WASTE CONTRACTORS &
RECYCLERS ASSOCIATION
OF N.S.W

Office of the NSW Chief Scientist and Engineer
Level 6, 52 Martin Place
Sydney NSW 2000

Attention asbestosreview@chiefscientist.nsw.gov.au

17 September 2024

Dear Sir

Re: The Management of Asbestos in NSW in recovered fines

Thank you for the opportunity to comment on the review being undertaken by the Office of the NSW Chief Scientist and Engineer (OCSE) into the management of asbestos in recovered fines, the residue remaining after all recyclable construction waste material has been removed from skip bins and other recovered materials. We note that the NSW Environment Protection Authority is currently reviewing its approach to the management of asbestos in the context of resource recovery to support a circular economy and to explore options for greater consistency between jurisdictions. The Waste Management and Resource Recovery Association of Australia (WMRR) and the Waste Contractors & Recyclers Association of NSW (WCRA) have developed a joint response on behalf of the construction and demolition (C&D) sector, which is the largest recycling sector in state.

WMRR is the national peak body for all stakeholders in the essential $17 billion waste and resource recovery (WARR) industry. We have more than 2,300 members across the nation – with more than 750 in NSW - involved in the breadth and depth of WARR activities, representing a broad range of business organisations, the three (3) tiers of government, universities, and NGOs. WCRA has been representing the NSW waste management sector since May 1948 and is a registered industrial organisation under both the *NSW Industrial Relations Act* 1996 and the *Fair Work (Registered Organisations) Act* 2009. WCRA currently has 210 members who own, operate and/or control the vast majority of assets used in waste management collection, processing, and disposal across NSW and the ACT.

Together, WMRR and WCRA represent industry operators in NSW who lead the way in circulating material in NSW, with the construction and demolition (C&D) sector in 2019-20 responsible for processing more than 12.5 million tonnes of materials which is about 60% of the total waste generated in NSW, representing the highest landfill diversion rate in the state at 76%. We will also be the sector most impacted by any change to the recovered fines resource recovery orders and exemptions, with potentially an additional 1.2 million tonnes of material forwarded to landfill if these orders were revoked.

Since 2007 the NSW C&D recycling industry has been attempting to work with the NSW EPA to develop an appropriate procedure for understanding and addressing the presence of asbestos in construction materials given the real possibility of there being a presence found at C&D recycling sites, including recovered fines. The issue of recovered fines in particular and the resource recovery orders and exemptions, has been an area that industry has engaged heavily with NSW EPA on, with industry preparing and providing detailed independent reports over many years, and most recently in 2020-21 by EnRisks, being the *Independent Review: Asbestos in Construction and Demolition Recycling* (Annexure B) and *Reuse of Recovered Fines in NSW (*Annexure C).

Industry would submit that these are high quality expert reports, with strong and meaningful recommendations that to date have not been given sufficient consideration by the NSW EPA to ensure that the necessary comprehensive reform of asbestos management in the C&D system in NSW is undertaken. Rather we have seen the proposals such as that mentioned in 2021 which proposed revocation of the order and did not solve the known challenges highlighted in the 2011 Hyder Report of for example, legislation, the inability technically to measure to ‘zero”, lack of clarity of sampling and testing, and lack of management of asbestos based on characterisation and risk.

Further we would state that the fundamental challenge in NSW has never been attempted to be addressed by the NSW EPA that being the definition of ‘*asbestos waste*’ in NSW under *the Protection of the Operations of the Environment Act* 1997 (POEO Act), which means *any waste that contains asbestos* i.e. regardless of concentration. This absolute statement is not a feasible, fair or reasonable measure. The term ‘any’ presents challenges and only brings more harm than benefit through issues of over-identification and over treatment, particularly given the amount of asbestos in the community more broadly.

Industry remains committed to working with the NSW government to address the risk posed by asbestos circulating in the environment as we are acutely aware that asbestos is particularly challenging for industry (and the community) as it is not always visible to the naked eye, making it extremely challenging to identify in the absence of measurement and testing. Industry has been attempting for over a decade in NSW to work with NSW EPA to develop an agreed protocol and standard for testing and sampling, given these challenges, however, to date no such protocol has been finalised.

As noted in a myriad of departments of Health advice, “*we are all exposed to low levels of asbestos in the air we breathe”*[1]. In fact, WA and Victoria go even further and quantify their advice, for example, WA Health states “We are all exposed to low levels of asbestos in the air we breathe every day. Ambient, or background, air usually contains between 10 and 200 asbestos fibres in every 1,000 litres (or cubic metre) of air (equivalent to 0.01 to 0.20 fibres per litre of air) meaning we may breathe up to 5,000 fibres per day. However, it is extremely rare to get an asbestos-related disease from this level of exposure.”

Table 3.1 Summary of background levels of asbestos reported in the environment

Exposure	Concentrations reported (f/cm^3 = f/mL)	Reference
Urban air (typically 10 times higher than rural)	0.000003 to 0.0198 for multiple countries 0.00004 to 0.05 (0.0011 mean) in US 0.0016 to 0.0037 (0.0016 mean) for 1990's US 0.0001 to 0.001 lowest background	(Krakowiak et al. 2009) (Abelmann et al. 2015) (ASCC 2008) (WHO 2000) (IARC 2012)
Rural air	0.0003 to 0.0218 for multiple countries 0.0000048 to 0.013 (0.00039 mean) in US 0.000014 to 0.000092 (0.000018 mean) in 2000's in US 0.00001 to <0.0001 lowest background	(Krakowiak et al. 2009) (Abelmann et al. 2015) (ASCC 2008) (WHO 2000) (IARC 2012)
Industrial air	<0.0006 to 91.4	(Krakowiak et al. 2009)
Heavy traffic road crossing or freeway	0.0009 to 0.0033	(WHO 2000)
Indoors	<0.001 buildings with no ACM <0.001 to 0.01 buildings with friable asbestos 0.00003 to 0.006 in homes, schools etc 0.00012 (mean) in US	(WHO 2000) (IARC 2012) (ATSDR 2001) (Lee & Van Orden 2008)
Outdoor ambient levels or background	0.00003 to 0.0047 in the US	(Glynn et al. 2018)

Industry appreciates that different types of asbestos place different levels of risk to workers and the community. Asbestos that is bonded in materials (ACM e.g. cement sheeting) poses the lowest risk, while loose fibres, such as those that are present in friable asbestos (FA), can easily move through the air and pose the greatest risk. However, there is no characterisation as such in the NSW EPA regime in the management of recovered fines. The WARR industry in no way means to downplay the risk of asbestos, but rather recognises that the

[1] enHealth 2013

management and detection of asbestos is fraught and can be a very emotional issue. However, it is vital in addressing this is NSW, that science and risk-based evidence is relied upon, to develop an informed and realistic position, to the safe benefit of all.

NSW Approach to Asbestos

Given, as noted above that asbestos is everywhere, it is no surprise that it may present in NSW C&D waste due to situations such as the following-

- Small amounts of bonded asbestos used as formwork in demolition material mixed with concrete for recycling;
- Being naturally occurring in the soil on which a building is being demolished/ constructed;
- Small fragments of bonded asbestos stuck behind nail heads following asbestos removal, prior to demolition mixed in waste for recycling;
- Settling of asbestos fibres generally present in the atmosphere for example due to historic uses (such as brake pads in cars).

The NSW WARR industry strongly believes that greater efforts should be made further up the supply chain to identify and remove asbestos, and correctly classify asbestos waste by those that generate this material, in order that asbestos containing material is not received at recycling facilities. It should be noted that asbestos is not an inclusion in the recovered fines order and exemption, and that is because it is not intended to be accepted at recyclers, however as noted above whilst asbestos is everywhere we often cannot always see it depending in the format it is in.

Most international jurisdictions make it clear that removal of asbestos at a site, prior to demolition is key to successfully managing asbestos in C&D material, as such it is disappointing to note that to date the effort on enforcing this removal and classification of asbestos has not been at site of generation to date, rather at the WARR end of the value chain- with every increasing penalties on recyclers such as those implemented in 2018 and 2024). Whilst generators have the same challenges of identifying asbestos not visible to the naked eye, there should be greater obligations and penalties placed on generators for testing, quantifying and classifying asbestos before it leaves the generation site and sent to a recycling or disposal facility. However as noted below the regulation governing the management of asbestos on these sites contain different asbestos levels than for those that produce recovered fines- ensuring that the NSW system remains convoluted and confusing.

The WARR industry would argue that the current advice on asbestos is mixed and highly problematic in NSW, with the NSW government's policy being an outlier in its unrealistic (and unscientific) requirement of 'zero presence', it is also disconnected from other NSW guidance and regulation in NSW. For example-

- *WHS Regulation* 2017 which relates to the removal and management of asbestos from buildings and structures prior to demolition (i.e. the step before the material arrives at a C&D recycling facility), does not require "zero asbestos" and allows for their t be trace levels of asbestos in soil for example (which is defined as <0.01% w/w);
- NSW also adopts NEPM levels in the management of contaminated soil, where risk-based guidelines for the presence of asbestos may remain in soil in different land use settings is defined;
- NSW EPA also allows for emissions to air of asbestos from stationary sources that may result in significant airborne asbestos exposures within the community, well above both background levels and the world health organisation guidance.

The requirement of zero asbestos only appears to apply to C&D facilities in NSW, and industry continues to advise the NSW EPA, such a situation is not workable when there is no similar requirement to have zero asbestos when it leaves the place that this material is generated.

In the ground	Naturally occurring asbestos	DPE/Councils
	Mineral extraction, abandoned mines	DPE
	Declared contaminated land	EPA
	Non-declared contaminated public land	EPA/Councils
	Non-declared contaminated non-workplace land	EPA/Councils
	Non-declared workplace - contaminated land	SafeWork NSW
	Asbestos remediation work	SafeWork NSW
	Illegal dumping	EPA
Supply	Illegal import/export	SafeWork NSW through DIBP
	Illegal supply	SafeWork NSW
Buildings and vehicles	Licensed asbestos assessors	SafeWork NSW
	At workplaces	SafeWork NSW
	At non-workplaces	Councils
Removal	Licensed removal work and asbestos assessors	SafeWork NSW
	At workplace not requiring a licensed removalist	SafeWork NSW
	At all locations by a PCBU or worker	SafeWork NSW
	At non-workplaces — all other cases	Councils
Emergencies	Response to emergency incidents	Fire & Rescue NSW (HAZMAT)
	Major recovery operations	Fire & Rescue NSW (HAZMAT)
	Routine recovery operations	Councils
	Waste export	EPA through DIBP
Transport and disposal	Transport by vehicle	EPA
	Landfill facilities	EPA
	Scheduled waste storage and disposal facilities	EPA
	Waste transport — interstate	EPA
	Temporary on-site waste storage — workplaces	SafeWork NSW
	Laundering facilities	SafeWork NSW

Figure 4.1: Regulatory responsibilities based on asbestos mineral life cycle (SafeWork NSW 2017)

NSW EPA and Management of Asbestos

The background presence of asbestos fibres in the atmosphere means that the idea of zero asbestos or zero asbestos exposure as currently required by the NSW EPA in recovered fines is meaningless, as not only is it not possible to have zero presence of asbestos, but it is also not in fact possible to measure technically to zero, as the method of detection depends on the reporting of the method limit. Whenever something is measured, the concept of zero is meaningless as it depends on the measurement method used, which has a unique detection limit or practical quantitation limit. There is in fact no way to measure zero for any chemical. The ASC NEPM (NEPC 1999 amended 2013e) indicates that the term non-detect should be used rather than zero or not present when reporting results in relation to contamination. This is arguably recognised in the regulations governing other parts of the value chain, where there are realistic presence and testing levels for asbestos in place (see below).

Arguably, NSW EPA has been hampered in taking a meaningful approach towards asbestos in recovered fines, due to the definition of asbestos in the NSW POEO Act which is very general, that is it fails to distinguish between types of asbestos (eg Asbestos containing material (ACM) and Friable Asbestos (FA/AF) and risk), equally the definition is *asbestos waste* is also very general which appears to have resulted in the *zero*- tolerance approach in NSW EPA where the concept of any asbestos means it is *asbestos waste.*

The use of such a general definition does not enable risk to be considered, nor the characteristics of asbestos, namely fibres of a particular length and width that are of importance to the hazard that asbestos poses. In addition, the definition does not allow the distinction between risks posed by asbestos containing material (ACM) that are likely to be visible (i.e. bonded or in products), which are low risk and asbestos fibres that can easily move in the air, which are high risk. The lack of regulatory definition and the lack of a link with the characteristics of asbestos that are hazardous, results in misunderstanding and misinformation about the hazards that relate to the general term asbestos.

Irrespective of the fact that it is recognised that it is not possible to measure to zero, the NSW EPA continues to require reporting that is not standard or accepted practice to meet the POEO Act interpretation, having advised in 2016 that: "The EPA is clarifying its position on the obligation of laboratories to report the presence of asbestos in samples, even where asbestos analysis was not requested by a client. It is the EPA's position that all laboratories should report the presence of asbestos in samples where it is detected, regardless of whether this has been asked for by the client. This advice does not mean that the EPA expects laboratories to undertake asbestos analysis of every sample received, merely that they report its presence where it is detected during the normal process of managing the sample. When undertaking analysis of samples and providing advice about sample compliance with the conditions of Resource Recovery Orders and Exemptions, the EPA considers that any laboratory that does not report the known presence of asbestos is likely to have supplied false or misleading information about those samples. Supplying false or misleading information about waste is a breach of section 144AA of the *Protection of the Environment Operations Act* 1997 with maximum penalties of $500,000 in the case of corporations, and $240,000 and/or 18 months gaol in the case of individuals."

The NSW EPA also emailed laboratories on 23 May 2016 and confirmed its position stating: "The EPA acknowledges that where a laboratory has not found asbestos in accordance with AS 4964, it allows for samples to be reported as 'no asbestos found at the reporting limit of 0.1g/ kg'. If asbestos is found, but is below the reporting limit, it is the EPA's position that the laboratory must still report the presence of asbestos, and the waste that is represented by the sample must be classified as Special Waste Asbestos as a minimum."

