Chapter 5

Sampling and analysis

5.1 Sampling and analysis quality plan

A sampling and analysis quality plan (SAQP) should be developed based on data quality objectives influenced by site-specific variables and project-specific data gaps and goals. The sampling and analysis plan should comply with the *Assessment and Management of Contaminated Sites (DWER, 2021)* and the ASC NEPM.

The SAQP should include a written protocol and procedures for the proposed sampling. Standard reference methods and procedures may be included as an appendix to the investigation report. The methodology should comply with the Contaminated Sites Guidelines and be demonstrated to be effective in previous investigations or trials.

When designing the SAQP, the following key questions should be addressed:

- What is the sampling intended to demonstrate?
- What is the current conceptual site model (CSM) 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 is necessary to aid in decision-making?
- Will the investigation meet the data quality objectives?

The SAQP should attempt to anticipate any likely constraints or limitations (e.g. access, vegetation, hard standings, buried structures) that may affect the accuracy and completeness of data and develop strategies to compensate and mitigate for these constraints and limitations in advance.

All contaminated sites SAQPs should allow for additional, discretionary asbestos contamination sampling to be conducted where it is possible that suspect material may be encountered during other contaminated sites works, even where asbestos in soil contamination has not been previously identified. For example, consideration should be given to the potential for construction waste to be buried on-site.

As results from field analysis are immediately available, allowance can be made in the SAQP to undertaken additional confirmatory or delineation sampling rather than return for subsequent investigations. Decision criteria for additional sampling may be outlined in the SAQP.

Sampling is required for both the site investigation (e.g. to delineate the impacted area to inform a remediation plan) and to validate remedial work against pre-determined objectives. Any delineation sampling will depend on the contamination circumstances but should ensure the impacted area is confidently captured, especially for areas of higher asbestos concentrations and fibrous asbestos.

The sampling strategy should be aimed at addressing data gaps and meeting the objectives of the site investigation. An investigation to confirm the extent of asbestos cement debris from a damaged structure may entail a less rigorous sampling program than an investigation required to confirm the various forms and quantity of asbestos contamination suspected to be mixed through uncontrolled fill brought to a site.

If the asbestos contamination is associated with a layer of uncontrolled fill, where feasible, the whole extent of the fill may be considered impacted and subject to remediation (e.g. containment). Supporting evidence and/or an intensive sampling regime must be provided to demonstrate otherwise, i.e. that suspect uncontrolled fill is not contaminated.

Consideration should always be given to the need for air quality monitoring data to assess whether airborne fibres are present.

5.2 Sampling approaches

Targeted judgmental sampling targets particular sampling locations based on known or likely asbestos contamination or to address data gaps. Judgemental sampling depends heavily on a thorough site inspection that properly identifies the targeted investigation area and relevant, representative sampling locations.

Grid sampling (for example, using 4 m x 4 m grid) is likely to be indicated when asbestos contamination is known to be widespread (e.g. cutting and filling are known to have occurred, mixing asbestos contamination through site soils) or where there are data gaps from site investigations and it can be reasonably suspected that contamination may be present at unknown locations (e.g. historical uncontrolled fill).

If the contamination is buried, then **test pits or trenching** are useful methods for identifying contamination and can be used in conjunction with judgmental or grid-based sampling.

The following situations are examples of judgmental sampling:

- “hot spots” are identified by the earlier stages of site investigation, and additional sampling is undertaken at the edges of the hot spot area to confirm the lateral extent
- sampling locations targeted within the former building ‘footprint’ of removed building structures known or suspected to contain asbestos building products
- adjacent to a below-ground service to delineate contamination from damaged asbestos-containing, below-ground infrastructure.

For pre-1990[5] buildings that have been removed, sampling within the footprint area may include targeted AF sampling locations corresponding to soils within soak wells and roof rainwater run-off locations, especially for former large commercial buildings with a large expanse of asbestos cement roofing.

5.3 Sampling triggers and densities

The sampling strategy selected will be primarily at the investigator’s discretion, with justification for any minimum number of sampling points considered for a particular site. For sampling strategies that include grid sampling for locating hot spots, the density should be some multiple (see Table 4) of the sampling density shown in Table 5.

The first three “likelihood” categories primarily apply to the low or uncertain likelihood of contamination. The fourth and fifth category, ‘Likely’ and “Known”, apply where characterisation of contamination (e.g. screening, confirming or delineating) is required.

