division has pre-approved standard operating procedures that will be implemented, you only need to submit a completed copy of this form.

The Soil Characterization and Management Plan should be mailed to: Colorado Department of Public Health and Environment, Division-B2 Attn: Solid Waste Unit Leader, 4300 Cherry Creek Drive South, Denver CO 80246-1530
or emailed to: comments.hmwmd@state.co.us .

Date and time reported:		
Contact person for entity performing soil-disturbing activity:	**Phone:**	**Ext:**
Organization, company or agency:		
Address:		
City:	**State:**	**Zip:**
Name of property owner/operator or property representative:		
Owner/operator contact (if different):	**Phone:**	**Ext:**
Address:	**Fax:**	
City:	**State:**	**Zip:**

Discovery date:	**Discovery time (include AM or PM):**		
Location of property: (Street address or other location description – e.g. highway mile marker)	**Street Address:**		
	County:	**City:**	**Zip:**
General Site Description:			
Activity resulting in discovery:			
Description of material encountered:			
Description of access or emissions controls implemented:			

Has the Division pre-approved standard procedures that will be implemented? ☐ **yes** ☐ **no**

If "no," implement interim actions and submit a Soil Characterization and Management Plan for Division review and approval.

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
Asbestos Contaminated Soil Notification Form

10 DAY NOTIFICATION OF PLANNED ASBESTOS MANAGEMENT

For notification of planned management of asbestos-contaminated soil, a completed copy of this form should be submitted to the Hazardous Materials and Waste Management Division at least 10 working days prior to any planned soil-disturbing activity. If the Division has not pre-approved standard operating procedures that will be implemented, you must also submit a **Soil Characterization and Management Plan** to the Division for approval. If the Division has pre-approved standard operating procedures that will be implemented, then you only need to submit a completed copy of this form.

The form and plan can be mailed to: Colorado Department of Public Health and Environment, Division-B2 Attn: Solid Waste Unit Leader, 4300 Cherry Creek Drive South, Denver CO 80246-1530
or emailed to: comments.hmwmd@state.co.us .

Date and time reported:			
Contact person for entity performing soil-disturbing activity:		**Phone:**	**Ext:**
Organization, company or agency:			
Address:			
City:		**State:**	**Zip:**
Name of property owner/operator or property representative:			
Owner/operator contact (if different):		**Phone:**	**Ext:**
Address:		**Fax:**	
City:		**State:**	**Zip:**
Location of property: (Street address or other location description – e.g. highway mile marker)	**Street Address:**		
	County:	**City:**	**Zip:**
General Site Description:			
Description of planned soil-disturbing activities:			
Description of material that will be disturbed:			
Has the Division pre-approved standard procedures that will be implemented? ☐ **yes** ☐ **no**			
If "no," submit a Soil Characterization and Management Plan for Division review and approval.			

APPENDIX B
Guidelines for Determining Background Concentrations

Assessing background concentrations of asbestos in soil requires knowledge of the background sources, the type and form of asbestos present, and the manner in which asbestos was distributed. Information on these topics should be gathered and studied to aide in designing a background assessment. It is often helpful to develop a conceptual site model of the potential sources and potential distribution patterns of the background concentrations. The conceptual site model is then used to develop the sampling design, including, for example, the number and locations of samples needed to assess background levels and type of asbestos. Sample design should employ a design process such as the seven step EPA data quality objective (DQO) process (Guidance for the Data Quality Objectives Process; EPA QA/G-4; EPA/600/R-96/055; August 2000) or some other appropriate design process.

The number and locations of samples to be collected to determine background or ambient concentration at a site will depend upon site-specific characteristics and history. All of this may be summarized in the conceptual site model. Distribution of asbestos in soil may be highly variable between individual points in a background area; however, the distribution of background concentrations might be expected to be relatively homogeneous at the site-level scale accounting for source and distribution mode. It is important to take a sufficient number of samples to account for variability at the sample scale while adequately assessing variability over larger site and local scales. In addition a sample pattern, such as a grid system, may be considered. More samples may be required where sites cover large areas with varying soil characteristics or where constituent concentrations vary significantly with depth. Professional judgment, in consultation with the Division, will be used to determine the number of samples required for background characterization on a site-by-site basis.

Background concentrations of naturally occurring constituents such as asbestos vary greatly depending upon the source of the soil matrix or depositional environment. Use of countrywide, statewide or regional background data for site-specific background may be considered but cannot be the only basis for assessing background concentrations. Background data from other sites may be used provided that the data were collected and analyzed using methods acceptable to the Division. For naturally occurring asbestos, the reference site must be located within the same geologic region and the samples must have been collected from a unit with the same lithology and characteristics as the strata at the site under investigation. For anthropogenic (ambient) asbestos concentrations, it must be demonstrated that the site is affected by the same anthropogenic source as the site under investigation. In addition, the source and pattern of asbestos distribution must be taken into consideration. For example, if the background location is impacted by brake pad emissions, there may be uniform asbestos contamination of only surface soils. However, this data should not be used for background comparisons with an area where asbestos contamination (surface and subsurface) is due to building demolition.

Background samples are taken to determine the amount and type of asbestos that is either 1) naturally occurring in the area of a site or 2) is derived from off-site anthropogenic sources affecting a large region around the site. Background samples should not be collected from areas where other on-site or off-site sources may have contributed the same constituents as those encountered at the area in question. Sampling conducted during a site characterization or investigation should be capable of determining whether on-site or off-site activities may have contributed to background concentrations present at the site. Samples must be taken up-wind and/or topographically upgradient from known or suspected contaminated areas. Information obtained during a historical site review, as discussed in Section 4 of this guidance, should be used to select sampling locations that have not been affected by on-site activities. Sampling programs should be designed to adequately limit the uncertainty associated with statistical testing.

DATA ANALYSIS

Ideally, data analysis techniques should be determined during the sample design planning. This is important because data analysis, along with cost and risk considerations, will influence the number of samples that are collected. Data may be analyzed in several ways; however, it should be noted that a normal distribution is not initially assumed. One simple way to analyze data is to plot data in a frequency histogram. The histogram is used to assess the data distribution, central tendencies, variation, and shape. A distribution may be approximated from the histogram and measures of central tendency and variability, such as mean and standard deviation, can be estimated for the distribution. Once the statistical parameters of the background distribution are calculated they may be used as standards against which the site-specific data are evaluated. Other statistical approaches to evaluating background data may also be used; however, sufficient documentation must be provided demonstrating the validity of the approach for the site circumstances. It is recommended that the method proposed be presented in a sampling plan and approved by Division prior to implementation.

COMPARISON TO SITE DATA

After the background data has been evaluated, a comparison can be made between the concentrations and type of asbestos in the site area to that of an established background. Similar to sample design for the background area, a sample plan should also be made for the target site. Again it is helpful for the plan to be based on a conceptual site model and use a design process such as data quality objectives process. The sampling plans and proposed data analysis technique should be discussed with Division staff and approved prior to implementation. Data analysis techniques should include hypothesis testing using an appropriate statistical test such as the t distribution to compare population means, or F distribution to compare population variances, or a rank-sum test.

APPENDIX C
Overview of Asbestos Toxicology and Risk Assessment

1. INTRODUCTION

This document presents an overview of information from the scientific literature and EPA workshops as well as guidance documents on the analysis of potential exposures and associated asbestos-related health risks. Unlike the majority of other chemicals, exposures to asbestos-contaminated soil cannot be adequately characterized by a single parameter of asbestos concentration in soil. Other factors that need to be addressed include concentration of asbestos generated in air due to disturbance of asbestos-contaminated soil as well as shape, size, and mineralogy of asbestos structures. Additionally, a determination of the potential future health risks to residents (or other types of subpopulations) from exposure to different types of asbestos (e.g., chrysotile, crocidolite, tremolite, and amosite) found at various sites is challenging because of the evolving asbestos science, for example, in the following areas: (a) Methods used to analyze asbestos; (b) Definition of asbestos; (c) Toxic potential of asbestos; and (d) Methods used to estimate potential exposure to airborne asbestos from contaminated soils (i.e., Risk assessment tools). Therefore, to facilitate the evaluation of the potential human health risk from exposure to asbestos-contaminated soils, this document provides a brief overview of:

1. The existing knowledge regarding asbestos and the associated health effects.
2. Risk assessment
   (a) Evidence supporting complete exposure pathway for potential exposures from asbestos contaminated soils with a focus on trace levels of contamination (i.e., <1% asbestos in soil);
   (b) Evaluation of potential future residential health risks from exposure to asbestos contaminated soil using EPA's risk assessment process.
3. Current state of asbestos toxicology and risk assessment.