This mandate quickly evolved into laboratories industry-wide reporting below the limit of reporting (LOR) under AS 4964:2004 i.e. 0.1 g/kg (0.01% w/w). This direction by NSW EPA is a significant contention issue, which undermines the validity of the analytical method.

This requirement of zero asbestos only appears to apply to C&D facilities in NSW, and industry continues to advise the NSW EPA, such a situation is not workable, this concern about workability and scientific approach taken by the NSW EPA was also arguably captured by the Wilkinson review (2021) undertaken by Dr Cathy Wilkinson, which identified 22 key recommendations in relation to the NSW Resource Recovery Framework. Recommendation 20 stated: "A scientific expert external to the EPA should review and provide advice on the NSW approach to management of asbestos contaminants in waste and recovered materials. The review should include, but not necessarily be limited to protection of human health and the environment and consideration of opportunities and constraints of beneficial reuse." when there is no similar requirement to have zero asbestos when it leaves the place that this material is generated.

Industry is of a strong view that this legislative framework in NSW must be addressed as a priority as part of a necessary whole of system review of asbestos management in NSW, not simply a continual tweaking, and definitely not simply cherry packing parts of other jurisdictions regimes when NSW is so fundamentally different in that there is no risk based approach in place at present when it comes to managing asbestos in waste.

Asbestos Management in Australia

The NSW position of zero asbestos, is also at odds with other Australian jurisdictions, for example both Victoria and WA provide a definition of an acceptable level of asbestos as measurable fibres in waste that is consistent with risk-based guidance in the ASC NEMP. The criteria adopted (0.01%) is also consistent with the detection limits that may be achievable for the analysis. The WA guidance also allows for the removal of visible ACM by emu-picking (given that it clearly distinguishes between ACM and friable asbestos which NSW does not), providing potentially a workable approach to dealing with low-risk asbestos in these materials, noting that this remains a challenge fo rother waste streams too not just recovered fines.

Industry notes that whilst this may appear to be a workable solution in the WA context, the possibility of cheery picking some of the WA approach to asbestos management and applying by NSW EPA, is not supported given the current definitions in the POEO Act, the lack of definition around asbestos in NSW, as well as the completely different legislative and regulatory frameworks in existence in the respective jurisdictions, as well as the problematic advice in place at this time from NSW EPA around testing and sampling, coupled with the complete lack of a risk based approach to managing asbestos by NSW EPA for recovered fines. The entire system requires overhaul, not just a part of it, including legislative changes.

Whilst SA and Queensland are silent on asbestos in C&D waste, SA EPA adopts the concept of trivial and has included consideration of background, which is important for asbestos. The concept of defining pollution based on its potential to cause harm and whether or not it is non- trivial is already in NSW guidance and legislation. SA references health-based guidelines in the ASC NEPM to assist in understanding what is trivial.

International Asbestos Management

Asbestos waste is “hazardous waste” when it contains more than 0.1% asbestos in England and Wales, with the same criteria for ‘special waste’ adopted in Scotland. The European Union (EU) notes that asbestos cannot be readily isolated from other components in the mineral fraction of demolition waste. For this reason, the only practical means of guaranteeing the absence of asbestos is to ensure removal prior to demolition, which in turn requires a comprehensive survey of the fabric of the structure to identify occurrences of this material. The EU has a comprehensive C&D waste management protocol that outlines the need for proper removal of asbestos, and Hazardous waste is defined as including breathable fibres. The EU decision of 16 January 2001 amending Decision 2000/532/EC defines construction materials containing asbestos as hazardous waste if any such waste contains more than 0.1% w/w asbestos.

Conclusion

To be able to effectively manage asbestos contamination that may be present in C&D materials taken to facilities for the purpose of recycling, there are some fundamental aspects of legislation and policy in NSW that have to be changed, including:

- Changes to the WHS Regulation to ensure that waste generated from the demolition of structures with asbestos (friable and non-friable) adopt the same threshold or definition of asbestos as required to be adopted by the C&D recycling industry. Only where requirements in relation to the presence (or otherwise) of asbestos is the same for the generators of the waste and the C&D recycling industry can future protocols relating to “unexpected finds” be relevant and applicable.
- Rework the definition of asbestos, so that it is better linked with the characteristics of asbestos that pose hazards to human health and can be matched with measurement methods.
- Providing a definition of threshold limit for asbestos in the context of measurement (i.e. reporting limits for methods) and background or non-trivial exposures and risks.

- Allowing for the hand-picking or emu-picking of visible ACM prior to transport to a facility, and emu-picking of genuine 'unexpected finds' at a facility as this is the material most likely to be present in C&D waste and this material is of low risk. There are numerous examples of procedures that can be used to ensure this is done effectively and safely.

Without the above legislative changes, it will be very difficult to establish a workable protocol or procedure for C&D waste recycling that does not result in significant liabilities remaining with the owners of these facilities in relation to the presence of asbestos. Industry's response to the queries posed by the OCSE can be found at Annexure A. Do not hesitate to contact the undersigned to discuss further.

Yours sincerely

[redacted]

Gayle Sloan
CEO
WMRR

[redacted]

Brett Lemin
Executive Director
WCRA

Annexure A

Thresholds and *screening levels*

Question 1: What factors should be considered when deriving a threshold or screening level for asbestos in recovered fines and material for beneficial reuse?

At the outset the WARR industry states that we have no intention of reusing or recycling asbestos containing materials, and we make all reasonable attempts in complying with the NSW Standards for Managing Construction Waste in NSW to identify and remove this material. However, we remain firmly of the view that there has not been sufficient emphasis (including regulation/ legislation) on the incorrect classification of asbestos containing material transported to recyclers from generators.

However, in determining levels that should be set for recovered fines and material for beneficial reuse, industry would advocate that these levels should be set in accord with the *precautionary principle* and consider factors which reduce risk, that is, the type of asbestos and source of origin, whether source separated material, quality management related processes, critical controls and control points in the process and the approved use of finished product.

Levels should not be established in isolation of where the material was derived from and the risk that this presents. For example, source separated brick, concrete and excavated spoil has a low risk as the work is regulated by SafeWorks and on commercial and industrial projects there is also a requirement for demolishers to be licenced for asbestos removal and independent asbestos clearances.

Further the levels need to also be set to reflect the intended use of the recycled product, for example, there is less risk of human exposure to asbestos fibres if the product is used in a buried application as opposed to an above ground application. Road bases, aggregates and sands are primarily used below the finished surfaces. The actual levels must be considered as part of an entire value chain approach and not a one size fits all, which is the current approach in NSW. and not a standalone consideration i.e. to be considered in conjunction with other factors which reduce risk i.e. source separated material, quality management related processes, critical controls and control points in the process, approved use of finished product / proposed land application. The actual risk of asbestos being present in the waste should determine what is a representative sample / number of samples
Key to the successful implementation of a screening or threshold levels, however, is also an agreed and accredited testing and measurement process, that to date despite industry attempting to identify a consistent process that includes this we still do not have in NSW. This was clearly drawn out in the Enrisk reports attached and will be discussed below given the NSW EPA Memo of 23 May 2016 requesting that labs follow a testing protocol specifically for them and not in accord with Australian Standards or NATA accreditation.

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Asbestos waste management at recycling facilities

Question 2: Can you provide any data on annual volumes of C&D waste being recycled or alternatively sent to landfill? Data on rejected loads due to asbestos presence and any other data related to all TOR items is welcomed.

According to NSW EPA's own data, C&D remains the highest amount of material generated, within in 2022- 2023 there being 12.674 million tonnes generated of the total 22.4 million tonnes generated in NSW (equalling ~58%), of which 78% of C&D tonnes was recovered and not sent to landfill, again the highest recovery stream in NSW. Not only is this sector a large generator of jobs in NSW (estimates prepared for industry in 2021 indicated almost 500 jobs alone in Western Sydney were created through this sector), it is also crucial to keep the cost of construction in NSW competitive, by providing report prepared by the NSW Department of Planning and

Environment, stating that an estimated 46% of industry's demand for sand and crushed rock product coming from these substitute materials.

Individual companies are best placed to provide direct information on rejected loads, however one industry example that the Associations hold is a member that has rejected over 1300 loads in a nine (9) month period. All of these loads have been rejected, and the information recorded as per standard 1.4 in the C&D waste facility's rejected loads register, and the driver directed to leave. However, the company can only identify 8% of these loads being received at landfill, which raises the question of what happened to the remaining 92%.

Please note that since 2017, the WARR industry has been attempting to have NSW EPA develop and implement a live system for linking and tracking these rejected loads (the **"rejected loads register"**) , to ensure that once suspected asbestos loads are rejected by a facility, they are not simply transported to another facility, unaware that they have been rejected at another recycler due to suspicion of containing asbestos. Industry requires real time data to assist with managing the risk of this occurring. However, to date the NSW EPA has not progressed this register.

Question 3: Can you provide any other information on the potential presence of asbestos in recycled C&D material?

I. ***Information on the methods of separating and removing asbestos from waste that can inform alternative approaches?***
II. ***What reuse scenarios are there for recycled waste, including end-products and their use?***

Given, as noted above that asbestos is everywhere, it is no surprise that it may present in NSW C&D waste due to situations such as the following-

- Small amounts of bonded asbestos used as formwork in demolition material mixed with concrete for recycling;
- Being naturally occurring in the soil on which a building is being demolished/ constructed;
- Small fragments of bonded asbestos stuck behind nail heads following asbestos removal, prior to demolition mixed in waste for recycling;
- Settling of asbestos fibres generally present in the atmosphere for example due to historic uses (such as brake pads in cars).

The NSW WARR industry strongly believes that greater efforts should be made further up the supply chain to identify and remove asbestos, and if not classify correctly asbestos waste by those that generate this material, in order that asbestos containing material is not received at recycling facilities. It should be noted that asbestos is not an inclusion in the recovered fines order and exemption, and that is due to the fact that it is not intended to be accepted at recyclers, however as noted above whilst asbestos is everywhere we cannot actually always see it depending in the format it is in.

Most international jurisdictions make it clear that removal of asbestos at a site, prior to demolition is key to successfully managing asbestos in C&D material, as such it is disappointing to note that to date the effort on enforcing this removal and classification of asbestos has not been at site of generation to date, rather at the WARR end of the value chain- with every increasing penalties on recyclers such as those implemented in 2018 and 2024. Whilst generators have the same challenges as recyclers of identifying asbestos, there should be greater obligations and penalties placed on generators to ensure that they make better use of waste plans, testing, identifying and classifying material containing asbestos before it leaves generation site and sent to a recycling or disposal facility. However as noted below the regulation around sites generation has different asbestos levels than those that produce recovered fines.

Further however NSW needs to update its approach comprehensively towards identifying and managing asbestos in construction and demolition materials, to recognise both the different characteristics and risk that it poses, as well as establish a realistic level of presence given that we know that asbestos is everywhere. At present the definitions are general and do not reflect the approach of the majority of Australian and international jurisdictions, and as mentioned above, the requirement of NSW EPA for a zero presence is meaningless, both because it is impossible to achieve and because laboratories comply with NATA accreditation with “zero” asbestos being below the level of reporting.

i. There is no known technology that industry is aware of, or other method currently to detect and remove asbestos (particularly after it has moved on from the tip floor). Traditionally industry has used picking stations as part of the QA process to detect asbestos, and some use asbestos guns that are often of most use when demonstrating to a customer that asbestos is detected. A number of recycling facilities have *unexpected finds* procedures, which establish the procedures for how facilities deal with unexpected finds of asbestos. However again, despite a number of years of attempting to resolve this issue, agreement has not been reached between industry and EPA regarding how to deal with unexpected finds at a facility. The NSW construction standards require daily stockpile inspections where detection could also occur or following sampling and testing in which case the facility will need to manage the affected stockpile according to site procedures and or to EPA satisfaction.

ii. In industry’s view there are various uses for this material depending on product, proposed location and engineering requirements, including for example fill, bedding materials, under turf or sub-bases for road construction etc. Sub surface or temporary uses in most cases.

Question 4: While this section focuses on C&D waste, are there other waste types which are suitable for beneficial reuse which have the potential to be contaminated with asbestos?

Yes, we have witnessed firsthand earlier this year the presence in mulch in NSW. However, it is interesting to note that this was not in fact the case in other jurisdictions, which may be explained by the fact that NSW EPA continues to insist on a “zero” presence of asbestos, so one (1) fibre is identified means that there is ‘asbestos containing waste’, whereas other states have differing approaches with levels of reporting, inspections based on characterisation of material, and identified a level where the material is hazardous or not trivial. NSW has no one of these approaches and as such any presence (which there will always be) will be a report of asbestos.

There are many challenges with the NSW EPA’s approach to asbestos, however one that is of greater concern is the level of fear that it creates in the community when there is a possible identification of asbestos. It would appear that almost all health and WorkSafe departments across Australia recognise that we all breathe in asbestos every day and as such they take a cautious and measured approach to community advice.

While there’s no easy way for a householder to appropriately dispose of a small quantity of ACM it is likely to find its way into other recovered materials, for example kerbside recycling and organics. However, the reality is given the prevalence of asbestos in the atmosphere- asbestos will be a risk for all feedstocks, particularly with the NSW existing requirement of zero presence.

Question 5: Is it appropriate for the health screening levels for asbestos in soils to apply to asbestos in waste? Note that the threshold level in this instance refers to a level where further action is required.
i. Why or why not?

Should be related to respiratory exposure risk as this is the main risk. Respiratory exposure risk considerations-
1. Is it present,

2. in what form is it present, and
3. is it at risk of becoming airborne.

Waste type is not relevant in this context. If fibres and number of fibres (depending on how fibre is defined) present the same health risk if airborne how would the health risk and therefore the health screening level for the different waste types be different? The key consideration would be the ability for fibre to become airborne. Bonded asbestos is low risk of becoming airborne. If 7mm or less is considered FA, a 7mm fragment in asbestos soils is low risk of becoming airborne and this for example should be factored into considerations for health screening levels (based on respiratory exposure risk) and suitability for land application (in subsurface applications to prevent it becoming airborne).

Question 6: Health screening levels are not the only tool used for managing asbestos in soils. If threshold levels in soils are applied to asbestos in waste for beneficial reuse.