[5] While manufacturing of many building products containing asbestos ended earlier, using 1990 provides a buffer for use of stock and construction time.

Therefore, sampling locations and density will be based on the nature of the contamination and the precision of lateral delineation required for any proposed remediation options. That is, sampling density will be influenced by evidence of contamination and data requirements for characterisation or remediation. The selected sampling densities and sample volumes for asbestos may be higher than for other contaminants, as asbestos contamination can be widespread and heterogeneous. However, for bonded ACM and FA, it is feasible (easier and inexpensive) to fill data gaps through successive field analysis from immediately available results.

Table 4 Sampling densities

Likelihood of asbestos	Example Scenarios	Sampling density
Unlikely	– grazing land with no building history – site developed after 1990	– no sampling required without evidence of contamination
Possible	– uncontrolled fill without building waste – undeveloped site (possible dumping)	– sampling of uncontrolled fill at 0.5 sampling points in Table 5.
Suspect	– uncontrolled fill with building waste – dumped waste material – demolished structure footprints (pre-1987)	– sampling points as per Table 5 for uncontrolled fill with at least 1 sample per final lot for subdivisions – every 5 – 10 m for building footprint – hot spot sampling for dumped material
Likely	– industry associated with asbestos – some isolated asbestos found – landfill present	– double the sampling points in Table 5 across surface and depth.
Known	– asbestos has been identified and needs further delineation	– judgmental graduated targeted sampling for linear extent and depth

Table 5 Minimum sampling points required for detection of circular hot spots using a systematic sampling pattern at 95% confidence level (AS 4485.1)

Investigation area ha (m2)	Number of sampling points	Equivalent sampling density (points/ha)	Diameter of hotspot that can be detected with 95% confidence	Grid size (m)
0.05 (500)	5	100.0	11.8	9.5
0.1 (1000)	6	60.0	15.2	12.9
0.2 (2000)	7	35.0	19.9	16.9
0.3 (3000)	9	30.0	21.5	18.2
0.4 (4000)	11	27.5	22.5	19.1
0.5 (5000)	13	26.0	23.1	19.6
0.6 (6000)	15	25.0	23.6	20
0.7 (7000)	17	24.3	23.9	20.3
0.8 (8000)	19	23.8	24.2	20.5
0.9 (9000)	20	22.2	25.0	21.2
1.0 (10 000)	21	21.0	25.7	21.8
1.5 (15 000)	25	16.7	28.9	24.5
2.0 (20 000)	30	15.0	30.5	25.4
2.5 (25 000)	35	14.0	31.5	26.7
3.0 (30 000)	40	13.3	32.4	27.4
3.5 (35 000)	45	12.9	32.9	27.9
4.0 (40 000)	50	12.5	33.4	28.3
4.5 (45 000)	52	11.6	34.6	29.3
5.0 (50 000)	55	11.0	35.6	30.1

Notes:

1. The provision in this table of the number of sampling points does not imply that minimum sampling is good practice for a given site. The investigator should be prepared to justify the appropriateness of applying this table or any other sampling rationale.
2. No guidance is provided for sites larger than five hectares (50 000 m^2). Such sites are usually subdivided into smaller areas for more effective sampling.
3. Judgmental sampling is preferred to grid-based where possible.

5.4 Surface sampling

These Guidelines require that all visible surface contamination is removed even where contamination levels are below the screening criteria.

Accessibility of the site surface should be addressed in the SAQP. The surface should include the readily accessible and disturbed surface layer, which may vary depending on the soil type, seasonal vegetation cover and compaction of the soil surface (default of 10 cm depth).

Table 6 describes the surface sampling method compatible with concomitant removal and validation processes (See Section 6.8 for validation requirements) from handpicking to remove asbestos material.

5.5 Sampling of bonded asbestos-containing material and fibrous asbestos

These guidelines and the ASC NEPM (1999) acknowledge that larger-sized fragments and quantities of bonded ACM and FA are likely to be visibly distinguishable in soil. Where site conditions are conducive, visible bonded ACM and FA may be used as the primary measure of contamination.