2. ASBESTOS AND ITS HEALTH EFFECTS: OVERVIEW

The major sources for the following information concerning asbestos and its health effects include reviews by the Agency for Toxic Substances and Disease Registry (ATSDR) (2001, 2003ab); EPA Integrated Risk Information System (IRIS) (2003); and Berman (2001, 2003)

2.1. Asbestos

The following characteristics of asbestos reflect the unique complexity associated with the nature of asbestos and have relevance to human health risk characterization.

- Asbestos is a generic term used to describe a group of fibrous silicate minerals that occur naturally in the environment, and have been used commercially. The most widely accepted definition of asbestos includes the fibrous varieties of six minerals. Asbestos falls into two mineralogical groups, serpentine and amphibole. The most common type of asbestos is chrysotile, which is serpentine. The other five asbestos minerals are amphiboles and include the minerals amosite, crocidolite, tremolite, anthophyllite and actinolite.

- The general chemical composition of serpentine asbestos is reported as magnesium silicate. Serpentine asbestos possesses relatively long, curved and flexible crystalline fibers that tend to form a tubular structure. Amphiboles (e.g., crocidolite) are generally ferro-magnesium silicates and have rod- or needle-shaped brittle fibers.
- Historically, regulatory agencies such as the Occupational Safety and Health Administration (OSHA) and EPA define an asbestos fiber as a particle with a length $\geq$5 um and aspect ratio (length-width ratio) $\geq$3:1. It should be noted that EPA defines a fiber as any particle with aspect ratio $\geq$5:1 when analyzing bulk samples for fiber content. This regulatory definition of a fiber, based on recent evidence, does not appear to be consistent with the biological activity of asbestos structures. Asbestos fibers can fracture or split and break into smaller diameter fibrils. A single fiber can split into hundreds of fibrils. These split fibers are called cleavage fragments.
- Asbestos dust is a complex mixture of fibrous structures. Not only do single fibers vary in dimensions but such fibers may also be found combined with other fibers in the form of bundles, clusters or matrices. These are known as asbestos structures that can be inhaled.
- Asbestos fibers are basically chemically inert. They do not evaporate, dissolve, burn or biodegrade in the environment. However, single fibers and clumps of fibers may be released in the air as dust as a result of wind erosion and other types of activities that generate dust.

2.2. Health effects of asbestos

The health effects of asbestos exposure have been previously reviewed extensively (ATSDR 2000, 2001, 2003b; EPA IRIS; Churg and Wright, 1994; and Stayner et al.1996, 1997) and a brief summary is provided below.

It is known that inhalation of asbestos fibers suspended in air can result in lung cancer, malignant mesothelioma and nonmalignant respiratory effects including pulmonary interstitial fibrosis (*asbestosis*); localized or diffuse areas of thickening of the pleura (*pleural plaques*); extensive thickening of the pleura (*pleural thickening*); pleural calcification; and fluid buildup in pleural space (*pleural effusions*). These findings are in agreement with results from mechanistic studies as well as studies of animals exposed by multiple routes. The risk of developing any one of these diseases depends upon many factors including the chemistry of fibers, shape and size of fibers, exposure level and duration, the individual's susceptibility and the smoking history of the exposed individual. According to the Agency for Toxic Substances and Disease Registry, (ATSDR, 2001), these diseases have been observed in groups of occupationally exposed workers with cumulative exposures ranging from about 5 to 1200 f-year/mL, where f stands for fiber. The cumulative dose of 5 f-year/mL, for example, can result from 40 years of low-level exposure to 0.125 f/mL or 10 years of higher-level exposure to 0.5 f/mL. However, a major limitation is that there is very limited information for responses at low levels experienced by modern workers (<0.1 f/mL of Occupational Safety and Health Administration limits) or at levels experienced in some nonoccupational environments. For example, an increased incidence of pleural plaques has been reported at relatively low cumulative nonoccupational exposures of about 0.12f-yr/mL (ATSDR, 2001).

Despite the debate in the scientific literature concerning the relative toxic potential of different types of asbestos, there is general agreement among the scientific community on the following issues regarding the health effects of asbestos.

a. National and international health agencies have classified asbestos as a known human carcinogen.
b. Exposure to any type of asbestos (i.e., serpentine or amphibole) can increase the risk of lung cancer, mesothelioma, and nonmalignant lung and pleural diseases.
c. Important determinants of toxicity include cumulative dose (exposure duration times exposure concentration), fiber dimension, and durability.
d. The combination of tobacco smoking and asbestos exposure synergistically increases the risk of developing lung cancer.
e. Asbestos-related diseases can occur as a result of either heavy exposure for a short time or lower exposure over a longer period of time. For example, some cases of asbestosis have occurred as a result of 1-day intense exposure (ATSDR, 2003a).
f. Most cases of asbestos-related disease occur after 15 or more years. In general, latency periods are 10-40 years.

3. RISK ASSESSMENT FOR FUTURE POTENTIAL ASBESTOS EXPOSURE

It is well known that asbestos exposure and health effects are related to asbestos fibers in air that are released from asbestos materials during natural and anthropogenic activities. Therefore, it is important to include some evidence showing a complete exposure pathway as a result of release of asbestos fibers into the air during soil disturbing activities. The evidence provided in Attachment 1 demonstrates that soil containing less than 1% asbestos can release hazardous levels of airborne asbestos fibers if disturbed by human and/or natural activities. Addison et al (1988) have shown that irrespective of the type of asbestos fiber, high airborne fiber concentrations can be generated from less than 1% asbestos in soil (even with 0.001% asbestos). Moreover, the EPA studies at Libby, MT and in Region 10 are some of the most recent and compelling studies regarding the ability of asbestos fibers to be released from soil matrices during routine residential activities.

3.1. Overview of EPA's risk assessment process

The primary purpose of risk assessment is to provide risk managers with an understanding of the current and future risks to human health posed by the site and any uncertainties associated with the assessment. Specifically, the 1990 National Contingency Plan (NCP) (55 Fed. Reg. 8665-8865 (Mar. 8, 1990) states that the risk assessment should " characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to ground water or surface water, releasing to air, leaching through soil, remaining in the soil…." (Section 300.430(d) (4) as cited by EPA, 1991a: OSWER DIRECTIVE 9355.0-30). Risk assessment is generally a four-step process consisting of hazard identification, exposure assessment, dose-response assessment, and characterization of risk based on the combination of results of the three previous steps, and the associated uncertainties (EPA, 1989, RAGs Part A; EPA, 1992a).

Traditionally, EPA recommends a tiered framework for risk assessment. The three-tiered framework could include an initial conservative screening analysis; a refined or simple site-specific screening approach; and a detailed site-specific modeling approach for more comprehensive consideration of site-specific conditions (e.g., EPA, 1994; 1996; 1998; 2000). The decision regarding which of the three approaches is most appropriate for a given site must balance the need for accuracy with considerations of cost and timeliness (EPA, 1996). It is important to note that risk assessment only provides one of several important tools in the whole risk management process. EPA's regulatory process also calls for consideration of non-scientific factors (e.g., economic, social, political, and legal factors) in decision-making (EPA, 1992a).

3.2. Application of EPA's Risk Assessment Process to Estimate Potential Risks due to Complete Asbestos Exposure Pathway from Asbestos Contaminated Soils into the Air as a result of Soil Disturbing Activities

It is important to note that asbestos risk assessment is an evolving science and the EPA is in the process of preparing an asbestos risk assessment toolbox. This appendix provides an overview of the currently available knowledge and tools that are being applied to conduct asbestos risk assessments, at various sites, in accordance with the four steps of EPA's risk assessment process: (1) hazard identification; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization and uncertainty analysis.