- ***i. what other tools can support managing asbestos in waste for beneficial reuse?***
- ***ii. what would be the limitations, costs or feasibility of safely removing asbestos in waste?***
- ***iii. are there certain scenarios where recycled C&D material should not be reused?***
- ***iv. are there certain scenarios where reuse of recycled C&D material could result in land legacy issues?***

Industry would submit that there should not be a difference between asbestos threshold levels applied. Asbestos levels in waste for beneficial reuse is not more or less a risk if it meets the same standards, than material that meets the health screening levels to be retained on a site pending the use of the space (i.e. commercial industrial, residential, public open space) and the use of the material (mostly subsurface for recovered fines).

i. A wholistic review to the management of asbestos in NSW is required, including amendments to the POEO Act to ensure that asbestos is clearly defined based on characterisation and risk, as well as establish a level where the presence of asbestos becomes hazardous (or non- trivial as adopted in South Australia) based on both recognition that asbestos is present in the environment and a realistic assessment of the risk that it poses, to ensure that we manage and attempt to reduce/ eliminate the presence of asbestos.

The implementation of greater generator obligation on identifying asbestos at the site of generation, and commensurate penalties for incorrect classification. This could be further enhanced by increased utilisation of waste plans in development to ensure appropriate testing and management of materials to be recovered/ disposed. Further, there is the real possibility of 'tracking' this material, possibly from site of generation, but at a minimum EPA must utilise in real time the rejected loads register that sites are required to maintain to ensure that loads rejected at one facility of attempting to deposit asbestos, cannot simply take this load to another after emu picking or hiding the suspected material.

Further, clear and agreed testing and sampling protocols for the identification and management of *unexpected finds* on site are required, including nationally adopted standards that can be used by hygienists and laboratories in accord with industry accreditation and not simply ad hoc requests from the NSW EPA.

ii. At present it currently requires occupational hygienist, licensed asbestos removalist, trained personnel, disposal to landfill (handling, transport and disposal costs and waste levy). These costs far outweigh the cost paid by a customer for the finished recovered product. Facilities and others should be able to deal with (i.e. assess risk and contamination levels and remove small amounts of non-friable and safely manageable fibres) themselves. Most facilities and sites currently producing / using these materials have procedures in place and or unexpected finds management plans that could be adapted to effectively manage small amounts of affected waste material and have in most cases been trained to do this.

iii. Given the concern about airborne fibres, consideration could be given to areas in proximity to health or socially sensitive receptors - schools, hospitals or in scenarios where there is material risk of fibres becoming airborne.

iv. The reality is that we have land legacy issues now given previous demolition of materials into soil, the presence of asbestos in the atmosphere and the existence of asbestos in situ in older residential settings. Given that this is largely a legacy of a manufactured product that neither the WARR industry or government produced, it would be a far better scenario to take a cooperative value chain approach to removing this material from circulation, than the current predominantly punitive approach that is taken towards largely C&D recyclers who do not make it, however can be unsuspectingly taking it!

Standards and guidelines for asbestos in waste

Question 7: Are there other standards or guidelines that would be applicable for managing asbestos in waste for beneficial reuse that can be provided?

As mentioned in the covering letter (and in Enrisks report) there is no alignment across NSW towards managing asbestos, which means the actual system will not work in NSW if there is not alignment across the supply chain and consistency across guidelines and standards. It makes no sense that those that remove this material on site under SafeWorks guidance where respiratory exposure is assessed based on risk and likelihood have a higher threshold than C&D sites. In theory therefore the NSW WHS requirements should in theory set the standard and provide the guidance for managing asbestos across the value chain, which would then align with contaminated land and transportation provisions.

In the event that this is not accepted, alignment with other Australian states should be considered- this will be discussed below further, however fundamental to applying standards is a wholistic review of the NSW system, including amending legislation and adopting accredited standards, i.e. not continuing to require its own, including for sampling and testing. For example, the adoption of AS5370:2024 would appear to be acceptable and applicable.

Question 8: Should the approach in the WA guideline (Managing asbestos at construction and demolition waste recycling facilities), be implemented in NSW and if so, why or why not?

i. Are there other factors that should be considered if the WA Guideline is to be implemented?

ii. Is there an alternative approach that could be considered?

In short, no, the WA DWER (2021) guideline is not based on respiratory exposure risk (assuming that this is the risk that everyone is trying to assess and manage) and does not address the disconnect in NSW between the different requirements of NSW legislation, including WHS, Contaminated Lands and Environment legislation. Managing asbestos in NSW C&D waste needs to be aligned across the NSW supply chain and fit for purpose for the NSW regulatory space. Industry undertook a technical review of the WA DWER (2021) guideline with the assistance of EP Risk and the key elements of the technical review were-

- The NSW legislative framework is convoluted with regards to asbestos and there are multiple pieces of legislation with various regulators / jurisdictions. The ASC NEPM (2013) has been approved by the NSW EPA under section 105 of the *Contaminated Land Management Act* 1997 (CLM Act 1997). The ASC NEPM (2013) cross-references the WA Department of Health (DOH) Guidelines for the assessment, remediation and management of asbestos contaminated sites, 2009 (WA DOH, 2009) and is essentially accepted by NSW EPA. However, WA DOH (2009) has since been replaced by WA DOH Guidelines for the assessment, remediation and management of asbestos contaminated sites, August 2021 (WA DOH, 2021).

- At the time of writing, the NSW EPA had not yet fully accepted WA DOH (2021) in its entirety, as there are significant departures in the WA framework compared to NSW. In particular, in NSW you cannot "un-waste" *asbestos waste* by emu picking (hand picking fragments) but can apply segregation and validation techniques in certain circumstances. Emu picking is approved in principle for on-site remediation, allowing for on-site reuse (and not off-site reuse) but not for 'waste' under the definition in the POEO Act. This must be assessed on a site-specific basis. In NSW, this is a complex issue and detailed knowledge of the legislation is required. This is contrary to the process detailed in WA DWER (2021) whereby emu picking is permissible.
- The Draft *NSW EPA Position Statement Management of Asbestos - Contaminated Sites*, v2, dated October 2023 (NSW EPA, 2023), attempted to address some of the key issues regarding asbestos in NSW. There has been significant industry consultation on NSW EPA (2023), however it is understood the final version will not be published until the findings of the OCSE review are complete, and potentially the actions of the review are implemented into the NSW framework.
- A threshold limit of 0.001 % weight for weight (w/w) is widely encouraged across the industry in NSW. However, there is a major legislative constraint in NSW, as discussed above with the definition of *asbestos waste* under the POEO Act, which states *any waste that contains asbesto*s i.e. regardless of concentration. In industry's view until this statutory definition is repealed or amended, substantive change is unlikely. The WA DWER (2021) guideline cannot simply be slotted into the NSW waste regulatory framework in its current state. The overarching issue is that the NSW EPA does not currently accept a threshold for asbestos in 'waste'. This is a major legislative constraint in NSW, as the definition of *asbestos waste* under the *Protection of the Environment Operations Act* 1997 (POEO Act) states 'means any waste that contains asbestos' i.e. regardless of concentration. Until this statutory definition is repealed or amended, substantive change is unlikely. However, as mentioned throughout this submission a threshold limit is widely encouraged across the industry in NSW.
- In NSW, there is no framework comparable to 'Customer Warranty' [section 3.3] under the POEO Act but there is strict liability, and the burden of proof is on all parts of the waste stream (producer, transporter, recycler, consumer etc.), under the provisions of the POEO Act. This has recently been tested and reinforced through the decision of the Grafil case, which is a landmark test case.
- NSW EPA does not currently accept a risk-based approach, which is contrary to section **3.3 - Risk Classification Matrix** and sections **3.4.1 to 3.4.2,** in terms of material type. In NSW all recycled waste, regardless of composition / source, must comply with the waste framework and the definition of asbestos waste. In NSW, generally you must have an EPL to accept waste unless it falls under specific Resource Recovery Orders/Exemptions (RRO/REE), or you have applied for a site-specific exemption for the land application of waste materials as fill. This is enforced by the POEO Act in NSW and hence the push for legislative change.
- WA DWER (2021) states [section 4.3.2] states: "Where suspected ACM fragments capable of being easily removed by hand are identified in a load, the suspect ACM must be removed from the load and either: 1. appropriately isolated and covered for asbestos testing." 2. assumed to be ACM and redirected to an appropriately authorised disposal facility. All suspected or assumed ACM must be segregated. Material must be clearly labelled, kept secure and sufficiently contained to prevent the release of asbestos, including wind-blown fibres." In NSW, in particular metro Sydney, it is not feasible to temporarily stockpile large volumes of material on-site within recycling facilities pending laboratory results, based on limited available land on-site and the quantum of the recycled material produced industry in NSW, which is an order of magnitude greater than in WA.
- WA DWER (2021) states [**section 4.3.3**] Sampling of road base and screened sand products must occur at a minimum rate of 40 locations per 4000 tonnes, or 14 samples per 1000 m3 of product. However, the NSW EPA RRO for Recovered Fines (Batch) states: "The processor must undertake one-off sampling by collecting 10 composite samples from every 400 tonnes".

- The testing regime requirements specified in WA DWER (2021) [**section 4.3.4**] (i.e. 1 sample per 70 m3 for conveyor sampling), would present a significant increase to current testing obligations, compared to the NSW EPA RRO/RRE for Recovered Fines (Continuous), which states "Routine sampling of the "continuous process" recovered fines by collecting one (1) composite sample each week". This would be an extra approximately 50-60,000 samples per annum that would require analysis for recovered fines and aggregate only (no data was available for recovered soil).
- However, the sampling ratio of 1 per 70m3 [**section 4.3.4**] is less than the NSW EPA Contaminated Land Guidelines Sampling Design – Part 1 Application, 2022 (NSW EPA, 2022), i.e. 1 per 25 m3, which is considered best practice in NSW. NSW EPA (2022) references the POEO Act 1997 i.e. the framework. NSW EPA (2022) references the 'NEPM gravimetric procedure' field screening a 10 L sample with a 7 mm sieve for non-friable asbestos, and collection of a 500mL sample for laboratory analysis to AS 4964. Refer to ASC NEPM (2013) Schedule B1, Section 4.8, Table 7, footnote 5 and Section 4.10 for further details on the gravimetric procedure, which is a separate to laboratory analysis.
- WA DOH (August 2021) states, in section 7.2, that the 500 mL soil samples should be undisturbed i.e. not collected from the < 7mm fraction. This is contrary to section **4.3.5** which pre-dates WA DWER (April 2021).
- Reduced sampling density, under strict criteria [**section 4.3.6**] to one (1) sample per 600 m3 is contrary to NSW EPA (2022) which adopts 1 per 25m3.

Industry has also calculated that the requirements in the WA guideline would result in approximately 50-60,000 additional samples per annum that would require analysis for recovered fines and aggregates only (no data was available for recovered soil). This could add approximately $4.6million (ex. GST) of additional unviable costs to the industry. It should also be noted the NSW waste industry is far greater in terms of scale of recycled material production, as well as the economics with for example the cost of land in Metropolitan Sydney being far greater than Metropolitan Perth.

As such there are substantial differences between the NSW and WA frameworks, not the least of which being the entire risk-based approach of the WA framework, including clear definitions and thresholds. In addition to the key legislative constraints, whatever changes are implemented in NSW they need to also be cognisant of the locality, scale and spatial constraints facing the NSW recycling industry locally.

The WARR industry is very clear that NSW EPA needs to undertake a comprehensive review and make changes to the POEO Act that address all of the challenges faced, not simply cherry pick parts of other jurisdictions frameworks, WA whilst risk based has a system that supports this, whereas NSW has an unrealistic strict compliance framework- hence unworkable.

I. Factors to be considered for implementation of any change to current requirements are: impact on operations (e.g. potential slow down if ability to accept waste is dependent on clearance procedures and markets for processed material and products being available - these are a choke point), sampling, testing, stockpile management, space requirements for material storage, financial constraints and costs, viability of resource recovery if cost to process and assess outweighs value and is not aligned to circular economy objectives. The cost of sampling and analysis based on number of samples required in the WA Guidelines is prohibitive for NSW based on volumes being produced, available laboratories with the resources and NATA certification to complete the analysis.

II. Setting screening levels above which further evaluation / investigation is required rather than relying solely on the initial result which currently determines the fate of the material. The level and the evaluation process should be related to respiratory exposure risk and methods to determine this National Environment Protection (Assessment of Site Contamination) Measure, establishes different health screening levels based on land use - could this be applied to product use given product is for land application and the Resource Recovery Exemption specifies applications for the material.

Sampling and analysis

Question 9: Apart from AS4964 and ASC NEPM, are there other sampling and analysis methods for detecting and quantifying asbestos in waste materials or recycled products that are being received and processed at recycling facilities?

I. ***Are you aware of any other methods/processes for sampling and analysis of asbestos that the Review should consider? If so, please provide details and basis for their relevance to this Review.***

II. ***How reliable and accurate are these methods in ensuring that recycled waste is not contaminated?***

AS5370 builds upon AS 4964 by including the use of electron microscopy techniques (SEM and TEM) as confirmatory analysis, resolving ambiguities that Polarised Light Microscopy (PLM) cannot. The new AS 5370 standard clarifies the LOR (0.01% w/w) to prevent over-detection of asbestos. The new Australian Standard AS 53707 is an adaptation of the International Standard ISO 22262-18 and AS 4964:2004, which may be of relevance to the review. Industry is advised that the introduction of AS 5370 incorporates advances in analytical techniques of Electron Microscopy (EM) and aligns the with other regulatory guidelines relevant to soil. We also understand that the National Association of Testing Authorities (NATA) is unable to offer accreditation under the new standard until they have sought feedback from stakeholders.

Please note that AS 5370 and AS 4964 do not specify the number of samples required to adequately characterise a batch of material, however they reference *AS 1141.3.1, Methods for sampling and testing aggregates, Method 3.1: sampling – Aggregates and BS EN 932-1,* Tests for general properties of aggregates, *Part 1: Methods for sampling*. The specific number of samples is detailed in the NSW EPA guidelines, resource recovery orders, and exemptions.