Suspect products/materials (e.g. fibre-cement sheeting, textiles, lagging) should be identified along with a description of the type of asbestos (bonded ACM vs FA). It is important to note that the appearance of the product/material may be disguised when mixed in with soil or other waste materials. As such, testing of suspect materials for asbestos fibre identification (NATA accredited laboratory for asbestos mineral fibre identification in bulk samples by PLM) is an important step in site investigations to confirm and characterise asbestos contamination in mixed materials and soils. A representative sample of each different type of suspect material should be collected. Once positive asbestos identification results are available, all material similar in appearance can be assumed to contain asbestos. The alternative assumption that any similar material does not contain asbestos cannot be made. Laboratory confirmation must be provided for deciding a material does not contain asbestos.

Great care needs to be taken to manage associated fibre release when sampling FA. The sampling methods used should minimise disturbance. Note that sieving is not recommended for quantifying FA.

Most reported asbestos in soil contamination is from fibre cement fragments. Field analysis allows information to be collected on the fragment size, distribution and relative proportions of fragments collected for any consecutive sampling passes. Field reports should document the locations, numbers and mass of fragment samples collected. The use of small grid patterns across an investigation area facilitates the notation and characterisation of surface contamination. Photographs are also highly recommended.

The presence of building and construction waste or industrial plant and equipment waste (e.g. gaskets, seals, pipe lagging, fibre ropes) from a time before the national ban on asbestos would be sufficient evidence that asbestos contamination is probable. The presence and relative quantity and distribution of associated waste material should be reported.

5.6 Sampling of asbestos fines contamination

AF are distinguished by their size and may include small fragments of bonded ACM, asbestos contaminated dust and debris from structures or loose fibre bundles that have become mixed with soil. Observation and estimation of AF in a soil sample is completed by a NATA accredited laboratory (Appendix Four).

Since these Guidelines were introduced in 2009, many sites have been reported with contamination from bonded asbestos cement fragments in reasonably sound condition. Sampling results support previous assumptions that AF contamination associated with broken, bonded asbestos cement fragments is minor.

AF sampling is necessary where there is information available that the AF portion is a non-trivial portion of the asbestos in soil contamination. For example,

- many smaller sized fragments are present suggestive of bonded ACM having been crushed or pulverised
- bonded ACM is known to have been subject to crushing or breakdown through the use of powered tools or equipment or from fire, for instance.

These impacted soils/areas should be regarded as potentially contaminated with AF, with a separate AF sample collected to estimate the concentration of asbestos in soil.

The nature of contamination may allow AF to be assumed to be present (e.g. probable AF contamination of soils around FA material) with sampling and analysis used to delineate the outer boundaries of the impacted area for remediation and provide validation following clean up. Where localised high concentration of AF is present, it may also be visibly discernible from the surrounding soil, and sampling can again be targeted to delineate the impacted soils and validate sampling following clean up.

To investigate AF, **separate, targeted and representative** samples of the suspect AF in soil should be collected. That is, AF sample collection should not be from a tampered with or mixed sample or diluted from a larger sample (e.g. collected from a sieved 10L sample).

Sample size should be determined based on data quality objectives. A sample of 500 mL (or approximately 1 kg) is generally sufficient to undertake quantitative estimates of the % w/w AF by conventional gravimetric methods by separating and weighing the <7mm fragments, fibre bundles and other asbestos debris observed within the known dry weight of soil.

5.6.1 Low concentration sample analysis

The soil sample size may be varied for specific data objectives. That is, the soil sample size should be selected based on the most appropriate sampling and analytical methodology required to meet those objectives (e.g. confirmation of fibre bundles or fibres present in soil may require a collection of a smaller, representative sample in the field which is preferable to laboratory sub sampling).

While there is currently no nationally adopted reference method to reliably quantify fibres, AS4964 provides a qualitative method that can identify asbestos fibres in soil, which may provide important supporting information for a site investigation. This has a practical limit of detection of 0.01 to 0.1%.

International reference methods may also be considered to estimate respirable asbestos fibres within soil samples in Tier 2 assessments. Further information is provided in Appendix Four.

5.7 Sample collection

This section outlines various methods that can be adopted in an SAQP for different investigation areas or assessment purposes or to provide supporting data for validating remedial works.

5.7.1 Bonded asbestos-containing material in surface soils

Surface asbestos cement fragments and other bonded ACM may be collected by hand (emu-bob) picking. Handpicking refers to the pick-up, collection and weighing of any visible asbestos-containing material across an impacted surface layer. Handpicking may be used to sample and concurrently remediate surface impacts. Table 6 describes the process and reporting of handpicking to remove asbestos material.