3.2.1. Hazard Identification

The potential hazard is that asbestos-containing friable debris and asbestos fibers can be present in surface and subsurface soils at any site. It should be noted that asbestos fibers in soil or dust do not inherently pose a risk to human health if left undisturbed. Therefore, health risks from asbestos-containing debris and fibers in soil will depend on the potential for asbestos fibers to become airborne and be inhaled. The asbestos containing waste material that is readily accessible on the surface is vulnerable to disturbance by various anthropogenic or natural activities. Consequently, current and future receptors can be potentially exposed to asbestos fibers released from asbestos-containing debris or soil due to disturbance by common human intrusive activities or natural processes (e.g., wind erosion, precipitation, and extreme changes in temperature) either now or in the future.

Asbestos is known to be persistent in the environment. Furthermore, the continued degradation of asbestos-containing debris would act as a continuous source of asbestos fibers in surface and subsurface soils that may become airborne when the soils are disturbed in the future. It should be noted that these soils act as a reservoir of loose asbestos fibers that could continue to be released to the air. Moreover, asbestos fibers can be tracked into homes by residents and pets, where they can create an on-going source of exposure by being re-entrained as a result of routine activities inside the home. Also, children can bring asbestos-containing debris and contaminated soils inside the home contained in toys used for outdoor playing activities.

There is no significant migration of asbestos fibers from the soil, except from disturbance by human or natural activities. It is, however, important to note that uncontrolled drainage of water from asbestos-contaminated areas may result in environmental dispersion of asbestos.

3.2.2. Exposure Assessment

The US EPA guidelines for exposure assessment (EPA, 1992b) establish a broad framework for conducting exposure assessments. The goal of the human exposure assessment is to estimate the magnitude of exposure to asbestos by a human population. The exposure assessment is addressed here by discussing the following:

(1) A conceptual site model: (i) the source; (ii) the mechanisms of release and transport; (iii) the affected media; (iv) the characterization of potential land uses; (v) identification of current and future potentially exposed populations; and (vi) identification of exposure pathways;

(2) Estimation of exposure point concentration; and

(3) Estimation of human exposure dose.

3.2.2.1. Conceptual site model

A conceptual site model is illustrated in Figure 1 and is discussed below.

1. Source of exposure – Typically, three major sources of exposure include: (1) asbestos-containing debris in surface and subsurface soils; (2) free asbestos fibers in surface and subsurface soils; and (3) indoor sources including settled dust, asbestos-containing debris and contaminated soil brought inside the home, and infiltration from outdoor air.

2. Mechanisms of asbestos release and transport – Asbestos may be released from each source by disturbance due to human activities and/or by natural processes. These are briefly described below:

   (a) Examples of common intrusive activities performed by residents:

- rototilling of soils in flower and vegetable gardens;
- rototilling for installing new landscaping when the existing lawn is dead (partially or completely);
- digging holes for planting trees and bushes;
- disturbance of the grass-covered yard soil from activities such as weeding; mowing the grass, aerating, and habitual digging by pets and wild animals;
- disturbances of sparsely vegetated areas of yard by walking, playing, biking, mowing, etc.;
- management of excavated soils by bagging and floor sweeping;
- disturbance by children of exposed soils that exist under swing sets and other play equipment;
- disturbance during physical handling of asbestos-containing debris and contaminated soils that might occur if children play with the materials.

(b) Examples of natural processes that may result in release of fibers from asbestos-containing debris and/or soils:

- forces exerted by wind currents on existing free asbestos fibers in soil at the surface or excavated soils due to the above activities;
- forces exerted on asbestos-containing debris by shifting soils due to extreme changes in temperature, precipitation, or other natural processes;
- re-suspension of settled dust when residents perform routine household activities.

(c) Examples of activities that may result in large amounts of excavated soils and a resultant on-going source of asbestos release in air:

- planting trees or bushes;
- excavating dead trees and bushes;
- outdoor minor construction such as installing an in-ground hot tub, play equipment, a deck, patio fences or other structures;
- installing or repairing sprinkler system;
- installing decorative pathways by flagstones on the grass-covered yard.

(d) Examples of mechanisms by which asbestos may be transported outdoors or indoors:

- wind transport through open doors and windows;
- track-in of adhered fibers on clothing and shoes of children as well as adults, and through pet animals;
- children physically carrying asbestos-contaminated soil and debris on or in toys brought inside home for playing.

3. Affected media – Potentially affected media include soils and air. However, risks associated with airborne asbestos fibers are evaluated because undisturbed asbestos in soil generally does not pose a risk to human health. Additionally, the ingestion of soils is not considered the potential exposure pathway of major concern because of the association of much lower potential health risks with ingested asbestos than with inhaled asbestos (ATSDR, 2001). Thus, by

addressing the substantial risks associated with the inhalation of asbestos fibers in air, the public health should be adequately protected.

4. Current and future land use – Residential, recreational, commercial/industrial (including construction)

5. Identification of current and future potentially exposed populations – The identification of potentially exposed populations (or human receptors) is based on the consideration of current and anticipated land uses. Therefore, the current and potential human receptors discussed here as examples are adult and child residents performing routine indoor and outdoor activities.

6. Potential exposure pathway – EPA (1989) defines an exposure pathway as the course a chemical or a physical agent takes from the contaminant source to the exposed individual. A complete exposure pathway includes a source, release mechanism, transport mechanism, an exposure medium (e.g., air in this case), an exposure point, and a receptor. Therefore, inhalation of airborne asbestos fibers is considered the primary route of exposure because air represents a primary medium for asbestos transport and exposure. The evidence in support of complete exposure pathway for asbestos to move from contaminated soil to the air is provided in Attachment 1

3.2.2.2. Exposure point concentration

The concentration of asbestos in soil and air to which an individual could be exposed is called the exposure point concentration. It is, however, important to emphasize that the relationship between soil and air levels of asbestos fibers is complex, and the generation of airborne fibers is not predominantly dependent on the type of asbestos. The potential for asbestos fibers to become airborne depends on the type and state of matrix in which it is present, as well as the potential for mechanical disruption of the matrix by human and/or natural activities. Therefore, air or soil sampling data for asbestos contamination represents only a snapshot in time that generally will not be a good representation of exposure under various complex activities and environmental conditions. Thus, semi-quantitative assessment of the distribution of the asbestos contaminated soil or waste and potential for asbestos fibers to become airborne remains the important aspect of exposure assessment. Various methods available for the estimation of asbestos concentration in soil and air are briefly noted below.

1. Determination of Exposure Point Concentration for Asbestos Fibers in Soil

   The intended use of the risk assessment usually defines the scope of exposure assessment or approaches used to estimate exposure (EPA, 1992b). For instance, there are studies that show that the presence of significantly less than one percent of asbestos fibers in soil (even up to 0.001%) can generate unacceptable levels of asbestos fibers in air, if disturbed (see Attachment-1). Therefore, for example, the objective of the soil sampling program could be to determine the presence or absence of asbestos fibers in soil using different techniques discussed in Attachment 2.

2. Estimation of Exposure Point Concentration for Asbestos Fibers in Air that are Released from Contaminated Soils Due to Soil Disturbing Activities

According to EPA's exposure assessment framework (EPA, 1992b), a variety of approaches can be used to estimate exposure point concentration. These range from quick screening level methods of using the existing data or models, to more sophisticated techniques of collecting new data. To estimate the exposure point concentration of asbestos fibers in air, the point of contact approach may be used. This approach involves measurement of asbestos fibers at the point where they contact the exposed individuals (i.e., breathing zone), usually by using personal monitors, during the various types of activities routinely performed by child and adult residents, and a record of the exposure time of contact during each type of activity. Sometimes, for an inhalation exposure assessment, the point of contact approach is combined with emission and dispersion models that are appropriate for the scenario specific circumstances under which such exposure is expected to occur. The available emission and dispersion models for dust particles, however, are not designed for modeling of asbestos concentrations in soil to predict concentrations of asbestos fibers in air. Several dust generation models with a series of adjustments are being considered for asbestos modeling (e.g., Berman, 2000). However, the use of these models is premature and is likely to add additional uncertainty in the prediction of airborne asbestos concentrations, because it is complex to model the releasable form of asbestos in the bulk form and then to model asbestos suspension and movement in air.