Other international standards, such as ISO 2859-1 and ISO 2859-210, should be considered to determine an appropriate acceptable quality level and the necessary samples for verifying confidence. The extent of sampling should be determined through a compromise with regulatory requirements and industry standards to balance costs and confidence levels.

Risk-based approaches for managing asbestos in waste

Question 10: Would a through-chain approach to managing asbestos in waste, where each business looks to minimise or eliminate the risk from asbestos in waste for beneficial reuse, work?

i. ***What elements would be part of the system/approach?***

ii. ***ii. What would be the advantages/disadvantages of such a system?***

Yes, as discussed throughout this submission industry is strongly supportive of a systems-based approach to managing and identifying asbestos, in particular at the point of generation, similar to Heavy Vehicle Chain of Responsibility requirements with critical control requirements and control points clearly identified.

The liability and obligations for proper assessment of waste needs to start from source and include an assessment of the likelihood of asbestos being present, it also should consider that the majority of building and demolition (B&D) waste is pre-classified and does not require proper assessment for waste classification and identification of asbestos. Requirements upstream of a waste facility for asbestos need to be as stringent as the requirements for a waste facility.

Consideration may also need to be given to the strengthening of asbestos management for residential demolitions, at present it is very difficult for example for householders to dispose easily of small amounts of asbestos. Which lends itself to deliberate contamination of other WARR materials, for example through kerbside. An asbestos assessment needs to happen on all houses prior to demolition and an independent clearance report should be issued. Further a review of the level of asbestos clearance report needs to happen on all demolitions. Is a visual report sufficient? Should demolitions that contain asbestos be required to vacuum the ground after removal of asbestos? This may also ensure asbestos fibres are not present in the demolition material.

Question 11: Are there other risk-based approaches to managing asbestos in waste for beneficial reuse?

Risk based approach should be concerned with risk of respiratory exposure regardless of where in the supply chain the exposure risk might occur including for beneficial reuse. For beneficial reuse the risk can be controlled by controlling where the product is used and for what purpose. Similarly, for management at a waste facility where there is a currently a conflict / disconnect between safe work and EPA requirements.

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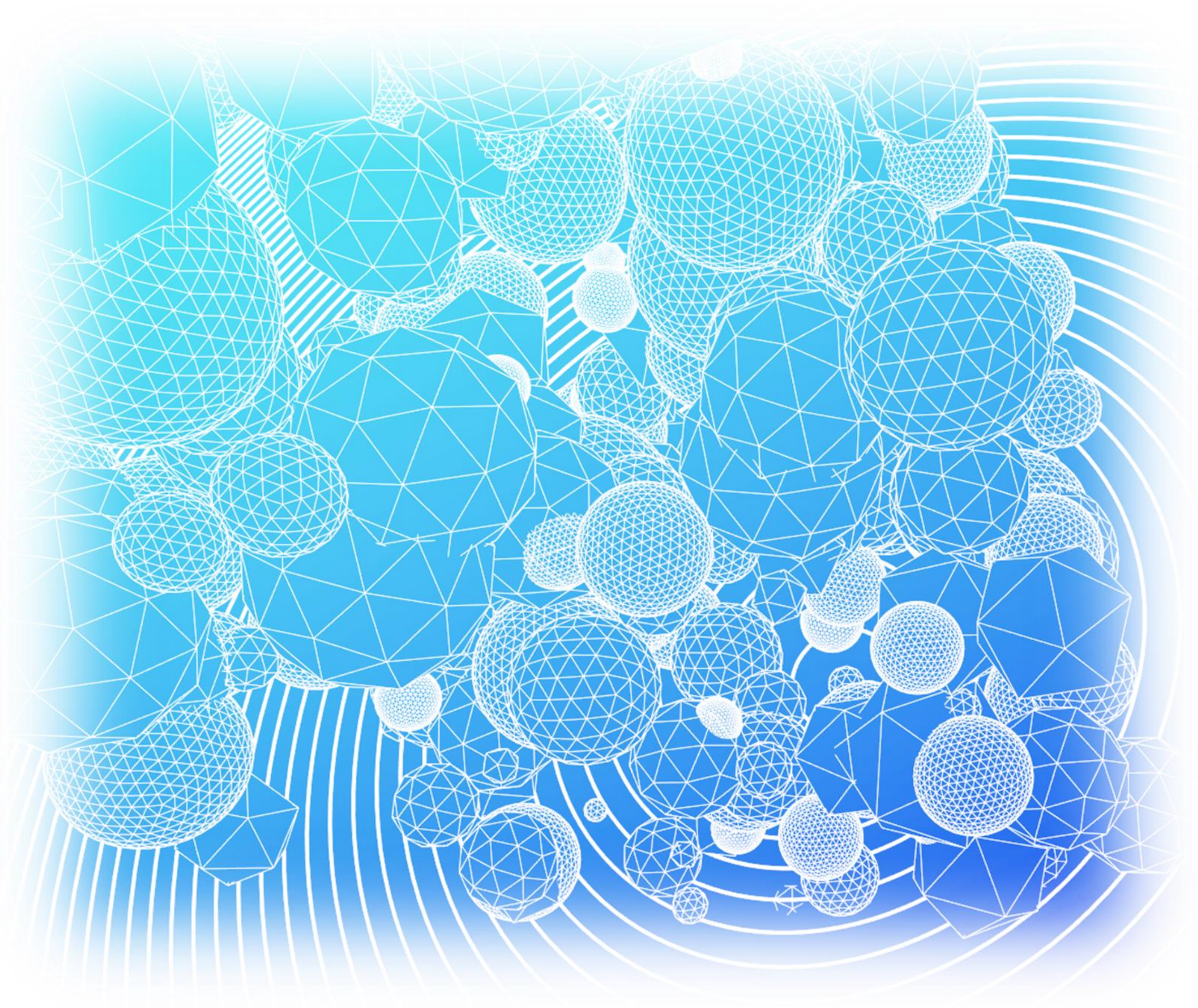

Independent review: Asbestos in Construction and Demolition Recycling

Prepared for: Beatty Legal Pty Limited

20 October 2020

Document History and Status

Report Reference	BL/20/CDRR001
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Limitations

Environmental Risk Sciences has prepared this report for the use of Beatty Legal Pty Limited in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in the **Section 1** of this report.

The methodology adopted and sources of information used are outlined in this report. Environmental Risk Sciences has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

This report was prepared between June and October 2020 and is based on the information provided and reviewed at that time. Environmental Risk Sciences disclaims responsibility for any changes that may have occurred after this time.

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Glossary of terms

Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).
Exposure Assessment	The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.
Exposure Pathway	The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as chemical leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.
Guideline Value	Guideline value is a concentration in soil, sediment, water, biota or air (established by relevant regulatory authorities such as the NSW Department of Environment and Conservation (DEC) or institutions such as the National Health and Medical Research Council (NHMRC), Australia and New Zealand Environment and Conservation Council (ANZECC) and World Health Organisation (WHO)), that is used to identify conditions below which no adverse effects, nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter- and intra-species variations and uncertainty factors. Separate guidelines may be identified for protection of human health and the environment. Dependent on the source, guidelines will have different names, such as investigation level, trigger value, ambient guideline etc.
HHRA	Human Health Risk Assessment
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way (see route of exposure).
Inhalation	The act of breathing. A hazardous substance can enter the body this way (see route of exposure).
Point of Exposure	The place where someone can come into contact with a substance present in the environment (see exposure pathway).
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
Receptor Population	People who could come into contact with hazardous substances (see exposure pathway).
Risk	The probability that something will cause injury or harm.
Route of Exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin (dermal contact)
Toxicity	The degree of danger posed by a substance to human, animal or plant life.
Toxicology	The study of the harmful effects of substances on humans or animals.

Executive summary

ES.1 Introduction

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by Beatty Legal Pty Limited to undertake an independent review of the technical information around the potential presence and risks posed by asbestos that may be present in construction and demolition (C&D) waste to be recycled.

As noted by enHealth in 2013 (enHealth 2013)

"We are all exposed to low levels of asbestos in the air we breathe every day."

Consequently, it is no surprise that it is possible that asbestos may be found in C&D waste being brought in for recycling. Asbestos may be present in such waste due to:

- mixing in of small amounts of bonded asbestos from demolition with concrete for recycling or
- it being naturally occurring in the soil on which a building is being demolished or constructed (i.e. soil containing asbestos gets mixed into the waste) or
- settling of asbestos fibres generally present in the atmosphere (i.e. source of fibres is off-site).

Since around 2007, the C&D recycling industry has been working with the NSW EPA to develop an appropriate protocol/procedure for understanding the issues arising from the potential for asbestos to be present in construction and demolition waste and how best to manage that during the recycling process. This procedure has not yet been finalised.

In 2019 a court case changed the understanding of the law in NSW around asbestos containing wastes (Environment Protection Authority v Grafil Pty Ltd)**.** The court case determined that 1 fibre of asbestos in a stockpile makes the stockpile asbestos waste.

This change in understanding has the real potential to affect the viability of the C&D recycling industry which would have significant impacts on the amount of waste that requires landfilling. Given the limited landfilling volume available in NSW, this matter requires serious consideration.

To better understand the health and environmental risks of asbestos in C&D recycling, a detailed independent technical review has been undertaken and presented in this report.

ES.2 Objectives

The objectives of the review presented in this report are:

- Undertake independent review and provide a summary document detailing:
  - what is asbestos (where it comes from; how it is present in our environment; how it moves around the environment)
  - general technical basis for managing asbestos including toxicology, risk assessment, sampling and analysis and ambient levels

  - hazard based versus risk based guidelines
  - management frameworks for other chemicals in wastes in Australian jurisdictions – similarities and differences for asbestos
  - management frameworks for asbestos containing waste in NSW and other jurisdictions including international jurisdictions. This will include information about the basis for these frameworks [i.e. risk based], where available, and the situations where these get applied (e.g. WHS or contaminated land or waste)
  - concept of trivial versus non-trivial when assessing environmental changes
  - general description of C&D recycling process including products produced and where they are used
  - current issues with the existing system for the management of asbestos in this industry
  - definitions in relation to asbestos containing wastes (existing and changes due to court case in 2019) including what is technically feasible to measure (including sampling methods)
  - technical basis of asbestos guidelines used for waste and for other industries (like contaminated land)
- Based on the review undertaken, outline a best practice approach to managing asbestos within C&D recycling processes, noting where these measures may require additional work, or revision or changes to current guidelines, policy or regulation.

ES.3 Outcomes

The review presented in this report has identified a number of key outcomes which are summarised below:

Hazards posed by asbestos

- It is clear that there are a range of hazards posed by the potential presence of asbestos in any environment. The key hazards relate to asbestos fibres that are of biological concern, i.e. those equal to or longer than 5 μm and having diameters up to 3 μm with an aspect ratio equal to or greater than 3:1, that can move into the air and be inhaled. When assessing asbestos, there are a range of different methods that can be used to quantify asbestos fibres, some of which enable characterisation of the fibres with characteristics that have the potential to pose hazards to human health when inhaled. The selection of the quantification method is important as each will report different aspects in relation to asbestos exposure and risk. Hence guidelines are often tied to specific analytical methods.
- Different types of asbestos pose different levels of risk to workers and the community. Asbestos that is bonded in materials (or cement sheeting) poses the lowest risk, while loose fibres, such as those present in friable asbestos, that can easily move into the air pose the highest risk.
- In relation to potential risks posed by C&D waste:
  - There is a low potential for friable asbestos to be present in C&D waste where these materials are effectively managed at the point of removal from buildings and structures (i.e. upstream)

  - The most likely form of asbestos is bonded asbestos, which is of low risk, except where the bonded material is mechanically damaged. When this occurs, there is the potential for some fibres to be released to air, where exposure may occur. This material can be more easily identified and managed in waste materials. The most effective way to manage the potential for this damage to occur is for it to be effectively removed upstream or identified at the gate.
- The background presence of asbestos fibres in air, which is relevant to all members of the community in urban and rural areas means that the concept of zero asbestos or zero asbestos exposure is meaningless.
- While it is accepted that zero tolerance is part of NSW asbestos waste regulations and community expectations, the concept is meaningless in technical terms. Everyone is exposed to fibres from natural sources. Such sources are not targeted for management by regulation or policy. In addition, the concept of 'zero' for anything that requires any form of measurement is meaningless as its detection depends on the reporting limit of the method. It is never possible to determine "zero", only that something cannot be detected.

Definition of asbestos

- The definition of asbestos in the POEO Act, which is adopted throughout all of the NSW regulations and is consistent with the definitions adopted in other states is very general. In addition, the definition of asbestos waste is very general and appears to have resulted in the zero-tolerance approach adopted in NSW, where the concept of any asbestos means it is an asbestos waste.
- The use of such a general definition does not enable risk to be considered, nor the characteristics of asbestos, namely fibres of a particular length and width that are of importance to the hazards that asbestos poses. In addition the definition does not allow any distinction between risks posed by ACM that are likely to be visible (i.e. bonded or in products), which are low risk, and asbestos fibres that can easily move into the air, which are high risk.
- This lack of regulatory definition, and link with the characteristics of asbestos that are hazardous, results in misunderstanding and misinformation that the hazards relate to the general term asbestos, and how these relate (or not) to the toxicological studies.

Current asbestos guidance

Current guidance on asbestos in NSW is mixed and is the cause of many of the issues identified by the C&D recycling industry. There is a requirement for this industry to have "zero" asbestos in waste received and managed at a facility, and "zero" tolerance on the presence of asbestos in recycled products produced.

While the concept of "zero" asbestos is meaningless, the requirement is also disconnected from other regulations and guidance in NSW:

- The key disconnect relates to the *WHS Regulation 2017*, that relates to the requirements for removing and managing asbestos from buildings and structures prior to demolition (the process that produces the waste received by a C&D facility). The *WHS Regulation 2017* does not require "zero asbestos" post asbestos removal and allows for soil to include trace

levels of asbestos, which is defined as <0.01% w/w. In addition, removal of small amounts of ACM (<10 m^2) poses the greatest risk of being present in such wastes.
- NSW utilises the NEPM (NEPC 1999 amended 2013a) for the assessment and management of contaminated soil, where risk-based guidelines for the presence of asbestos that may remain in soil in different land use settings is defined.
- NSW allows for emissions to air of asbestos from stationary sources (NSW EPA 2016a), at levels that may result in significant airborne asbestos exposures within the community, well above background levels and well above WHO air guidelines.