For loose soils, surface inspection and handpicking may include raking to ensure that the full depth of the surface layer is observed. The design of the rake (e.g. tine length and spacing) should be small enough that the bonded ACM debris present at the site does cannot pass through. Where this is not possible (i.e. debris is too small to be collected by the rake), the soil could be screened.

Where asbestos contamination is found, its quantification should relate to that particular immediate impacted surface layer. Care should be taken to prevent averaging and “dilution” of the calculated level of contamination. For instance, the level of contamination should not be quantified across a large raked or tilled area or large-sized grid area that contains both contaminated and uncontaminated soils.

Where raking across the surface is impractical or limited by dense vegetation, shallow surface trenching/sampling may be used that targets the cross-section of the impacted surface layer. Care must be taken when collecting the required sampling volume to avoid diluting the sample with uncontaminated layers. See Figure 9.

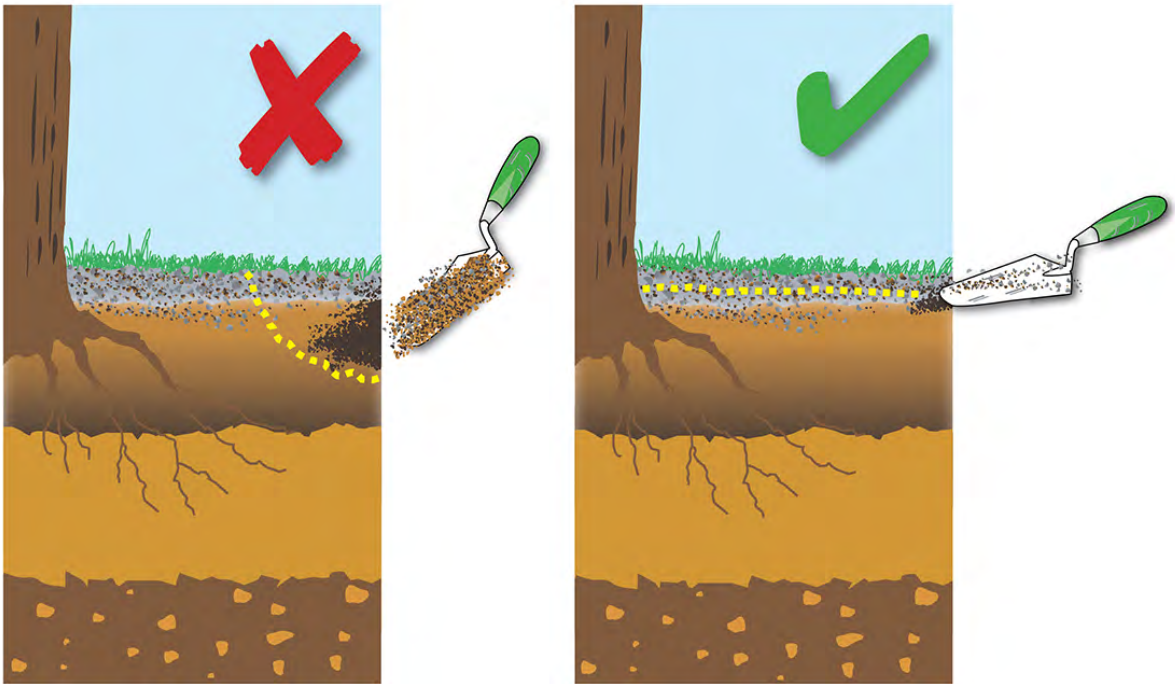

Figure 9 Collecting a representative and targeted surface sample.

A shallow 10L sample of impacted surface soils can be collected to estimate asbestos concentration as per the test pitting method Section 5.7.2.

Tilling (Table 7) refers to mechanically turning over surface soils to facilitate the presentation and collection of asbestos cement fragments. However, it is rarely used as it is generally difficult to implement and validate effectively. It is included here for completeness, but its use must be well justified by site-specific conditions.