Typically, for site-specific risk assessment purposes (Tier-2), exposure point concentration in air is estimated by personal monitoring in the breathing zone while individuals actually perform various task-based activities. However, for the initial screening-level analyses (Tier 1), the following techniques can be used: (1) simulation of asbestos release by conducting new experimental studies using techniques such as experimental enclosures (i.e., a glove box) and Berman's Elutriator method (see Attachment 1 for details) and/or (2) using the existing monitoring data from other experimental and/or site-specific studies. In accordance with EPA's exposure assessment framework (EPA, 1992b), existing point of contact monitoring data from other studies can be used. However, "the assessor must consider the factors that existed in the original study and that influenced the exposure levels measured. Some of these factors are proximity to source, activities of the studied individuals, time of day, seasons, and weather conditions." (EPA, 1992 b; p. 22909).

3.2.2.3. Estimation of human exposure dose

The final step of the exposure assessment is to quantify the pathway-specific intake dose for the identified receptor population by integrating the exposure point concentration with exposure and intake parameters (e.g., frequency and duration of exposure, and inhalation rate). The use of these exposure parameters is briefly discussed below.

1. Exposure parameters

According to EPA guidance (EPA, 1989, 1992b), intake and exposure variable values for a given exposure pathway are selected so that the combination of all intake variables result in an estimate of dose of the "reasonable maximum exposure" (RME), which is defined as the maximum exposure that is reasonably expected to occur at a site. Conceptually, the reasonable maximum exposure describes exposures above the 90th percentile of the population distribution, i.e., 90th to 95th percentile (EPA RAGs, 1989). The quantitative information on exposure/intake parameters is generally based on EPA's default values. It is, however, important to emphasize that a determination of reasonable exposure cannot be based solely on EPA's quantitative information or default values, but also requires the use of professional judgment. Accordingly, the following examples of exposure parameters for various scenario specific activities are based on a combination of EPA's recommendations (EPA 1991b OSWER Directive), information from other sites, and professional judgment.

a. Default exposure parameters for a residential scenario:

Exposure duration for a resident = 30 years (EPA, 1991b)
Exposure duration for a child resident = 6 years (EPA, 1991b)
Averaging time for carcinogens = 70 years (EPA, 1991b)

b. Scenario/activity-specific exposure parameters for adults and children:

- Gardening/yard activities for Adults:

According to EPA's Exposure Factor Handbook (EPA, 1997; Volume III), no data specific to gardening times and frequencies could be found; thus, no firm recommendations are made by EPA. However, EPA (1997) provides three sets of indirect data for consideration in deriving time estimates for gardening. These data indicate time spent in the garden or other circumstances working with soil for persons 18-64 years old for the 90th, 95th, and 99th percentile at 16, 40, and 200 hours/month, respectively. However, EPA (1997; Vol. III, p. 15-16) recommends an upper percentile of 40 hours/month for adults. This information is combined with professional judgment, and data from other site-specific assessments to select the following examples of assumptions:

Rototilling activity = 2 hr/day; 8 days/year (adopted from EPA, December 2001 Weis memo).

Other soil-intrusive activities listed above (e.g., planting trees/bushes, vegetables, and flowers, weeding, excavating dead bushes/trees etc.) = 2 hr/day; 20 days/year.

Management of excavated soils (e.g., bagging soil, and sweeping floor) = 1 hr/day; 8 days/year.

- Recreational activities for Children:

  According to EPA (1997), activities can vary significantly with differences in age. Therefore, special attention should be given to the activities of populations under the age of 12 years. Based on the EPA recommended study, outdoor activities for children (ages 3-11 years) accounted for 5 hrs/day for weekdays and 7 hrs/day on weekends. Also, site-specific risk assessment for the Rocky Mountain Arsenal (RMA, Record of Decision, 1996) used 8 hrs/day for 108 days/year for outdoor recreational activities by children. Based on this information, some examples of assumptions for risk screening analysis are provided below:

  Time spent on play-equipment (swings, slides, etc.) = 1 hr/day; 80 days/year

  Time spent playing with excavated soils or helping parents in bagging soil = 1 hr/day; 15 days/year.

3.2.3. Toxicity Assessment

The objective of the toxicity assessment is to evaluate the available evidence regarding the toxic potential of asbestos and to provide, where possible, an estimate of the relationship between dose and the increased likelihood and/or severity of adverse health effects. EPA has not yet derived any noncancer toxicity value for asbestos and this effort is underway.

It is important to note that the currently available EPA IRIS (Integrated Risk Information System) cancer potency factor for asbestos is being re-evaluated by the EPA. EPA Office of Solid Waste and Emergency Response is developing an interim cancer model, which will include all forms of asbestos. The key model under review as an interim approach is the Berman and Crump model. Therefore, risks can be estimated using two approaches: (1) the approach currently recommended by the EPA (IRIS, 1988/2006); and (2) new protocol developed by Berman and Crump (2001, 2003).

(1) EPA Integrated Risk Information System (IRIS) Approach- EPA has classified asbestos as a known human carcinogen and provided an inhalation unit risk factor of 0.23 per PCM (phase contrast microscopy) f/cc in IRIS (1988/2006) (that is, the cancer risk per asbestos fiber per cc of air inhaled over a lifetime). This value estimates additive risk of lung cancer and mesothelioma using a relative risk model for lung cancer and an absolute risk model for mesothelioma. This means that the mesothelioma risk model is independent of the background risk, which is considered to be negligible in the general population. The mesothelioma model also assumes that risk increases exponentially with time after a 10-year lag period. Since a relative risk model is used for lung cancer, the absolute risk for lung cancer due to asbestos exposure depends not only on cumulative dose for asbestos, but also on the underlying risk for lung cancer due to other causes. All asbestos types are considered equipotent in the EPA Integrated Risk Information System approach. Therefore, this approach is highly likely to significantly underestimate risks from amphiboles, based on the evidence discussed elsewhere in this document (see Section 4.1(f)). Risks from chrysotile are possibly overestimated to a low degree. This

toxicity factor is designed to be applied to asbestos structures satisfying the dimensional criteria for 7402 structures (phase contrast microscopy-equivalent (PCME) structures). These structures are longer than 5 um and thicker than 0.25 um that exhibit an aspect ratio (length to width) of equal or greater than 3:1. Additionally, it is important to know that the use of EPA's inhalation unit risk factor (EPA IRIS, 1988/2006) is likely to over- or underestimate cancer risk based on a comparison with other available risk models. The EPA analysis has been extensively reviewed and discussed in the scientific literature (e.g., Hodgson and Darnton, 2000; Camus et al., 1998; Lash et al., 1997; Gustavsson et al., 2002).

(2) Berman and Crump (2001, 2003) Approach – These cancer potency factors are adjusted to match exposures expressed as "protocol structures". These structures are between 5 and 10 um in length that are thinner than 0.5 um with the fraction of structures longer than 10 um separately enumerated. Berman and Crump (2003) provides a revision to the Berman and Crump (2001) based on a peer-review. Accordingly, the optimal exposure index that best reconciles the published literature assigns equal potency to fibers longer than 10 um and thinner than 0.4 um and assigns no potency to fibers of other dimensions.

For this method, separate risk estimates are provided for (a) chrysotile and amphibole asbestos; (b) smokers and nonsmokers; and (c) men and women. Additionally, risk tables present estimates of the additional risk of death from lung cancer, from mesothelioma, and from two diseases combined that are attributable to lifetime, continuous exposure at an asbestos concentration of 0.0001 TEM f/cc (Transmission Electron Microscopy). Risks from lifetime exposures to asbestos levels other than 0.0001 may be estimated by multiplying the appropriate table value by the airborne asbestos concentration of interest and dividing by 0.0001.

For this approach, samples must be analyzed by transmission electron microscopy. Overall, this interim exposure index is focused on the thinner and longer structures that are better related to biological activity

3.2.4. Risk Characterization

The general approach discussed here for risk characterization is based on EPA's framework (EPA RAGs, 1989, and EPA, 2000). Risk characterization also serves as the bridge between risk assessment and risk management. This section will also discuss how quantitative risk estimates can be integrated with qualitative and quantitative information regarding uncertainty and variability to characterize risk.