The requirement for “zero” asbestos appears to only apply to the C&D recycling facilities. Such a requirement is not workable where the waste being delivered does not have a requirement to have “zero” asbestos when it leaves the place where such waste was produced. This places the onus and liability (of prosecution) of managing asbestos to a zero-tolerance level on the operators of the C&D facilities alone and not onto the producers of the waste being recycled.

Current NSW EPA Standard (EPA 2019)

These documents relate to visual identification of ACM.

- ACM, where bonded in materials which would be visible is considered to be low risk in terms of health and can be easily removed from soil or waste using an emu-picking approach (noted to be permitted in the 2010 Worksafe guidance, but not in 2019).
- The greatest risk, however, relates to loose asbestos fibres. As discussed in **Sections 2, 3** and **4**, the key risk for workers and the community (including consumers) relates to the inhalation of fibres. The potential for friable asbestos to be present in C&D waste is low, and the release of any fibres from bonded asbestos can be minimised by the effective removal of these materials prior to mechanical damage.

Other Australian States

- South Australia and Queensland are silent on the management of asbestos in C&D waste.
- Victoria and Western Australia provide a definition of an acceptable level of asbestos, as measurable fibres, in waste that is consistent with risk-based guidance in the ASC NEPM. The criteria of 0.001% is also consistent with the detection limits that may be achievable for the analysis. This guidance includes the requirement to analyse for fibres addressed the key risk related to asbestos – the inhalation of fibres that are not visible so cannot be addressed by current control measures. The WA guidance also allows for the removal of visible ACM by emu-picking, which provides a workable approach to dealing with low risk asbestos in these materials.

International approaches

- Most international jurisdictions are clear that the removal of asbestos at a site, prior to demolition is key to managing asbestos in C&D waste. Some jurisdictions adopt the concept of zero asbestos in waste.
- The UK and Canada go further and allow for trace amounts of asbestos to remain. The UK adopts the reporting limit for the detection of fibres (using a specified method). Canada

provides a definition of trace levels that is higher than in the UK. Ontario references the term trivial but does not define trivial.
- Canada also provides a definition of zero asbestos in air, which is essentially the reporting limit of the method (with the analysis method stated).
- The concept of zero asbestos is meaningless, as we are all exposed to background levels of asbestos all of the time, and with anything that requires measurement, a non-detection never means zero.
- Being able to define what is meant by “zero” or allowing consideration of trivial levels of asbestos and defining what is trivial enables these concepts to be better understood by industry and the community.

Trivial

- The concept of defining pollution based on its potential to cause harm and whether or not it is non-trivial is already within NSW legislation and guidance. The concept of non-trivial, however, is not defined particularly in terms of asbestos, where it gets caught up in the definitions of asbestos in the POEO Regulation which effectively mean zero-tolerance.
- The SA EPA also adopts the concept of trivial and has included consideration of background, which is important for asbestos. They reference the health based guidelines on asbestos in the ASC NEPM to assist in understanding what is considered trivial.
- Where background exposures to dust and asbestos are considered, adopting a soil or waste guideline of 0.001% w/w for friable asbestos (which is consistent with NEPC guidance on contaminated land, and also consistent with the criteria for asbestos in C&D waste in Victoria and Western Australia) would result in inhalation exposures that are below background in urban and rural areas, and could be considered to be trivial.
- Given the concept of trivial is already relevant in NSW, it would be appropriate to provide a definition of what is non-trivial in terms of asbestos in C&D recycling industry.

ES.4 Recommendations

To be able to effectively manage asbestos contamination that may be present in C&D materials taken to facilities for the purpose of recycling, there are some fundamental aspects of legislation and policy in NSW that have to be changed, including:

- Changes to the *WHS Regulation* to ensure that waste generated from the demolition of structures with asbestos (friable and non-friable) adopt the same threshold or definition of “zero” asbestos as required to be adopted by the C&D recycling industry. Only where requirements in relation to the presence (or otherwise) of asbestos is the same for the generators of the waste and the C&D recycling industry can future protocols relating to “unexpected finds” be relevant and applicable.
- Rework the definition of asbestos, so that it is better linked with the characteristics of asbestos that pose hazards to human health, and can be matched with measurement methods.
- Providing a definition of zero asbestos in the context of measurement (i.e. reporting limits for methods) and background or non-trivial exposures and risks.

- Allowing for the hand-picking or emu-picking of visible ACM prior to transport to a facility, and at receipt at a facility as this is the material most likely to be present in C&D waste and this material is of low risk. There are numerous examples of procedures that can be used to ensure this is done effectively and safely.

Without the above legislative changes, it will be very difficult to establish a workable protocol or procedure for C&D waste recycling that does not result in significant liabilities remaining with the owners of these facilities in relation to the presence of asbestos.

Section 1. Introduction

1.1 General

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- it being naturally occurring in the soil on which a building is being demolished or constructed (i.e. soil containing asbestos gets mixed into the waste) or
- settling of asbestos fibres generally present in the atmosphere (i.e. source of fibres is off-site).

Since around 2007, the C&D recycling industry has been working with the NSW EPA to develop an appropriate protocol/procedure for understanding the issues arising from the potential for asbestos to be present in construction and demolition waste and how best to manage that during the recycling process. This procedure has not yet been finalised.

In 2019 a court case changed the understanding of the law in NSW around asbestos containing wastes (Environment Protection Authority v Grafil Pty Ltd). The court case determined that 1 fibre of asbestos in a stockpile makes the stockpile asbestos waste.

This change in understanding has the real potential to affect the viability of the C&D recycling industry which would have significant impacts on the amount of waste that requires landfilling. Given the limited landfilling volume available in NSW, this matter requires serious consideration.

To better understand the health and environmental risks of asbestos in C&D recycling, a detailed independent technical review has been undertaken and presented in this report. This review presents the technical background for asbestos (including information about the toxicology and risks posed by different types of asbestos, the analysis of asbestos as well as background levels of asbestos (ambient levels) commonly present in air that the community is exposed to); description of the C&D recycling process, how asbestos might be present and how it asbestos is currently managed; a description of how other jurisdictions manage asbestos containing wastes; and proposing a practical, technically feasible framework for managing asbestos containing wastes into the future.

This document could then be used in discussions with NSW EPA and other relevant stakeholders and the general public (or interested groups).

1.2 Objectives

The objectives of the review presented in this report are:

- Undertake independent review and provide a summary document detailing:
  - what is asbestos (where it comes from; how it is present in our environment; how it moves around the environment)
  - general technical basis for managing asbestos including toxicology, risk assessment, sampling and analysis and ambient levels
  - hazard based versus risk based guidelines
  - management frameworks for other chemicals in wastes in Australian jurisdictions – similarities and differences for asbestos
  - management frameworks for asbestos containing waste in NSW and other jurisdictions including international jurisdictions. This will include information about the basis for these frameworks [i.e. risk based], where available, and the situations where these get applied (e.g. WHS or contaminated land or waste)
  - concept of trivial versus non-trivial when assessing environmental changes
  - general description of C&D recycling process including products produced and where they are used
  - current issues with the existing system for the management of asbestos in this industry
  - definitions in relation to asbestos containing wastes (existing and changes due to court case in 2019) including what is technically feasible to measure (including sampling methods)
  - technical basis of asbestos guidelines used for waste and for other industries (like contaminated land)
- Based on the review undertaken, outline a best practice approach to managing asbestos within C&D recycling processes, noting where these measures may require additional work, or revision or changes to current guidelines, policy or regulation.

1.3 Approach

The approach taken for the assessment of potential risks to human health is in accordance with guidelines / protocols endorsed by Australian regulators, including:

- enHealth, Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth 2012a);
- enHealth, Australian Exposure Factor Guide (enHealth 2012b);
- NEPM (1999 amended 2013) National Environmental Protection Measure – Assessment of Site Contamination including:
  - Schedule B1 Investigation Levels for Soil and Groundwater (NEPC 1999 amended 2013a)
  - Schedule B4 Guideline on Health Risk Assessment Methodology(NEPC 1999 amended 2013c)
  - Schedule B7 Guideline on Health-Based Investigation Levels (NEPC 1999 amended 2013d)

  - Toolbox Note – Key principles for the remediation and management of contaminated sites
- Relevant Standard Methods including:
  - Australian Standard 2004, Method for the qualitative identification of asbestos in bulk samples, Method No. 4964 (Standards Australia 2004);
  - NOHSC 2005, Guidance note on the membrane filter method for estimating airborne asbestos fibres, 2nd Edition, National Occupational Health and Safety Commission (NOHSC 2005)
- Environmental Health Standing Committee (enHealth), Asbestos: A guide for householders and the general public, Australian Health Protection Principal Committee, Canberra, 2013 (enHealth 2013);
- Environmental Health Standing Committee (enHealth), Management of asbestos in the non-occupational environment, Australian Health Protection Principal Committee, Canberra, 2005 (enHealth 2005);
- NSW Approved Methods for Modelling and Assessment of Air Pollutants in NSW (NSW EPA 2016a);
- National Waste Policy (2018);
- NSW Waste Avoidance and Resource Recovery Strategy (2014-2021); and
- SafeWork Australia and SafeWork NSW guidance on asbestos in the workplace and asbestos in and on soil.

Other guidelines adopted in the preparation of this report are referenced throughout this report.

Section 2. Hazards: Asbestos

2.1 General

This section provides a summary of the properties and hazard of asbestos.

Hazard identification examines the capacity of an agent to cause adverse health effects in humans and other animals. It is a qualitative description based on the type and quality of data, complementary information (such as structure-activity analysis, genetic toxicity and pharmacokinetics) and the weight of evidence from these various sources (enHealth 2012a). The hazard assessment can also consider the available data and determine a dose-response relationship that can be used to define quantitative guidelines or toxicity reference values for use in a risk assessment. The dose-response relationship is key to being able to quantify hazards and therefore risks.

The presence of a hazard does not, by itself, automatically result in adverse health effects. It is the dose or level of exposure that is important to making decisions about the potential for health effects (i.e. the risks).

Risk assessment incorporates the understanding of hazard with information related to exposure to determine if the dose or exposure is sufficiently elevated to result (or potentially result) in adverse health effects.

2.2 What is asbestos

Asbestos is the generic name given to the fibrous variety of six naturally occurring minerals. These minerals have been used in a wide range of commercial products. The minerals are hydrated silicates including a serpentine mineral (*chrysotile*) (also known as 'white asbestos'), and five amphibole minerals (*actinolite, amosite* (also known as 'brown asbestos'), *anthophyllite, crocidolite* (also known as 'blue asbestos'), and *tremolite*) (enHealth 2005, 2013; IARC 1973; USGS 2001).

The structure of these silicate minerals depends on the conditions under which they were formed. They may be long, thin fibres or they may take a range of other shapes. It is when they are in the form of the long, thin fibres that they are of most concern. The terms 'asbestos' or 'asbestiform minerals' refer only to those silicate minerals that occur in these long, thin fibres and as polyfilamentous bundles. The bundles are composed of extremely flexible fibres with a relatively small diameter and a large length. These fibre bundles have splaying ends, and the fibres are easily separated from one another (HSE 2005; USGS 2001).

Most asbestos used for commercial purposes was the serpentine mineral – chrysotile. Chrysotile is the only one of the three principal serpentine silicate minerals that can present in a fibrous form. Of the amphibole silicate minerals, amosite and crocidolite occur only in the asbestiform habit, while tremolite, actinolite and anthophyllite occur in both asbestiform and non-asbestiform habits (i.e. as fibres and as other shapes which do not require the same sort of evaluation) (enHealth 2005, 2013; HSE 2005; NTP 2005; USGS 2001).

Asbestos fibres are strong (e.g. high tensile strength, wear and friction characteristics), flexible (e.g. the ability to be woven), heat resistant (e.g. heat stability; thermal, electrical and acoustic insulation) and they have insulating properties and they are resistant to chemical, thermal and biological degradation (enHealth 2005, 2013; HSE 2005; NTP 2005; USGS 2001).

The fibres are light and their shape means they do not settle out onto surfaces very quickly unlike larger particles or particles of different shapes so they remain airborne for some time (enHealth 2013).

2.3 Sources of asbestos

Asbestos is widely distributed in the Earth's crust, and chrysotile, which accounts for more than 95% of global mining and use, occurs in virtually all serpentine minerals. Asbestos deposits have served as commercial sources in more than 40 countries, but the largest natural deposits are located in Canada, South Africa, China, and Russia. Amosite and crocidolite have been mined from South Africa, while crocidolite was once mined in Western Australia.

Asbestos fibres are basically chemically inert. They do not evaporate, dissolve, burn, or biodegrade, making them environmentally stable and cumulative. Asbestos fibres can be released into the air as a result of mechanical and natural disruption of asbestos containing materials (ACM) during use and disposal. Because of the widespread use of asbestos and their natural occurrence, the fibres are ubiquitous in the environment. Asbestos-containing materials that do not result in respirable fibres pose virtually no risk to health similar to other inert materials.

Asbestos fibres are present in normal urban air. Such fibres are present due to historic uses including in brake pads in cars. They are also present because this is a naturally occurring material, where fibres can be disturbed from rocks containing the mineral deposits (enHealth 2013).

Man-made asbestos containing products (ACM) can be divided into two types – bonded and friable asbestos. In good condition, bonded asbestos products such as asbestos cement sheet do not pose a risk because the asbestos fibres are bound together in solid cement. Friable asbestos products produce airborne fibres and so do pose a risk. It should be noted that bonded asbestos products can be damaged to become friable (enHealth 2013).

2.4 Health effects associated with asbestos exposure

2.4.1 General

Although the link between occupational exposure to asbestos and lung diseases such as mesothelioma was suspected over a century ago, it wasn't until the 1960's that the link was well established. Most evidence of the adverse health effects of asbestos (IARC 2012) comes from epidemiological studies of groups with known occupational exposures to asbestos such as those employed in the asbestos mining, processing or production industries or in the building trade. However, it is also clear that environmental (e.g. living near an asbestos mine) or para-occupational exposures (e.g. household contact with exposed workers) can result in asbestos related diseases.