Table 6 Summary of handpicking sampling method

Process

- Collect material from the soil surface, using a rake in sandy soils to uncover material in the accessible surface layer.
- The use of small grid sections facilitates notation and calculation of asbestos contamination.
- Most suitable for asbestos cement sheeting fragments or other well bonded ACM.
- Relevant where contamination is known or considered to be only on the soil surface (i.e. attributed to a defined event such as a building asbestos removal or dumping).
- Has limited application for contamination at depth or there is surface vegetation or debris.
- Used to characterise the extent and level of contamination and to validate surface clean up.

Implementation

- Record and report location and numbers of fragments, weights and description of collected asbestos material.
- Rakes should be selected, or purpose made, with tines of the smallest usable width and appropriate to reach the depth of surface soils being investigated.
- At least two passes of picking (and raking if appropriate) made with a 90º direction change between each and using a manageable grid pattern (based on level of contamination and soil characteristics).
- Material should not be further damaged or buried by the process.
- To validate concomitant removal, the final raked (3rd or more) pass and confirmatory lead inspector/auditor visual inspection of the area should not detect surface impacts.

Table 7 Summary of tilling sampling method

Process

- Suitable for asbestos cement sheeting fragments or other well bonded ACM.
- Generally conducted for large areas of impact across the entire area of suspected impact.
- Relevant for surface investigation and remediation of sandy soils - limited application for other soil types, deeper contamination or when there is substantial surface vegetation or debris.
- Used to characterise the extent and level of contamination while concurrently reducing bonded ACM impact.

Implementation

- Should be preceded by the removal of obvious larger pieces of bonded ACM to avoid breakage.
- Report and record the location and weights of asbestos material.
- Soils should be pre-wet to the tilling depth, dust control measures implemented, and personal and control monitoring undertaken during works.
- May require consultation with WorkSafe Division, DMIRS.
- Rows of tines (preferably non-rotary) should be spaced and designed to optimally reveal bonded ACM with 1 or 2 spotters walking behind tines at a controlled speed.
- Material should not be further damaged or buried from the process.
- At least two passes with 90º direction change using a grid pattern.
- Evaluated areas normally cannot be considered representative of other locations.
- Level of contamination may be calculated as per Appendix Two using an estimate of the average tilled depth and area for each grid.
- Final visual inspection of the area should not detect surface bonded ACM.

5.7.2 Test pitting and trenching

Sampling by test pits and trenching is the most common and effective sampling method for identifying and delineating bonded ACM and FA contamination below surface soils.

The excavation of soils allows differing strata to be identified and provides more confidence in sampling results.

Table 8 Summary of test pit and trenching sampling methods

Process

- Suitable for all asbestos types, but especially visible bonded ACM and FA (where fibre disturbance is manageable).
- Relevant if contamination is buried and of unknown location, distribution and depth.

Implementation

- Sampling should be conducted to below the likely lower limit of potential contamination or to virgin soils.
- Suspect asbestos material or building debris should be targeted, and all sample locations noted.
- The excavation should be such that the sidewall can be examined to assist sample targeting.
- Precautions are necessary to protect workers and the public from wall collapse or hole hazards and potential fibre release from excavation/sampling.

Bonded ACM and FA

- At least one 10 L or 20 kg sample from each relevant stratum (or per 1 m depth) of one wall and discretionary samples from other suspect spots.
- Sample screened manually through a ≤ 7 mm sieve or spread out for inspection on a contrasting colour material (recommended for suspect FA to minimise disturbance).
- Identified bonded ACM and FA weighed to calculate asbestos soil concentration for individual samples as per Appendix Two.

AF

- At least one targeted, wetted 500 mL or 1 kg sample from each representative strata or section of waste material and discretionary samples from other suspect spots.
- May be done in the same representative location as bonded ACM/FA sampling, either taken first (before screening) or at another wall position.
- Whole sample submitted for laboratory analysis.

5.7.3 Mechanical screening of bonded asbestos-containing material in soils

Mechanical screening is only suitable for separating bonded ACM from the soil. It can be used to quantify and remediate bonded ACM contamination in sandy soils concomitantly. It is most appropriate for low-level impacts. Mechanical screening may be subject to other local government or DWER approval.

Alternatives to mechanical screening that do not require extensive dust management are available and preferred where sensitive receptors are located nearby.

The sampling method is outlined in Table 9.

Table 9 Summary of mechanical screening validation sampling

Process

- Most suitable for low levels of asbestos cement fragments and other well-bonded materials.
- Mechanical screening is generally conducted across the entire area of suspected impact.
- Relevant for larger volumes of reasonably accessible and delineated contamination.
- Used to effectively confirm and characterise the extent and level of contamination whilst concurrently reducing bonded ACM impact.