This analysis calculates individual cancer risk, which is the risk accruing to an individual in a defined exposure scenario. Individual cancer risk is calculated as the excess risk from the daily incremental dose of asbestos above the background dose and the human cancer risk factor as established by the EPA Integrated Risk Information System. The cancer risk factor converts estimated daily dose averaged over a lifetime to an incremental probability. Therefore, the cancer risk estimate is defined as the incremental upper bound probability of an individual developing cancer over a lifetime.

There are a number of outdoor and indoor activities that are routinely performed by residents that could result in unacceptable levels of exposure/risk. However, it is not feasible to evaluate risk for each type of activity. Therefore, some examples of typical activities should be selected by combining a high impact, moderate impact, and low impact activities.

It is important to note that if it is not feasible to calculate indoor risks (e.g., planning of future residential development), the indoor risks should be addressed qualitatively in the discussion of uncertainties.

3.2.4.1. Risk estimation for adult resident

Cancer risk is calculated by Exposure concentration for asbestos in air multiplied by Time weighted factor multiplied by Inhalation unit risk.

Time weighted factor is calculated using averaging time, exposure duration, exposure time and exposure frequency.

3.2.4.2. Risk Estimation for child resident

Cancer risk is calculated by Exposure concentration for asbestos in air multiplied by Time weighted factor multiplied by child-adjusted Inhalation unit risk.

Other child-specific exposure parameters that need to be used include inhalation rate and body weight. These values are used along with the cancer slope factor.

3.2.4.3. Estimation of cumulative risks from various activities

It is necessary to calculate the cumulative risk from all types of outdoor activities and indoor activities for both adults and children:

- total adult risk from various outdoor activities;
- total adult risk from various indoor activities;
- total child risk from various outdoor activities;
- total child risk from various indoor activities.

3.2.5. Uncertainty Analysis

Risk screening analysis is not an exact science. In general, EPA and the Colorado Department of Public Health and Environment use assumptions and models that may overestimate risk instead of those that might underestimate the risk in order to make sure that the risk management decisions are protective of the public health. While the EPA risk assessment process attempts to estimate risk as accurately as possible, there are numerous sources of uncertainty in the risk assessment process (EPA, 1992b; and EPA, 2000). According to EPA, several sources of uncertainty must be considered to place the risk estimates in a proper perspective. These sources range from the estimation of exposure point concentration to the available toxicity information regarding asbestos.

One source, especially, relevant to the asbestos risk assessment process is that the data on exposure assessment represents a snapshot in time and cannot be used to predict long term release of asbestos fibers. As an example, recent risk assessments conducted at the North Ridge Estates, Klamath Falls, Oregon using the modified Elutriator method (Berman, 2004) as well as by activity based personal monitoring (EPA Region 10, 2004) cannot be used to predict long term (>2 years) risks of asbestos and risk management decision-making because a substantial amount of extremely friable asbestos has already resurfaced. This excessive exposure to asbestos could not be addressed in the risk assessment process. Another important source of uncertainty includes quantitative estimation of indoor risks where it is not feasible to estimate indoor risks as a result of future potential residential development. Various sources of uncertainty in exposure as well as toxicity data, and risk estimates should be discussed on a site-specific basis.

For example, discuss the following:

- uncertainty in exposure assessment;
- uncertainty in toxicity assessment;
    - for example, no noncancer toxicity value available a this time;
    - two different cancer toxicity values ;
        - EPA IRIS (1988/2006) and ;
        - Berman and Crump (2001);
- uncertainty in risk estimates;
    - uncertainties associated with estimation of child risk;
    - uncertainty associated with estimation of indoor risks.

4. CURRENT STATE OF ASBESTOS TOXICOLOGY AND RISK ASSESSMENT

4.1 Current State of Asbestos Toxicology: asbestos definition and fiber definition in relation to fiber potency

Unlike the majority of other chemicals, asbestos exposures cannot be adequately characterized by a single parameter of concentration. Other factors that need to be addressed include shape, size and mineralogy of structures. Therefore, proper definition of asbestos is needed to better relate to its biological activity.

As noted above, regulatory agencies define asbestos fiber as a particle with a length ≥5 um and a diameter of ≤3 um with an aspect ratio (ratio of length: width) of ≥3:1. EPA uses an aspect ratio of ≥5:1 when analyzing bulk samples. However, the validity of this definition is uncertain in term of its relevance to toxicity; although the current EPA Integrated Risk Information System uses this definition to evaluate toxicity (i.e., phase contrast microscopy-equivalent (PCME) structures with a mean diameter of 0.2 to 3.0 um). Some of the current issues in asbestos toxicology are briefly noted below (ATSDR, 2001; Koppikar, 2003; Berman and Crump, 2001, 2003):

(a) <u>Alternate fiber definition to better relate biological activity</u>

- Berman's protocol structures are defined as a complex structure that is longer than 5 um and thinner than 0.5 um. To determine risk-related concentrations, protocol structures longer than 10 um must be separately evaluated because they are assigned a greater potency than structures with lengths between 5 and 10 um (Berman and Crump, 2001). According to Berman and Crump (2003), a revision to the Berman and Crump (2001) the optimal exposure index that best reconciles the published literature assigns equal potency to fibers longer than 10 um and thinner than 0.4 um and assigns no potency to fibers of other dimensions.

(b) Issues related to fiber diameter and toxic potential

- Fibers with a diameter of $\leq$ 0.5 um to 1.5 um may be relevant for toxicity as they can reach the respiratory zone of lungs in humans (e.g., mouth breathers) (Koppiker, 2003).
- The results of some studies indicate that it is a cutoff in absolute width that defines the bounds of biological activity rather than a cutoff in aspect ratio (Berman and crump, 2003).

(c) Issues related to fiber length and carcinogenic potency

There are uncertainties associated with the relative importance of long and short inhaled fibers in asbestos-related diseases. Human and animal data are available in support of the importance of both short and long fibers in the induction of asbestos-related diseases (e.g., Sebastian et al., 1980; Stanton et al., 1981; Berman et al. 1995; Dodson et al., 1997, 1999; and Davis et al., 1991).

- The toxicological significance of <5 um fibers is debatable. Some believe that fibers <5 um present a very low risk, possibly zero for cancer based on human data. Others believe that they cause inflammation and may potentiate the pulmonary reactions to long fibers based on animal and in vitro studies (Koppiker, 2003).
- Longer fiber >10 um fibers present greater risk for lung cancer but the exact size cut-off for the length and magnitude of relative potency is uncertain (Koppiker, 2003). The supporting literature suggests that the optimum cutoff for increased potency occurs at a length that is closer to 20 um than to 10 um (Berman and Crump, 2003).
- Thinner fibers and fibers in the range of 5-10 um in length are more important for mesothelioma (Koppiker, 2003).
- The potency appears to increase with increasing length, at least up to a length of 20 um and potentially up to a length of 40 um. The structures (fibers) longer than 40 um may be as much as 500 times

more potent than structures between 5 and 40 um in length (Berman and Crump, 2003).

(d) Issues related to aspect ratio and toxic potential (Koppiker, 2003)

- Aspect ratio of 3:1 is not considered relevant to toxic potential of fiber.
- This issue has been debatable for purposes of quantifying exposure levels since the establishment of the definition.
- Part of the debate is the uncertainty associated with the relative importance of long and short inhaled fibers in asbestos pathogenicity.

(e) Issues Related to toxic potential of cleavage fragments (Koppiker, 2003)

- The exact role of the surface properties of asbestiform fibers and cleavage fragments in the toxic potency is currently unknown.
- Insufficient data are available regarding the toxic potential of cleavage fragments.
- Cleavage fragments may have a higher or lower toxic potential due to differences in the surface properties in comparison to fibers because of the manner in which cleavage fragments and fibers are formed (e.g., cleavage fragments have unsatisfied chemical bonds).
- The available evidence suggests that it is prudent to assume equal potency of fibers and cleavage fragments that meet the fiber definition.

(f) Issues Related to Fiber Mineralogy and carcinogenic potency

- Mesothelioma - The role of chrysotile fibers in the induction of mesothelioma is debatable. For example, based on the limited available data, chrysotile fibers are believed to be removed from the lungs more quickly than amphibole asbestos fibers. Some scientists have proposed that chrysotile fibers may not be the primary cause of mesothelioma in humans. There is compelling evidence that amphibole asbestos is significantly more potent than chrysotile, at least by more than two orders of magnitude (e.g., Berman et al., 1995; Churg and Wright, 1994; and Stayner et al., 1996; Berman and Crump, 2001, 2003).