Additionally, the background level of asbestos related disease may be related to the ubiquity of this naturally occurring mineral fibre. The annual mesothelioma rate in adults with no history of asbestos exposure is about 1.5 per million people (McDonald, J. & McDonald 1977; Peto 1984). This is considered low. The etiology (i.e. the cause) of these cases is unknown. Low-level environmental exposure to asbestos and asbestiform minerals has been postulated as a factor in these cases

(Omenn GS 1986). Berry et al (Berry, GR, AJ. Pooley, FD. 1989) reported that the lung burden of amosite and crocidolite fibres in 37 'unexposed' mesothelioma cases ranged up to 8.1 million fibres per gram of dry lung tissue (median 0.31). In summary, asbestos fibres are widespread in the environment, but the incidence of asbestos-related disease is extremely low, except in cases of high occupational or para-occupational exposure. This means everyone breathes in asbestos fibres during their lifetime. The small burden of fibres resulting from this background exposure appears to be tolerated.

Extensive epidemiological research on asbestos shows clear associations between asbestos exposure and asbestosis, lung cancer, and mesothelioma. The epidemiological evidence for other types of cancer is less extensive than it is for lung cancer and mesothelioma, but is still considerable for some. Epidemiological evidence shows a high incidence of lung cancer among workers exposed to chrysotile, amosite, anthophyllite, and with mixed fibres containing crocidolite, and tremolite. Pleural and peritoneal mesotheliomas were reported to be associated with occupational exposures to crocidolite, amosite, and chrysotile. Gastrointestinal tract cancers were reported to have been demonstrated in groups occupationally exposed to amosite, chrysotile or mixed fibres containing chrysotile. An excess of cancer of the larynx in occupationally exposed individuals has also been noted. In summary, all types of commercially available asbestos are well known to cause fibrosis of the lung and pleura as well as cancer of the lung, mesothelium and possibly the gastrointestinal tract in humans (IARC 2012).

Asbestos-related health effects result primarily from chronic exposures to asbestos, but relatively brief, high-level and low-level neighbourhood exposures in the vicinity of a crocidolite mine or mill, can also cause these diseases. The increased risk of mesothelioma is dose-dependent (enHealth 2005). Short-term exposures to low concentrations of airborne asbestos are likely to be associated with very low health risks (i.e. unlikely to result in disease) (enHealth 2005).

The four main asbestos-related conditions are pleural plaques, asbestosis, lung cancer and mesothelioma (HACA 2016):

- Pleural plaques are areas of white, smooth, raised scar tissue on the outer lining of the lung, internal chest wall and diaphragm. Pleural plaques are uncommon, and their occurrence is usually associated with exposure to asbestos. Most people with pleural plaques have no symptoms. Refer to **Section 2.4.2** for further discussion.
- Asbestosis is a chronic lung disease caused by inflammation or scarring in the lungs. It is associated with asbestos exposure and causes breathlessness, coughing, and permanent lung damage. Refer to **Section 2.4.2** for further discussion.
- Lung cancer is a tumour that develops in the lungs. People who are exposed to asbestos and smoke or have pre-existing lung disease have a higher chance of developing lung cancer. Refer to **Section 2.4.3** for further discussion.
- Mesothelioma is a cancer of the tissue that lines the body cavities, particularly the chest and abdominal cavities. It is almost exclusively caused by exposure to asbestos and usually takes a very long time to develop. Refer to **Section 2.4.4** for further discussion.

Asbestos-related diseases can take a long time to develop. Asbestosis can take 10 to 20 years to develop after initial exposure, whereas mesothelioma may take 30 to 45 years to develop (HACA 2016).

2.4.2 Asbestosis and pleural disease

Asbestosis and asbestos pleural disease are non-malignant asbestos diseases (i.e. not cancer) that are slowly progressive.

Asbestosis is a chronic inflammatory and fibrotic medical condition affecting the parenchymal tissue of the lungs caused by the inhalation and retention of asbestos fibres. Sufferers may experience severe dyspnoea (shortness of breath) and are at an increased risk for certain malignancies, including lung cancer but especially mesothelioma. The characteristic pulmonary function finding in asbestosis is a reduction in lung volumes, particularly the vital capacity (VC) and total lung capacity (TLC). In the more severe cases, the drastic reduction in lung function due to the stiffening of the lungs and reduced TLC may induce right-sided heart failure.

The onset of visible fibrosis rarely occurs earlier than 15–20 years from first exposure to high concentrations of respirable fibres. Not all individuals exposed to high levels of asbestos fibre develop asbestosis. There may be a threshold for asbestosis development of between 25 to 100 fibres-years/mL, effectively a high exposure. This compares to the current occupational time weighted average (TWA) exposure for asbestos fibres of 0.1 fibres/mL (which would require 10 years exposure at 0.1 fibres/mL to equate to 1 fibre-year/mL) (enHealth 2005).

In a review of the epidemiologic evidence for an asbestosis exposure response relationship, the World Health Organization Task Group on Environmental Criteria for Chrysotile Asbestos (WHO 1998) concluded that “the risk at lower exposure levels is not known.” There is evidence of an increased incidence of asbestosis in smokers which may be due to a number of issues such as smoking effects on lung function and defence mechanisms, however, no specific ‘dose’ of tobacco that caused this enhanced incidence could be determined (ATSDR 2001). Lung fibre retention is expected to play a role in the development of asbestosis with trapped asbestos fibres having a prolonged lung residence time. Therefore, the progression of asbestosis may continue for many years after exposure (ATSDR 2001).

Asbestos pleural disease is a non-malignant disease caused by inhalation of asbestos fibres that scar the pleura. The pleura is the thin membrane lining the lung and chest cavity. If the scarring is diffuse and extends along the chest wall, it is called pleural thickening. If the scarring is more focused and well defined, it is called pleural plaques. Asbestos pleural disease results in a similar scarring process as the one that occurs inside the lung with asbestosis; however, it occurs in the lining of the lungs rather than in the lungs themselves (ATSDR 2001). In regards to pleural plaques, enHealth (2005) provides the following:

> *The relationship between dose and response for pleural plaques is much weaker than for asbestosis. A good correlation has been shown between pleural plaques and asbestos fibres in the lungs; however, there is large variation.*

As these diseases generally occur only after heavy industrial exposure they are of limited relevance to this review and have not been specifically discussed further.

2.4.3 Lung cancer

National and international health agencies have classified asbestos as a known human carcinogen. This includes classifications available from IARC (IARC 2012) and the USEPA (USEPA 2020).

Asbestos, by itself or acting synergistically with tobacco smoke, causes lung cancer. Lung cancer can occur many years after initial exposure (10–40 years). Lung cancer has been identified in people exposed to respirable asbestos in occupational environments and has been associated with exposure to both amphibole and chrysotile asbestos (ATSDR 2001). The causal association between asbestos exposure and lung cancer is generally well recognised, but there are still substantial controversies on how the risk might vary by exposure to different fibre types and sizes, and whether there is a risk at low levels of exposure (i.e. environmental/community exposures).

There is some evidence that chrysotile asbestos may be less potent for the induction of lung cancer than the amphibole forms of asbestos (e.g. crocidolite, amosite and tremolite). This “amphibole hypothesis” (Cullen 1996; McDonald, JC. 1998; Stayner, Dankovic & Lemen 1996) is based on the observation from experimental studies that chrysotile asbestos is less biopersistent (i.e. has a shorter half-life) in the lung than the amphiboles. IARC (IARC 2012) noted that the lower biopersistence of chrysotile in the lung does not necessarily imply that it would be less potent than amphiboles for lung cancer.

2.4.4 Mesothelioma

Mesothelioma is a cancer of the lining of the chest cavity (the pleura) or, less commonly, the lining of the abdominal cavity (the peritoneum).

It is generally, but not always, associated with continued occupational or other high exposure to respirable asbestos. Fairly consistent and strong epidemiological evidence indicates that approximately 70% to 90% of mesothelioma cases can be related to asbestos exposure (Youakim 2005), and hence it is commonly accepted that asbestos exposure is the cause.

The ability to link asbestos exposure to the development of mesothelioma is subject to sufficient time elapsing since the exposure occurred, to permit the disease to have initiated and developed. Mesothelioma generally does not occur until 20–50 years after exposure. Mesothelioma has been associated with all types of asbestos. However, the evidence for causality is strongest for amphiboles. Unlike lung cancer, mesothelioma occurrence does not appear to be affected by smoking history.

Mesothelioma can occur with low asbestos exposure; however, very low background environmental/community exposures carry only an extremely low risk. The dose necessary for effect appears to be lower for asbestos-induced mesothelioma than for pulmonary asbestosis or lung cancer (ATSDR 2001).

The incidence rates of malignant mesothelioma have been increasing in Australia since 1965 and it is clear that these rates of mesothelioma are related to the use and production of asbestos in Australia in previous decades. There is no indication of when the incidence rates of mesothelioma will start to decline although a recent update of Wittenoom workers stated that by the end of 2008, the number of mesothelioma deaths related to direct exposure at Wittenoom had reached 4.7% for all the male workers and 3.1% for the females and predicted that about another 60 to 70 deaths with mesothelioma may occur in men by 2020 (Berry, G et al. 2012).

The link between asbestos exposure and the incidence of lung cancer and mesothelioma has been assessed in more than 20 epidemiological studies of occupational exposure in traditional asbestos industries. There is much less evidence of a link between non-occupational or para-occupational exposures and asbestos related disease. In the first published study to show exposure-response relationships between incidence of mesothelioma and environmental/community exposure to any form of asbestos, the incidence rate of mesothelioma for Wittenoom residents with household contact with crocidolite miners or neighbourhood exposure to crocidolite tailings has been estimated to be 260 per million person-years (Hansen et al. 1998). The incidence of mesothelioma increased significantly with increasing time following first residence at Wittenoom and with increased level of exposure to crocidolite. The incidence of mesothelioma increased from about 210 per million person-years (pmpy) at 20–29 years since first exposure, to over 1,600 pmpy at 40 or more years from first exposure. This rate is substantially higher than the 1998 Western Australian rate of 50 pmpy for men and 8 pmpy for women. The corresponding figures for the Wittenoom workers' cohort were approximately 900 and 7,000 pmpy. (Hansen et al. 1998).

The background incidence rate of mesothelioma in people without occupational, domestic or neighbourhood exposure to asbestos and with normal lung fibre content is about one or two annual deaths per million of population, which translates broadly to a lifetime risk of 8 to 16 per 100,000 for either sex although recent data indicates this could be as high as 25 per 100,000. Whether this background level is in fact caused by naturally occurring asbestos, or asbestos-like materials in the natural environment, by other causes or by a mixture of causes, is not known (WATCH 2002-2012).

2.5 Asbestos mode/mechanism of action

2.5.1 General

The quantitative assessment of potential risks to human health for any chemical requires the consideration of the health end-points and, where carcinogenicity is identified; the mechanism of action needs to be understood. The IARC (IARC 2012) review concluded that "*The mechanistic basis for asbestos carcinogenicity is a complex interaction between crystalline mineral fibres and target cells in vivo. The most important physicochemical properties of asbestos fibres related to pathogenicity are surface chemistry and reactivity, surface area, fibre dimensions, and biopersistence*."

In addition to the degree of exposure (magnitude or intensity, frequency and duration), the physical properties of the fibres, including fibre type, size and shape are important determinants of asbestos related diseases. The physical and chemical properties, persistence in the lungs and capacity to translocate across membranes are factors that underpin the intrinsic toxicity of the various asbestos types.

2.5.2 Fibre dimensions

Fibre dimension determines the likelihood that a fibre will enter the body insofar as the size and shape influence the respirability and clearance of the fibres as well as the potential for translocation across cells and biological membranes. In terms of shape, fibres >8 μm long and <0.25 μm diameter, with an aspect ratio (length/width) ≥10 appear to be most dangerous. In terms of length, fibres >20 μm and <100 μm long tend to be more carcinogenic. Fibres >100 μm long are not respirable (cannot reach the lungs) and hence do not pose a risk, unless they are first broken down into shorter fibres.

Asbestosis has been associated with fibres longer than 2 μm, mesothelioma with fibres longer than 5 μm, and lung cancer with fibres longer than 10 μm (Lippmann 1988, 1990). Fibres <5 μm are considered to be much less potent than longer fibres, however, in typical occupational environments, fibres shorter than 5 μm outnumber the longer fibres by a factor of 10 or more (Dement & Wallingford 1990). As noted, studies report that longer thinner fibres are more carcinogenic but do not identify a precise fibre length that did not have biological activity (Berman & Krump 2008; Stanton & Wrench 1972). Studies looking at human tissues have also found that the majority of asbestos fibres in mesothelial tissues were shorter than 5 μm in length, thus indicating the ability of the shorter fibres to reach the tumour site, remain there, and have an unspecified role in the etiology of disease (Dodson, Ronald F et al. 2001; Suzuki & Yuen 2002). There is clear evidence that short fibres predominate in the lung, thoracic lymph nodes and mesothelial tissue following asbestos exposure (Dodson, Ronald F. et al. 2003). Furthermore, short fibres appear to more readily migrate to the pleura and are present in substantial amounts in pleural plaques, pleural fibrotic tissue and mesotheliomas.

2.5.3 Fibre respirability

Fibre diameter is an important determinant of carcinogenic potency, as it influences fibres' aerodynamic diameter, a contributing factor for pulmonary deposition. Specifically, the diameter of fibres impacts their deposition rate and clearance rate from the lungs and the body overall, and thus the amount of time they have to interact with biological systems.

The following general conclusions can be made about particle respirability (USEPA 2003):

- Fibres that are deposited in the lung are usually thinner than approximately 0.7 μm and are almost always thinner than 1 μm.
- Long, thin fibres are deposited in the lung with greater efficiency.
- Because of physical/chemical differences, short, thick chrysotile structures will be deposited more efficiently in the lung than corresponding (i.e., short, thick) amphibole structures and longer, thinner amphibole structures are typically deposited more efficiently than corresponding chrysotile structures.
- Curly chrysotile structures are less likely to reach the lung than are straight amphibole (or chrysotile) structures.