Implementation

- Should be preceded by surface handpicking and/or separate and removing large material and concentrated hot spots.
- May follow a process of 'screening down' from larger mesh sizes to the final screening mesh size.
- Mesh sizes > 7mm x 7mm require validation sampling (screening process to include a "spotter" able to identify asbestos and include a minimum of 1 sample per 70 m3 from the conveyor).
- Impacted soil should not be mixed with other soil in a way that might compromise the concentration calculations (i.e. dilution is not permitted).
- Soils should be pre-wet with continued dust suppression and air quality monitoring outlined in a detailed Dust Management Plan that includes community and stakeholder consultation, where appropriate.
- The level of contamination may be calculated as per Appendix Two using the weight of asbestos found for particular strata, area or volume.
- Final visual inspection of the stockpile surface should be clear of contamination.

5.7.4 Bore samples

Test pits and trenches are recommended over borehole sampling for bonded ACM. Borehole sampling may be useful to prevent exposure to field workers where the main origin of contamination is loose FA (e.g. insulation, asbestos manufacturing waste). For FA contamination, borehole sampling may be suitable to provide data on material profile, distribution and depth to assist in the delineation of contamination

Where borehole sampling is considered for bonded ACM, it must be supported by appropriate data quality objectives as this method is unlikely to provide sufficient information regarding contamination levels of bonded ACM.

Consideration should be given to ensuring an appropriate sample size is collected, which should be addressed as part of the SAQP data quality objectives.

The process and its implementation are outlined in Table 10.

Table 10 Summary of bore sampling method

Process

- Most suitable for buried FA (e.g. buried loose-fill insulation or industrial waste).
- Relevant if contamination is buried and of unknown location, distribution and depth.

Implementation

- Sampling should be conducted to below the likely lower limit of potential contamination where the vertical delineation is required.
- Suspect soils should be targeted, and all sample locations/ depths noted.
- A larger corer diameter (e.g. 15 mm) should be selected.
- For FA samples, a split tube core sample is recommended, both to reduce potential exposure to personnel examining the sample and to better identify contamination within different soil strata. For suspect FA contamination, it is recommended that the entire core sample is submitted to the laboratory to be examined under controlled conditions and to allow sub-sampling of soil layers and separation and identification of suspect material.

5.7.5 Stockpile sampling

Soils should always be assessed in situ before any site works or material movement is undertaken.

In some circumstances, retrospective assessment of fresh stockpiles is required following evidence of asbestos contamination. Stockpiles may also need to be assessed against landfill classification criteria to:

- confirm stockpiles are not contaminated and acceptable for re-use
- confirm stockpiles are not classifiable as asbestos “special” waste.

DOH adopts a conservative approach to retrospective stockpile assessment of suspect contamination because of increased uncertainty from the mixing of soils. Investigations of stockpiles should consider the likely contaminants, whether bonded ACM, AF or FA is likely to be present and is subject to sampling criteria in Table 11.

If there is a high degree of confidence that the stockpile is contaminated with bonded asbestos cement fragments only and the material has not been subjected to crushing processes, then sampling for bonded ACM would be sufficient.

Where AF is suspected to be present, separate AF samples should be collected from soils suspected to be contaminated. For example, for stockpile materials that have been through any crushing processes, AF sampling is to be included. Further information is available in the Guidelines for management of asbestos at construction and demolition waste recycling facilities (external site) (Department of Environment and Conservation, DWER, 2021).

Stockpiles deemed to be from areas assessed as not contaminated (or for which there is no evidence or suspicion of contamination) can be subject to a close visual examination over the whole stockpile surface with further observation during material movement to confirm that there are no indicators of asbestos contamination or other commonly co-located waste (e.g. building waste).

Remediated stockpiles for reuse at the same site must comply with the site-specific clean up goals and the requirement to have the surface cover layer free of visible contamination. Soil stockpiles intended for re-use at an **alternate** site should meet the stricter requirements for "uncontaminated fill" as per the thresholds in Table 6 of the waste classification criteria (external site).

Table 11 Summary of stockpile sampling method

Process

- Suitable for all asbestos types
- Confidence in results can be improved with adequate information on the history and origin of the stockpile material and its potential to be contaminated with asbestos.