- Lung cancer - There are different views about the relative potency of chrysotile and amphiboles for lung cancer. Some assert that amphibole asbestos is more potent (about 5 times) than chrysotile in inducing lung cancer. Others believe that differences in the potency of chrysotile and amphibole in inducing lung cancer cannot be reliably discerned from available data (Berman et al., 1995; Stayner et al., 1996; ATSDR, 2001; Berman and Crump, 2001, 2003; and EPA workshop, February, 2003).

- Unregulated amphiboles - The set of minerals included in the current definition of asbestos inadequately cover the range of minerals that potentially contribute to asbestos-related diseases. For example, several studies have implicated fibrous amphibole, such as those found in Libby vermiculite (e.g., containing a maximum amount of non-regulated amphibole fibers winchite and richterite), in cases of asbestos-relate disease. Another 2003 study implicated the non-regulated amphibole fluoro-edenite in a cluster of deaths from pleural mesothelioma (Comba et al., 2003)

(g) Issues related to effects of asbestos at extrathoracic sites

- The available evidence does not support a definitive conclusion whether the increased risk for gastrointestinal cancer observed in some of the epidemiological studies is real or not. According to the Agency for Toxic Substances and Disease Registry (ATSDR 2001), it is prudent to consider increased risk of gastrointestinal cancer an effect of concern from ingested asbestos exposure.
- The available evidence is insufficient to conclude whether inhalation of asbestos increases the risk of cancer at extrathoracic sites (larynx, kidney, ovary, etc.).

(h) Issues Related to toxicity of low level chronic or short-term high exposures

There is uncertainty regarding the actual risks for malignant and nonmalignant asbestos-related diseases that may exist after exposures to lower levels or shorter duration or both. However, the available epidemiological data from case studies and extrapolation of data using the EPA Integrated Risk Information System risk model (or other models) indicate that low level exposure can result in asbestos-related diseases, as briefly demonstrated below.

- A recent case study discussed a fatal asbestosis after a brief high intensity exposure to amphibole asbestos. The worker was exposed to the same fibrous amphibole as those found in Libby, MT while working two summers at the California exfoliation plant. The worker died 50 years later, when fatal asbestosis occurred quickly (Wright et al., 2002).

- EPA Integrated Risk Information System (IRIS) calculated that lifetime exposure to asbestos air concentrations of 0.0001 f/mL could result in up to 2 to 4 excess cancer deaths per 100,000 people (ATSDR, 2001). According to EPA IRIS, 0.000004 f/cc is a risk-based asbestos concentration in air at the lifetime excess cancer risk of 1 in a million.

- Recently, Hodgson and Darnton (2000) have calculated cancer risk in terms of the cumulative exposure dose to the three types of asbestos (i.e., chrysotile, crocidoloite, and amosite). These investigators expressed lung cancer and mesothelioma potency of different types of asbestos, based on a recent analysis of 17 cohorts, as a number of excess deaths per 100,000 exposed. Overall, this analysis demonstrates that all three types of asbestos can increase the risk of lung cancer as well as mesothelioma even at a low level of cumulative exposure to 0.01f-yr/mL.

4.2. Current State of Asbestos Risk Assessment

1. Historical use of one percent asbestos rule
    - In August 2004, EPA removed the one percent asbestos rule as a decision point for action regarding materials containing asbestos (Office of Solid Waste and Emergency Response (OSWER) Directive 9345.4-05). In summary, this Directive states, " Recent data from the Libby site and other sites provide evidence that soil/debris containing significantly less than 1 percent asbestos can release unacceptable air concentrations of all types of asbestos fibers (i.e., serpentine/chrysotile and amphibole/tremolite)." According to EPA, an accurate exposure value could only be determined through site sampling techniques that generate fibers from soil and bulk samples. Therefore, EPA recommends the development of risk-based, site-specific action levels to determine if response actions for asbestos in soil/debris should be undertaken.
2. Need of another value in place of one percent asbestos rule
    - The one percent rule has not been replaced by another value, and therefore, EPA's Technical Review Workgroup (TRW) Asbestos Committee is working to develop tools for risk assessment and provide support for site-specific asbestos issues. Currently, the Office of Superfund Remediation and Technology Innovation has an interim toolbox on EPA's intranet. This will be available on the Internet after finalization.
    - Currently, 0.25 percent seems to be under consideration as an interim value. It is, however, known that when soil screening levels are below 0.25 percent using polarized light microscopy (bulk asbestos fiber analysis), air concentrations may rise to dangerous levels depending on the activity. Therefore, it is necessary to sample air (EPA National Risk Assessors Conference Call, RATs, July 13, 2005).

3. <u>Methods for determining exposure to asbestos fibers in air generated from contaminated soil</u>
    - While personal air monitoring of asbestos fibers during task-based activities remains the best available method, the EPA's Technical Review Workgroup (TRW) Asbestos Committee is also considering the use of screening techniques such as an Elutriator and a glove box for simulating asbestos release (EPA National Risk Assessors Conference Call, RATs, July 13, 2005).
4. <u>Methods for analyzing asbestos concentrations in air and soil</u>
    - New methods are being developed to for exposure measurements of asbestos in air and soil.

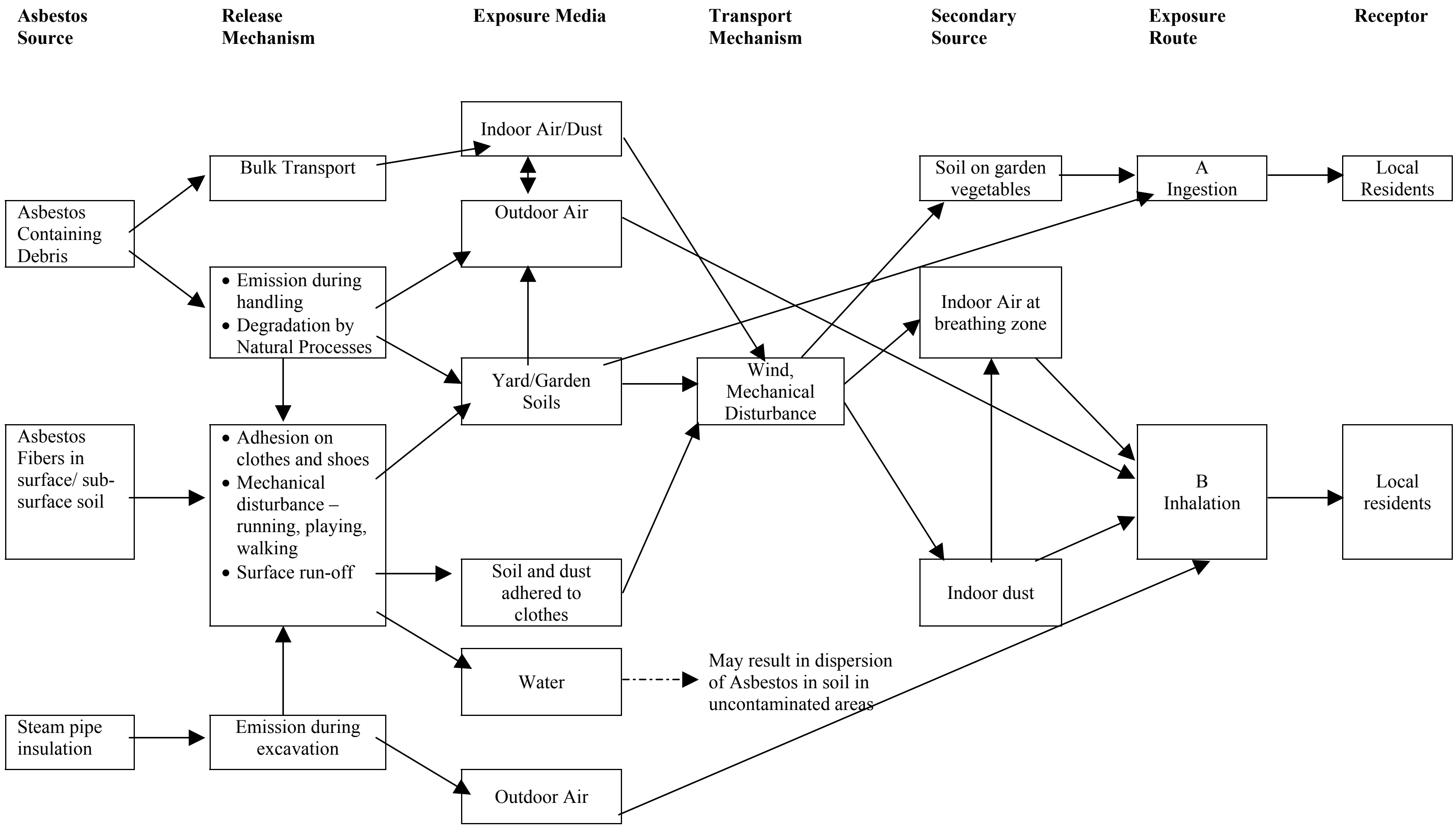


Figure 1: Conceptual Model of Potential Exposure Pathways Using Example of Steam Pipe Insulation As A Source of Asbestos in Soil