2.5.4 Fibre clearance

Once inhaled, asbestos fibres can be removed from their site of deposition (WHO 2000) by:

- Mucociliary clearance
- Translocation within alveolar macrophages
- Uptake by epithelial cells.

These mechanisms usually remove 95-98% of deposited fibres, as most of the fibres have lengths less than <5 μm. Fibres less than 15 μm are often engulfed by macrophages. Longer fibres may be more pathogenic because they are harder to clear from the lungs. Most reports have shown that fibre accumulation is proportional to measured exposure for amphiboles, but this is not generally true for chrysotile. For amosite and crocidolite, estimated clearance half-times are measured in years to decades, whereas for chrysotile, the available, rather indirect, data suggest that the vast majority of fibres are cleared within months, although some fibres may be sequestered and only cleared very slowly. Although both chrysotile and amphibole asbestos are generally insoluble, within the lungs, chrysotile fibres can subdivide into constituent fibrils that will partially dissolve and those that don't dissolve at all. Overall, these studies suggest that the differences between amphibole and chrysotile fibre burdens in man reflect much faster clearance of chrysotile fibres, rather than a failure of chrysotile deposition.

Clearance rates partially determine biopersistence, that is, the degree to which fibres remain or persist in the body. Biopersistence is influenced by fibre size which in turn dictates respirability, deposition, as well as clearance from the lung. Chrysotile has been shown to be rapidly removed from the lung following inhalation exposure in experimental animals (Bernstein, Chevalier & Smith 2005), while lung analyses from humans (Albin et al. 1994) who were primarily exposed to chrysotile fibres show low levels of chrysotile compared to amphibole fibres even when amphibole exposure represented a trace impurity of overall exposure (Rowlands, Gibbs & McDonald 1982).

In summary, there is clear support for the view that the epidemiological literature and mechanistic animal studies show a strong correlation between fibre length and carcinogenic potency for asbestos (ATSDR 2001). Risk assessments should thus give greater importance to fibres greater than 10 μm in length while accepting that shorter fibres may also play a role in asbestos cancer etiology.

2.5.5 Fibre type

There is some uncertainty around the types or severity of illness attributable to the different mineralogical types of commonly encountered asbestos. The asbestos industry has supported research and published various studies claiming that chrysotile is much less toxic than the amphibole forms such as crocidolite and amosite.

For example, arguments have been presented that:

- mesothelioma incidence associated with chrysotile exposure is actually attributable to relatively low concentrations of other asbestos fibre types
- chrysotile is less potent than other asbestos fibres in the induction of asbestosis and lung cancer based upon observed differences in fibre persistence, morphology, composition and lung fibre burdens
- there is a threshold for chrysotile fibre exposure below which pathological effects will not occur or will be undetectable in epidemiological studies.

However, strong experimental support for reduced chrysotile toxicity on a mechanistic basis remains lacking. WHO (WHO 2014) states that: *'The scientific evidence is clear. The firm conclusion of the WHO and IARC assessments is that chrysotile causes cancer of the lung, larynx and ovary, mesothelioma and asbestosis, whether or not it is less potent than amphibole types of asbestos in doing so. Assertions about differing physicochemical properties, the question of whether or not historical epidemiological studies may have been dealing with chrysotile contaminated with* *amphibole types of asbestos, and the physical containment of chrysotile in modern high-density cement (at the time of manufacture) do not alter this finding.'*

The WA Rationale states that *'While it is reasonable to anticipate differences in toxicity according to the mineralogy and dimensions of asbestos fibres, current scientific knowledge is not yet able to provide meaningful distinction. In addition, it is evident that the influence of confounding environmental exposure factors on asbestos toxicity may be significant, particularly in non-occupational settings. From a regulatory perspective, the assumption that the potential health impacts posed by different asbestos fibre types and dimensions are equivalent is therefore considered both conservative and reasonable.'*

Based on the existing data, most regulators adopt different risk levels for the different types of asbestos based on some large meta-analyses (Berman & Krump 2008; Hodgson, J & Darnton 2000). Some of these risk levels have recently been re-appraised. (Hodgson, JT & Darnton 2010) updated their meta-analysis of the potency of chrysotile asbestos fibres to cause mesothelioma and revised their potency estimate upward (i.e. higher risk).

2.5.6 Human susceptibility to asbestos-related disease

Studies have also demonstrated that not all people are similarly affected by exposure to the same levels of asbestos as is the case for many diseases. Multiple diseases are associated with asbestos exposure and other environmental or genetic factors may interact e.g. there is a synergistic effect between cigarette smoking and lung cancer.

Several populations that may be unusually susceptible to asbestos exposure have been identified (ATSDR 2001). The long-term retention of asbestos fibres in the lung and the long latency period for the onset of asbestos related disease suggests that those exposed earlier in life (as children) may be at greater risk. Early developmental differences may also lead to increased childhood susceptibility. An association has been noted between certain genotypes and increased risks of mesothelioma, cancers and non-malignant respiratory disease (Neri et al. 2008). In Cappadocia, Turkey, certain families in specific villages show an autosomal dominant susceptibility to developing mesothelioma after exposure to erionite, a naturally occurring mineral that shares the same structure as asbestos (Ascoli et al. 1998; Huncharek, Klassen & Christlani 1995).

Animal studies suggest that those who are immunologically deficient may experience increased severity of pulmonary lesions in response to asbestos exposure. Further studies indicate that genetic differences in immunological capabilities may be a predisposing factor for asbestos related disease. Some human studies have suggested that individuals infected with Simian Virus 40 may be at increased risk of developing mesothelioma.

2.5.7 Mode of action

Fibres that persist within the lung or the mesothelium are capable of producing fibrogenic and tumorigenic effects in these tissues. Although the precise mechanisms by which asbestos fibres cause toxic injury have not been determined, there are several proposed modes of action including both direct interaction between fibres and cellular components and induced cell-mediated pathways (ATSDR 2001).

- *Direct action*: Asbestos fibres can adsorb to a variety of cellular macromolecules (e.g., proteins, membrane lipids, RNA, DNA), an interaction mediated by surface charge. Fibres can also bind to fibronectin, a glycoprotein found in abundance in the alveolar lining fluid. Fibre binding can alter protein shape, stiffen membranes and interfere with chromosome segregation.
- *Active oxygen mechanism:* In response to asbestos fibres, alveolar macrophages produce reactive oxygen species in an attempt to digest the fibre. The reactive oxygen species include hydrogen peroxide and superoxide radical anion which can interact to produce potent hydroxyl radicals. Cell membrane lipids have been shown to undergo peroxidation, resulting in increased membrane permeability in rat lung fibroblasts cultured with asbestos. Overall, cytotoxic and oxidative responses indicative of oxidative stress in a variety of lung tissues have been observed following asbestos exposure.
- *Other Cell-Mediated Mechanisms*: In addition to the release of active oxygen species, alveolar macrophages and other cells, including pleural mesothelial and lung cells, release a number of cellular factors in response to asbestos exposure. These factors are mediators of a number of cellular reactions including inflammation, macrophage recruitment and cell proliferation.

2.6 Quantification of hazard

Asbestos is considered to act with a non-threshold dose response relationship (WHO 2000, 2014). This means that there is no safe dose for asbestos exposure, however, the risk of asbestos-related disease increases with increasing dose or exposure.

The WHO (2000) provides unit risk values relevant to the assessment of asbestos exposure, and mesothelioma, based on data from a number of studies. The WHO best estimate (which notes a number of uncertainties) is a risk of $2x10^{-5}$ for exposure to 100 f/m^3. This assessment has been used in the derivation of the NEPM guidelines for asbestos in soil (NEPC 1999 amended 2013a; WA DOH 2009)

The WHO (WHO 2000) further indicates that, with a lifetime exposure to 1000 f/m^3 (0.0005 f/ml or 500 f/m^3, optically measured) in a population of whom 30% are smokers, the excess risk due to lung cancer would be in the order of $10^{–6}$–$10^{–5}$. For the same lifetime exposure, the mesothelioma risk for the general population would be in the range $10^{–5}$–$10^{–4}$.

The USEPA currently adopts an inhalation unit risk of 0.23 (f/mL)$^{-1}$ and the most recent review (USEPA 2020) has proposed an inhalation unit risk of 0.16 (f/mL)$^{-1}$ for chrysotile asbestos exposures.

2.7 Asbestos fibre measurement

The inhalation of micron-scale asbestos fibres is the major exposure pathway for this material. Consequently, the determination of risk and occupational exposure limits is based, in large part, on the accurate determination of fibre concentrations in the air. However, all measurement procedures are complicated by the considerable variation in physical structure and chemical composition that are found with the different forms of asbestos.

Regulatory definitions specify mineral species identification based on chemistry and crystal structure, but can also specify physical parameters, such as length and width, which apply to and define particles that meet specific counting rules. This is frequently done by identifying approved analytical methods, such as ISO 10312 (ISO 2019) or NIOSH 7400 (NIOSH 2019), that clearly define for the analyst which particles should and should not be counted.

Historically, the most commonly used definitions (e.g., those used by the Occupational Safety and Health Administration [OSHA], National Institute for Occupational Safety and Health [NIOSH], and World Health Organization [WHO]) for a regulated form of “asbestos” are limited to those structures longer than 5 μm and with a defined length-to-width (aspect) ratio of 3:1 or sometimes 5:1; rarer definitions (e.g., AHERA as used by the U.S. Environmental Protection Agency [EPA]) include different length parameters.

Most regulations are based on numbers of countable particles per unit volume of air. Generally, the regulatory definitions have evolved historically for practical reasons related to the analytical sensitivities of the instruments used in regulatory measurements. As such, they may include categories that do not produce health effects or, conversely, may exclude some that do (Case et al 2011).

Three main forms of microscopy have been used for measuring asbestos: ordinary light microscopy (OLM); phase contrast microscopy (PCM); and transmission electron microscopy (TEM).

Ordinary light microscopy **(OLM)** is the most limited method as there can be no distinction made between mineralogies or morphologies. OLM is generally limited to detecting particles that are much larger than those detected using phase contrast and electron microscopy, which makes it the least useful of the readily available methods.

In the 1980s, the USEPA developed an approach for assessing asbestos risks (USEPA 1986) which assumes no differences between the potencies of different asbestos types (amphibole and chrysotile). At the time, the most likely analytical method used for asbestos analysis was Phase contrast microscopy (PCM).

Phase contrast microscopy **(PCM)** using the membrane filter method has been used for many years as the standard procedure for the determination of asbestos fibres in air in Australia. The Australian National Occupational Health and Safety Commission (NOHSC) has published a Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres (2nd. Ed.) (NOHSC 2005).

“Countable fibres” are defined as any fibrous objects having a maximum width less than 3 μm, a length greater than 5 μm and a length/width ratio greater than 3:1. These guidelines do not place a requirement on the quantification of fibres below 5 μm in length in occupational settings even though the available evidence indicates that such fibres represent the majority of fibres released from asbestos building materials (Spurny 1989; Teichert 1986b).

The detection limit of this method is 0.01 f/mL level. Laboratories are present in Australia that are NATA accredited for analysis using PCM.

This methodology has been adapted from occupational hygiene practice in the asbestos industries in the 1970's and 1980's and has been adapted for use on sites involving asbestos removal from the 1980's. The PCM methodology is somewhat limited in all but high public risk situations because almost all data are recorded as below detection limit (e.g. <0.01 f/mL or <10,000 fibres per cubic metre of air). The method does not provide an air quality dataset that may be able to be used on a daily basis to understand emerging changes in risk during site remediation and identify any warning signs that elevated levels could occur.

Unlike OLM, PCM is able to measure smaller asbestos structures and also determine their shape. However, PCM can only measure particles greater than 0.25 μm in diameter and 0.5 μm in length. This can result in underestimation of narrow asbestos particles, which may be important for accurately quantifying asbestos cancer risk (Berman, D & Crump, K 2008; Berman, DW & Crump, KS 2008). It has been shown in previous studies that PCM significantly underestimates asbestos fibre concentration in air when compared to TEM, primarily because of poor resolution (Perry 2004). Other limitations of PCM include the inability to distinguish between particle mineralogy and, in some instances, the inability to distinguish between asbestiform and non-asbestiform particles. Depending on the sample matrix, this inability to clearly identify only asbestos fibres could potentially result in overestimation of the concentration of asbestos present on a filter. The possibility of either underestimation from poor resolution, or overestimation from misidentification of non-asbestiform particles, causes PCM to be an inaccurate method for estimation of asbestos concentrations.

***Transmission electron microscopy* (TEM) or scanning electron microscopy (SEM)** – Analytical Method 7402 –Asbestos measured by TEM (Baron & Platek 1990) quantifies the asbestos fibre fraction of all fibres in air samples when there is any uncertainty as to the composition of the samples. Unlike other analytical techniques used for asbestos analysis, TEM/SEM is able to distinguish different fibre mineralogies. TEM is able to reveal fibres that are less than 0.01 μm in diameter and SEM is able to reveal fibres down to 0.05 μm in diameter. As a consequence, different fibre size classes of both amphibole and chrysotile asbestos can be differentiated. TEM is slower and more expensive and may be able to achieve lower detection limits than PCM. It is noted, however, that the detection limit is affected by the small portion of the sample that can be observed under high magnification.

In general, there is a lack of standardised methods for TEM/SEM and an absence of proficiency testing. Few laboratories have been identified in Australia that can conduct TEM/SEM analysis. Review of the NATA website indicates that only one laboratory in Australia is NATA accredited for asbestos and inorganic fibre identification using SEM.

Overall

PCM is the predominant method used in all workplace determinations principally because of its relative ease of use and cost advantage. There are limitations with each of these procedures. For example, PCM may underestimate the concentration of relevant fibres as this visual procedure cannot accurately determine fibres below 0.2 μm in diameter. Importantly, all of the asbestos types can produce fibres below this size which cannot be easily determined by optical resolution (Brown 2000). In addition, PCM procedures routinely count only fibres longer than 5 μm in length. The conventional PCM method is adequate for monitoring the breathing zone of workers (wearing respiratory protection) so that the level of protection to workers near asbestos sources are quantitatively monitored. Static asbestos-in-air monitoring at the boundary of sites undergoing remediation etc. using the conventional membrane filter method will typically produce 'below limit of detection' data.