Implementation

- Visually inspect the entire surface of the stockpile and note the materials observed.
- Sampling should be evenly spread through the stockpile. Collect three samples for all stockpiles less than 75 m^3, with an extra sample for every additional 25 m^3.
- Suspect asbestos material or construction debris should be targeted, and all sample locations noted.

Bonded ACM and FA

- At least one 10L sample from each location screened with a sieve capable of capturing ≥ 7mm x 7mm fragments or spread out for inspection on a contrasting colour fabric (recommended for suspect presence of FA).
- Identified bonded ACM and FA weighed to calculate asbestos soil concentration.

AF

- At least one wetted 500mL or 1kg sample from each location.
- Taken within the same impacted soil layer but separate spot from the 10L sample.
- Whole sample submitted for laboratory analysis.

5.8 Laboratory analysis

5.8.1 Identification of asbestos mineral fibres

Identification of asbestos mineral fibres should be undertaken in accordance with a relevant, validated method.

AS4964–2004 Method for the qualitative identification of asbestos in bulk samples is commonly used to identify asbestos in soil samples. NATA accredited laboratories can also seek accreditation for in house methods that support the (pre-)analysis of AF samples as described in Appendix Four. Other reference methods may be considered (See Appendix Four).

5.8.2 Estimating asbestos fines concentration

The same principles are used to estimate the concentration of AF in soil samples as for bonded ACM. This method provides an estimate of total AF concentration in soil (w/w).

This method allows the soil sample to be examined under laboratory-controlled conditions and can utilise stereo microscopy to identify suspect AF. The laboratory examines the entire sample and can separate, weigh and positively identify any suspect material or debris or fibrous matter found within the various size fractions, such as sub 10 mm, +7 mm, 7 mm to 2 mm and sub 2 mm.

For the estimate of concentration to be meaningful, it is important to ensure that samples submitted for analysis are representative of the asbestos contamination and not seeded with incidental finds nor diluted with uncontaminated soils (see Figure 10).

Note that where a larger fraction +2mm material is present in a soil sample, it will be the main contributor to the concentration measurement. It may be important, such as in Tier 2 or Tier 3 assessments, to have detailed observations of the AF fraction. It may also be relevant to submit a smaller, representative soil sample volume, particularly where this improves the collection of a discrete, targeted and representative area of contamination. Any variations or decisions regarding sample size should be justified by the sampling plan and data quality objectives and discussed with the laboratory undertaking the analysis.

Identifying respirable asbestos fibres in soil samples may provide important supportive information for characterising the asbestos contamination. Discretion must be used for comparing AS 4964 trace analysis results against assessment criteria. However, results may provide important qualitative data relevant to exposure assessment.

It is important to note that the laboratory sees a very small, targeted sample of soil. The origin and distribution of AF material within the investigation area may be unknown to the analyst. As such, analysts do not have the information necessary to advise whether the observed AF represents site contamination and whether the contamination should be characterised as friable, non-friable or minor contamination for legislative control or management.

There are several reference methods available internationally that can be accredited for use in Australia. These can be utilised where additional confirmatory analysis is required, such as for higher Tier assessments. Further information for laboratories is provided in Appendix Four.

5.9 Air quality monitoring

5.9.1 Air monitoring principles

The purpose of any air sampling should be clearly identified. The sampling strategy should be developed by a suitably qualified and experienced person (e.g. occupational hygienist).

The Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres NOHSC:3003 (2005) (MFM) is regularly employed for control monitoring at contaminated sites. Where real-time monitoring is required to determine the effectiveness of dust controls measures during asbestos work, a direct reading dust measurement may be used to supplement airborne fibre monitoring (see Section 5.9.3).

Control monitoring is used to confirm that control measures have effectively prevented the release of fibres during remediation or site works. Where best practice dust control measures are used, it is expected that a sampling plan will be in place that outlines the number and position of samples and that the action level is the limit of reporting of 0.01 f/mL.

Personal air monitoring provides an index or estimate of exposure to respirable fibres in air. The air monitoring program must consider the need for exposure monitoring of workers undertaking tasks that may expose them to elevated levels of particulate emissions (including sample collection and remediation works). Personal monitoring of asbestos in air to assess and control workplace exposure is an occupational health and safety issue; however, results may also be used in site investigation reports to show that controls have been effective in minimising fibre release and, in effect, protecting public health. The WorkSafe Division, DMIRS, is the lead agency with regard to employee exposure.