A: pathway is complete but minor (no need to quantitatively evaluate)

B: significant exposure pathway (quantitative evaluation needed)

ATTACHMENT 1

Evidence in Support of Complete Exposure Pathway for Asbestos to Move from Contaminated Soil, especially, at Trace Levels (i.e., <1%) to the Air: Release of Hazardous Levels of Asbestos into the Air During Soil Disturbing Activities

A-1. Evidence based on personal monitoring during simulated task-based activities

A-1.1 Background on activity-based personal monitoring

In summary, workers dressed in personal protective equipment mimic the various types of outdoor activities conducted by residential adults and children to determine whether asbestos fibers in soil could be released into the breathing zone of individuals conducting these activities. The concentrations of asbestos fibers measured by personal monitoring during the various planned activities (e.g., child playing in soil, gardening, weed trimming, and rototilling) are used to estimate risks associated with these activities

A-1.2. Results from some recently conducted studies

<u>Evidence of asbestos release based on the Libby, MT site-specific studies (EPA, July and December 2001; Weis memo):</u>

a. Release of asbestos fibers, from soil containing <1% to 6% asbestos, during removal activities by workers at the Screening Plant (Table 2; EPA, July, 2001):

   - It was demonstrated that concentrations significantly above the Occupational Safety and Health Administration (OSHA) occupational limit of 0.1 f/cc were detected by personal air monitors in the breathing zone of workers, during routine activities including soil bagging and sweeping floors for most size classes as measured by transmission electron microscopy analysis. (OSHA's occupational provisions do not apply to residents). It should be noted that according to OSHA estimates, 0.1f/cc limit is recognized as being associated with significant risk (of 3.4 additional cancers per 1000 individuals) to workers and risks to residents could be higher (EPA, 2001, Weis memo Dec 20, 2001). For example, the concentrations were:

     < 0.61 f/cc for fibers of length = 0.5 to 5 um; diameter <0.5 um
     3.055 f/cc for fibers of length = 5-10 um; diameter <0.5 um
     1.222 f/cc for fibers of length >10 um; diameter <0.5 um
     1.222 f/cc for fibers of diameter >0.5 um

     These initial findings prompted more studies which resulted in the maximum concentration of 1.72 PCM f/cc (phase contrast microscopy).

b. Release of asbestos fibers, from soil containing < 1% to 5% asbestos, from locations along Rainy Creek Road (Table 4; EPA, July, 2001):

- As a result of disturbance by vehicular traffic, the levels of asbestos fibers in air were clearly elevated in stationary monitors, up to a maximum of 0.0116 TEM f/cc (diameter < 0.5; length = 0.5 –5 um) (Transmission Electron Microscopy (TEM)).

c. Indoor release of asbestos fibers, from materials containing <1% to 10% asbestos as a result of routine activities performed by residents:

- Phase 1 results- Elevated levels of asbestos fibers were observed in the breathing zone of residents by personal monitors during the following activities (Table 3; EPA, July, 2001):
  Routine activity = 0.001 PCME-asbestos f/cc (phase contrast microscopy-equivalent);
  Active cleaning = 0.033 TEM PCME f/cc (transmission electron microscopy phase contrast microscopy-equivalent);
  Simulated remodeling = 0.557 PCME-asbestos f/cc (phase contrast microscopy).

  (Please note that "PCME-asbestos" represents "phase contrast microscopy-equivalent" of transmission electron microscopy measurements).

- Phase 2 results - Elevated levels of asbestos fibers were observed in the breathing zone of residents by personal monitors during the following activities (Table 6; EPA, December, 2001):
  Routine activities = 0.023 – 0.048 PCME-asbestos f/cc (phase contrast microscopy-equivalent);
  Active cleaning = 0.004 – 0.013 PCME-asbestos f/cc (phase contrast microscopy-equivalent).

d. Outdoor release of asbestos fibers, from garden soils containing <1% asbestos, during rototilling by residents:

- Exposure of an individual engaged in rototilling a garden in Libby was monitored. Elevated levels of asbestos fibers were observed in both personal monitor (0.066 PCME-asbestos f/cc) and stationary monitor (0.019 PCME-asbestos f/cc) (phase contrast microscopy-equivalent) (Table 5; EPA, December, 2001). Release of asbestos from vermiculite containing less than 1% asbestos (Table 7; EPA, December, 2001).

Evidence of asbestos release (chrysotile and amphibole) based on EPA Region 10 activity based personal air monitoring results (Januch and McDermott, 2004)

- Release of asbestos fibers from soil containing <1% asbestos during leaf blowing activity:

  0.045 f/cc for equipment operator

  0.033 f/cc for observer away from the activity

A-2. Evidence based on simulated asbestos release in experimental enclosures (i.e., glove box studies)

A-2.1. Background on glove box method

In general, a glove box is a sealed stainless steel chamber. A glove box used in EPA Region 10 studies (Januch and McDermott, 2004) is briefly described here. They used a stainless steel Kewaunee Scientific Equipment (KSE) glove box. The inside dimensions of the glove box were about 4 feet long by 3 feet high with a depth of 21 inches at the top and 27 inches at the bottom. This glove box contained about 680 liters of air. The glove box was equipped with a front glass viewing panel and fluorescent lighting. The air inside the glove box was drawn through 25 mm air monitoring cassettes with 0.45 um mixed cellulose ester filters. The cassettes were suspended inside the center of the glove box, about 14 inches above the work area, and were connected to two high volume sampling pumps. Replacement air was introduced into the glove box during the sample pump operation.

Soil samples were agitated with a stainless steel spoon for several minutes until airborne dust was visible. Air samples were collected from inside the work area approximately one hour after the soil was agitated. Air filters were analyzed by transmission electron microscopy.

A- 2.2. Results from some studies in the scientific literature

<u>Addison et al. (1988) study demonstrated release of asbestos fibers (>OSHA occupational limit of 0.1 f/mL) from soils containing 0.001% asbestos:</u>

Addison et al. (1988) conclude by stating, " Mixtures of asbestos in dry soils with asbestos content as low as 0.001% can produce airborne respirable asbestos concentrations greater than 0.1 f/mL in dust clouds where the respirable dust concentrations are less than 5 mg/m^3." (p. 21).
<u>Examples of data for average airborne respirable fibers specific to soil and asbestos types are noted below.</u>

i. <u>Examples of data for scanning electron microscopy (SEM) vs. phase contrast optical microscopy (PCOM) based on the dust concentration of 5 mg/m^3 (Table 3.6 of Addison et al., 1988):</u>

Chrysotile 0.001% in intermediate soil = 0.23 f/mL by scanning electron microscopy; 0.08 f/mL by phase contrast optical microscopy
Chrysotile 0.1 % in clay = 1.17 f/mL by scanning electron microscopy; 0.42 f/mL by phase contrast optical microscopy
Chrysotile 1% in intermediate soil = 48.5 f/mL by scanning electron microscopy; 5.76 f/mL by phase contrast optical microscopy