5.9.2 Air monitoring for public health exposure assessment

A specific sampling plan should be considered for exposure assessment undertaken as part of the contaminated sites assessments, i.e. in Tier 2 or 3 assessments where more information is required to characterise exposure risks consider monitoring during activities that have the potential to release fibres. Undertaking simulated activities (activity-based sampling) for exposure assessment may require approval from DMIRS. (See Section 3.9.1).

In low-level exposure settings, the MFM may significantly underestimate and sometimes overestimate the fibre concentration in air. For example, fibre counts may include other background fibres present in the environment (organic and other mineral fibres), and MCE filters may also contribute to the fibre count. In addition to ensuring that field blank filters (which are a requirement) are included for all sampling events, a methodology that allows a lower limit of reporting (LOR) should be considered. The analytical sensitivity of MFM may be improved for individual samples and/or relevant international methods can be used that allow a lower LOR and identification of fibre type. Laboratories may seek NATA accreditation for relevant methods.

Exposure assessments have been completed in Western Australia based on a modification of *ISO 14966:2002 Ambient air — Determination of numerical concentration of inorganic fibrous particles — Scanning electron microscopy method* which has a limit of reporting of 0.002 f/mL.

Air sampling results taken during periods of no activity or when effective remediation controls are in place should not be used to conclude that there has been no asbestos fibre release from soils or to justify the use of less stringent site management measures.

5.9.3 Dust/Particulate monitoring

Dust monitoring does provide a useful surrogate for assessing the effectiveness of overall dust control measures at a site for the following reasons:

- real-time dust sampling can be undertaken with alarms/action levels set that provide immediate feedback regarding the effectiveness of dust control measures or changes in conditions that may lead to elevated dust levels
- dust monitoring is commonly used, well known and does not require specific asbestos monitoring expertise
- results are immediately available and easy to interpret, and data logging provides evidence that adequate dust management has been employed during the entire period of remedial/site works.

Dust monitoring equipment should demonstrate that particulate levels are kept as low as reasonably possible. The site dust management plan will need to identify triggers used for control actions. Dust monitoring should be considered as an adjunct, not as a substitute for fibre monitoring.

Equipment should be located along the site perimeter at “background” upwind and downwind locations, taking into account local site features and topography. Where there is a well-defined diurnal and seasonal variation in the dominant wind direction, monitoring stations should be located along the key axes. Generally, regional meteorological data will be sufficient to aid the planning of fixed dust monitoring stations, and portable devices may be repositioned depending on daily conditions. For fixed stations (e.g. Tapered Element Oscillating Microbalance), a detailed log of atypical meteorological conditions may be useful for interpreting results or addressing complaints.

Dust/particulate control monitoring cannot be used as a surrogate for asbestos exposure monitoring.

5.10 Quality assurance/Quality control

Quality assurance and quality control (QA/QC) practices should be consistent with guidance provided by the NEPM, which also provides information on the development of Data Quality Objectives (DQO) and on quality control samples.

Relevant considerations particular to asbestos include:

- investigators should have adequate asbestos experience and breadth of knowledge to ensure the quality of recommended visual detection and quantitation methodologies
- sampling and analytical procedures should be justified as to their appropriateness and effectiveness
- GHS labelling and safe sample packaging and transport requirements are to be met
- analytical methods should be consistent and allow results to be reproducible within and between laboratories. Importantly, fibre-counting criteria should be consistent for all sample analyses
- National Association of Testing Authorities (NATA) asbestos accreditation is a standard QA/QC requirement
- wherever there is analytical uncertainty regarding whether fibres in a sample are asbestos, the fibres should be assumed to be asbestos. Re-sampling should be considered to clarify the presence of asbestos at a site
- Australian Standard Method for the Qualitative Identification of asbestos in bulk samples (AS4964-2004) or relevant, validated international method can be used to identify asbestos in bulk materials (including soil).

Figure 10 Buried waste FA found during site works.

The use of duplicates during sampling for asbestos is not a mandatory requirement. However, there may be situations, for instance, the potential for legal challenge, where a duplicate or triplicate sample may be useful. In such a case, it may be a division of a single asbestos material sample (e.g. division of a suspect ACM fragment) rather than an attempt to collect equivalent samples.