Crocidolite 0.1 % in clay = 2.75 f/mL by scanning electron microscopy; 1.12 f/mL by phase contrast optical microscopy

ii. Examples of data by phase contrast optical microscopy normalized to the dust concentration of 1 mg/m^3 (Table 3.1 of Addison et al., 1988):

Chrysotile 0.1% in intermediate soil = 0.06 $f/mL/mg/m^3$ of dust concentration
Chrysotile 1.0% in intermediate soil = 1.74 $f/mL/mg/m^3$ of dust concentration
Crocidolite 0.1% in intermediate soil= 0.27 $f/mL/mg/m^3$ of dust concentration
Crocidolite 1.0 % in intermediate soil= 2.9 $f/mL/mg/m^3$ of dust concentration

Evidence based on EPA Region 10 glove box studies (Januch and McDermott, 2004)

Mixture of < 1% Libby, MT amphibole plus amosite and chrysotile = up to 6.5 f/cc

A-3. Evidence based on the Simulated Asbestos Release Using the Modified Elutriator Method of Berman and Kolk (2000)

A-.3.1. Background on the Modified Elutriator Method (Berman and Kolk, 2000)

In the modified Elutriator method, samples are placed in a specially designed dust-generator to separate and concentrate the respirable fraction (i.e., less or equal to 10 um in diameter or called PM_{10} fraction of particulate matter of each sample). The respirable fraction is then deposited on a filter, weighed, and prepared for analyses by transmission electron microscopy (TEM). The results are reported as the ratio of the number of asbestos structures per gram of the respirable dust that is produced. This dust generation, or elutriation, technique provides a mechanism for measuring asbestos concentrations that are inherent properties of the bulk material analyzed. All samples are analyzed using the counting rules of ISO 10312 (ISO 1995) with the counting rules modified to count only structures satisfying the traditional definition of a fiber and structures satisfying the dimensions of biologically active structures defined in Berman and Crump (2003). Biologically active structures defined by Berman and Crump are generally longer than 5 um and thinner than 0.5 um and are termed “protocol structures”. In contrast, traditionally defined fibers are generally those longer than 5 um, thicker than 0.25 um, and exhibiting an aspect ratio (length to width) of greater than 3:1 and are termed “7402 structures” by Berman and Crump or “phase contrast microscopy-equivalent (PCME) fibers” by EPA.

The method does not mimic the manner in which asbestos emissions occur in the field. Therefore, Modified Elutriator measurements, of the protocol structures per gram of the respirable dust, are linked with published dust emission and dispersion models in order to predict airborne exposures and assess the attendant risks. These adaptations of the published emission and dispersion models for asbestos have not been validated. Also, in some cases, the modifications are introduced for modeling some of the exposure pathways of interest that require use of the models outside the range of parameters over which such models have been formally evaluated and validated. Thus, the overall uncertainty of this method is considered high. More detailed information of this method is available elsewhere (Berman and Kolk, 2000). It is, however, important to note that EPA's evaluation of this method as a screening tool is underway.

A-3.2. Results from some studies in the scientific literature

(a) EPA Region 10 Results from Analyses of soil samples and samples of Associated Asbestos-Containing Material (ACM) at the North Ridge Estates Site in Klamath Falls, Oregon (Prepared by Berman, 2004)

- Handling and playing with asbestos-containing material for 1 hr/day, 50 days/year for 15 years.
    - The estimated risk for the exposure pathways involving abrasion of chrysotile-containing ACM = 1.7E-04
    - The estimated risk for the exposure pathways involving abrasion of amphibole-containing ACM = 1E-03

(b) Results from Air Force's Initial Health risk Assessment at the Former Lowry Air Force Base, Colorado (Parsons, 2004)

- Presence of <1% chrysotile in surface soil (0-1 inch) resulted in excess potential lifetime cancer risks during some activities, for example:
    - running by residents for 2 hr/day, 365 days/year for 30 years = 4E-05
    - walking by residents for 2 hrs/day, 365 days/year for 30 years = 1E-05
    - construction worker for 8 hrs/day, 250 days for one year = 2E-04

ATTACHMENT 2

Overview of Analytical Methods for Detection of Asbestos in Air and Soil

The detection and analysis of asbestos in air and bulk material requires both fiber quantification and identification of mineral type of asbestos. Due to the complex nature of asbestos, a variety of analytical techniques are used to measure asbestos concentration in air or bulk soil samples. Some of the major limitations of the existing analytical techniques are briefly noted below. Other sources of more detailed information can be found elsewhere (e.g., Berman and Crump, 2003; and Perry, 2004).

The available methods vary in their ability to fully characterize asbestos exposure and health risks because all methods are not capable of resolving all of the characteristics of asbestos dust that are now known to be important determinants of asbestos biological activity. For example, fiber size, shape and composition, and fiber surface properties contribute collectively to the toxic potential of asbestos in ways that are not well understood and are still being studied. All available methods have strengths and weaknesses. EPA is currently working to develop more sensitive methods of measurement, especially for bulk soil samples. New methods are also under consideration to assess health risks posed by varying size and type of fibers. These methods will also bring consistency between the measurement methods for toxicity criteria and environmental exposure.

The definition and procedures for counting complex structures (i.e., bundles, clusters, and matrices) vary significantly across methods. The most common particle counting techniques include: (a) polarized light microscopy (PLM); (b) phase contrast microscopy (PCM); (c) scanning electron microscopy (SEM); and (d) transmission electron microscopy (TEM). Asbestos in soil is generally analyzed using polarized light microscopy, transmission electron microscopy, and scanning electron microscopy. Asbestos in air is generally analyzed using phase contrast microscopy, transmission electron microscopy, and scanning electron microscopy.

<u>Polarized light microscopy (PLM)</u>- This method relies on optical microscopy. This method cannot identify fibers <1 um in diameter, and has a detection limit of about 1 % asbestos in bulk samples. Polarized light microscopy gives results in “percent by area”. Recently, EPA Region 8 reported a detection limit of 0.25 % (Florida Asbestos Workshop, December, 2004). A detection limit of 1% means that when a soil sample is observed under a microscope on a slide divided up into a 100-point grid, one point is positive for asbestos. There is uncertainty associated with the assumption that the 1% by area result typically provided by polarized light microscopy is equivalent to any % by weight value. Also, polarized light microscopy is useful at determining if a fiber is composed of asbestos from the main categories such as amphibole and chrysotile but specific asbestos type cannot be identified (e.g., different types of amphibole). **The polarized light microscopy method is generally used as a method of “screening” soil samples of a large area to determine the presence of asbestos and the extent of contamination but the data generated are not suitable for use in risk assessment.**

Phase Contrast Microscopy (PCM**)** **–** This is a light microscopy method which accurately assesses fibers >5 um in length and about 0.25 um in diameter. This technique cannot distinguish asbestos from non-asbestos. Historically, epidemiological studies used this method and EPA Integrated Risk Information System (IRIS) toxicity values are based on phase contrast microscopy counts. Therefore, results of phase contrast microscopy analysis can be used to assess risk.

Scanning Electron Microscopy (SEM) – This method is capable of differentiating asbestos and non-asbestos structures. It can also accurately assess fibers thicker than about 0.1 um. This method is not widely available for use.

Transmission Electron Microscopy (TEM) – This is the most common method of choice that allows the detection of fibers of all sizes up to (or less than) 0.01 um in diameter. Thus, in the same air sample, the fibers counted by transmission electron microscopy can be 50-70 times higher than those counted by phase contrast microscopy. The use of transmission electron microscopy for asbestos analysis is considered more appropriate. However, the EPA Integrated Risk Information System (IRIS) toxicity values relating to asbestos are expressed in terms of phase contrast microscopy (PCM) fibers (called PCM-equivalent or PCME). Therefore, transmission electron microscopy measurements cannot be used directly in a risk assessment using the EPA Integrated Risk Information System (IRIS) recommended cancer potency factor. However, the cancer potency factor recommended by Berman and Crump (2001, 2003) require transmission electron microscopy measurements. The transmission electron microscopy sample preparation and analyses are more complicated than phase contrast microscopy. This method examines a much smaller portion of the sample than scanning electron microscopy and phase contrast microscopy. Therefore, in order to represent the whole sample, a very homogenized sample of soil is required.

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