PCM techniques are not able in some situations to accurately distinguish morphologically non-asbestos fibres from asbestos fibres. Fibres below 5 µm in length may still be very relevant to asbestos mediated health effects in humans (Suzuki, Yuen & Ashley 2005; Tossavainen, Karjalainen & Karhunen 1994) and are best evaluated using electron microscopy methods. However, the more sensitive analytical methods utilizing electron microscopy are time and labour intensive and suffer from standardisation problems between laboratories (Wagner 2002).

Currently, environmental laboratories offering asbestos in soil analysis can provide a variety of methods, some of which are accredited and some are not:

- Gross visual screen, often performed as soils are mixed and weighed out for other analyses – this will only detect ACM – no quantification
- Detailed screen using a x10 – x40 standard optical microscope – this will detect ACM and most free fibres – no quantification
- Identification of asbestos type by Phase Contrast Optical Microscopy (PCOM) or Polarised Light Microscopy (PLM) – no quantification
- Quantification by gravimetric measurement – visible pieces or large bundles are picked out manually and weighed – this will only detect ACM to 0.1%
- Quantification by sedimentation and fibre measurement using PCOM or PLM (fibres) – this will detect fibres to 0.001%
- Quantification and identification by Transmission Electron Microscopy – this is a high resolution method which will detect fibres to 0.0001%, but the equipment is extremely expensive and only available in a very small number of laboratories

Comments on hazards and measurement

It is clear that there are a range of hazards posed by the potential presence of asbestos in any environment. The key hazards relate to asbestos fibres that are of biological concern, i.e. those equal to or longer than 5 μm and having diameters up to 3 μm with an aspect ratio equal to or greater than 3:1, that can move into the air and be inhaled.

Asbestos is naturally occurring in many areas and is also present as a result of historical uses of asbestos materials, hence asbestos is expected to always be present in the environment.

When assessing asbestos, there are a range of different methods that can be used to quantify asbestos fibres, some of which enable characterisation of the fibres with characteristics that have the potential to pose hazards to human health when inhaled. The selection of the quantification method is important as each will report different aspects in relation to asbestos exposure and risk. Hence guidelines are often tied to specific analytical methods.

Section 3. Asbestos exposure and risk

3.1 General

Breathing in asbestos fibres is the main pathway linked to risk of developing an asbestos related disease. This risk is increased with the number of fibres breathed in (i.e. the dose) and the length of time of exposure. This is illustrated in **Figure 3.1**, that illustrates the risk factors relevant to asbestos (enHealth 2013). Touching the fibres or eating them has not been linked to disease.

Every Australian is exposed to very low levels of asbestos in the air we breathe every day. There are usually between 10 and 200 asbestos fibres in every 1000 litres of air. This means we breathe in up to 3000 asbestos fibres a day (also refer to **Section 3.4** for additional discussion in background exposures). Despite this very few people experience ill effects from such exposure (HACA 2016).

Most people who have developed asbestos related diseases in Australia have had exposure to much higher levels of asbestos fibres through working directly with asbestos or asbestos products. Family members of these workers have also been known to develop asbestos-related diseases because the workers carried asbestos fibres home on their clothing, skin and hair (HACA 2016).

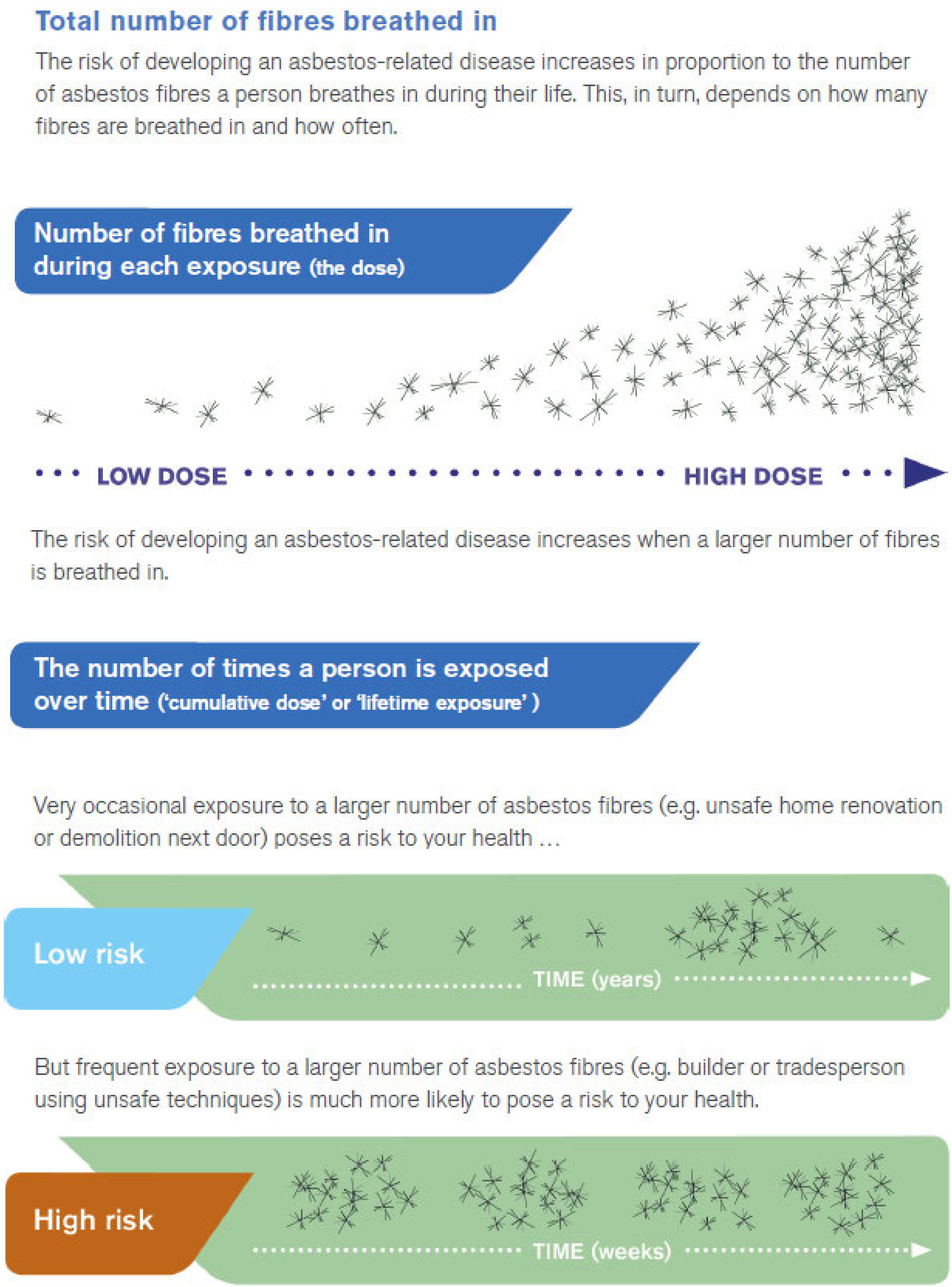


Figure 3.1: Risk factors in developing asbestos-related disease (enHealth 2013)

3.2 Risks posed by asbestos

The hazards associated with exposure to asbestos relate to the inhalation of small fibres (refer to **Section 2**) (enHealth 2013). Hence risks posed by the presence of asbestos materials depends on the nature and condition of the material and the potential for asbestos fibres to be released to air.

The common forms of asbestos include (enHealth 2005, 2013):

- Bonded products, where asbestos is bound into solid products with asbestos comprising around 10% to 15%. The materials are solid, rigid and non-friable and the fibres are not often released to air. These materials are commonly referred to as 'fibro', 'asbestos cement' and 'AC sheeting'. Bonded ACM is visible. **Where intact, these materials are considered very low risk. Where damaged or badly weathered, the materials may become friable and the risk is increased in such situations**. Further discussion on the potential for asbestos fibres to be released to air from weathering and mechanical damage is provided in **Section 3.3**.

- Friable products are generally soft and loose and crumble into fine material or dust with light pressure. Such products contain a high levels of asbestos (up to 100%) and the fibres can easily be released to air. **These materials pose the highest risk**. Unless present in complete products, once disturbed or crushed the fibres are not visible.

  In the demolition of structures in NSW (and Australia), all friable asbestos (including any building that has fire damaged asbestos materials) is required to be properly removed by a suitably licenced person. Where this process is properly undertaken, there should be no friable asbestos present in demolition materials removed from the site (post asbestos removal).

Figure 3.2 produced by enHealth graphically displays this risk information (enHealth 2013). The risk terms outlined by enHealth, as presented in this figure, have been used in this assessment with the following contextualisation relevant to this assessment:

- A '**very low risk**' is considered to relate to concentrations of asbestos fibres indistinguishable from background ranges and estimated not to exceed 0.01 f/mL in concentration.
- A '**low risk**' is considered to relate to concentrations of asbestos fibres slightly above background for a short period of time. These slightly increased concentrations are very unlikely to exceed 0.01 f/mL and are estimated to not exceed the occupational guideline of 0.1 f/mL.

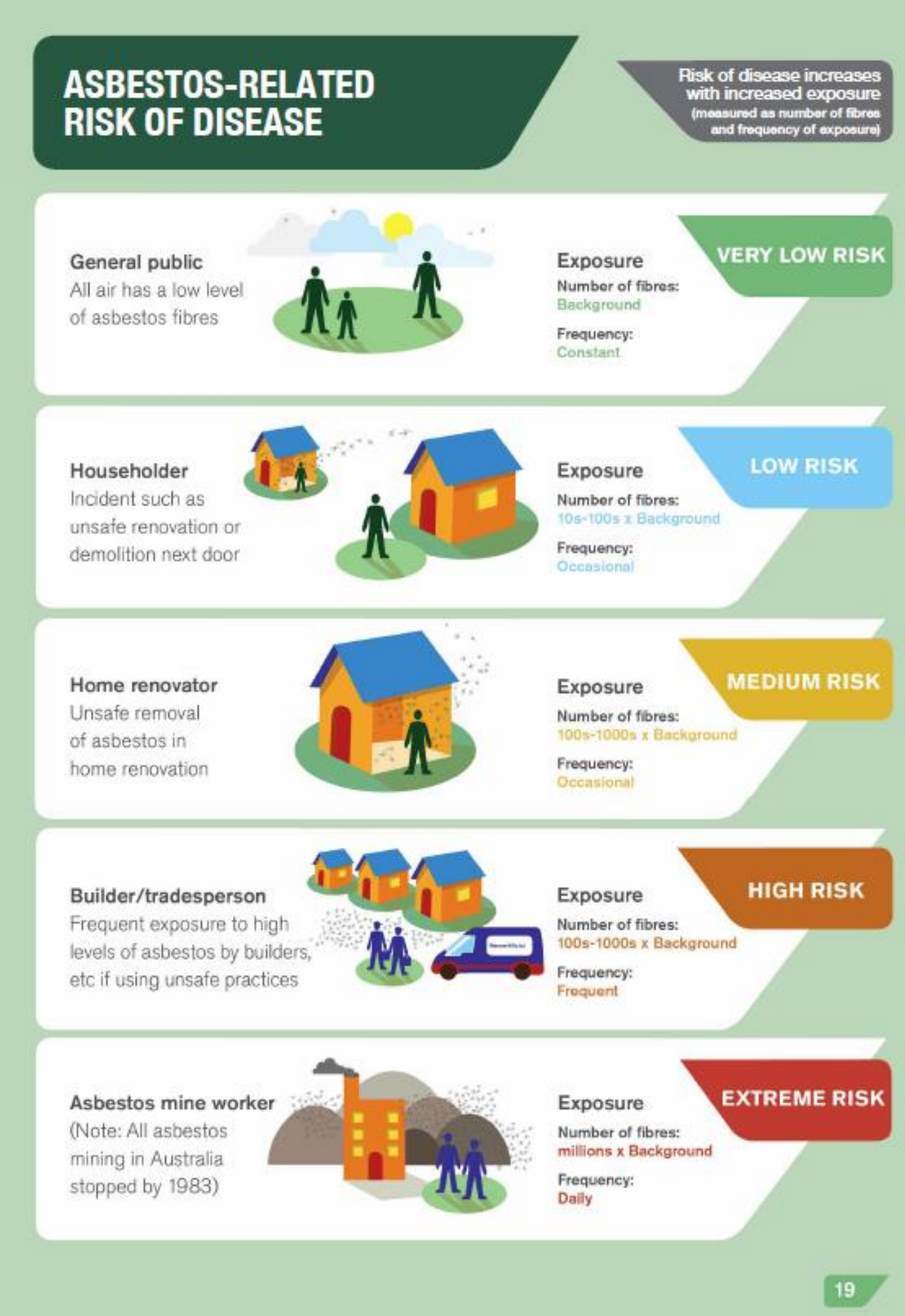


Figure 3.2: Asbestos related risk guide developed by enHealth (2013)

3.3 Effects of weathering and damage of asbestos in cement materials

The performance of asbestos cement (AC) materials requires that the cement matrix adheres to the outside of the asbestos fibres and fibre bundles so that the high tensile strength of the fibres is used to create a stronger product, than if just cement alone was used. The asbestos is added to the cement and wet mixed before being formed, compressed and cured to produce the end product.

In the asbestos cement, which contains approximately 10% – 15% of asbestos by weight, the larger asbestos bundles may be visible by eye especially at newly fractured edges. Any physical breaking and cracking of AC material exerts high mechanical forces to the fracture surface and tends to pull out asbestos fibres and bundles, thus making them more able to become airborne. Fires and very high temperatures cause the hydrated cement to release water vapour and the cement sheet to expand internally, leading to explosive failure where the sheet will crack and spall extensively, leaving areas of pulled-out fibres. A proportion of the fibres disturbed during mechanical breakage will be made airborne at the time. Mechanical attrition of the cement will also lead to release of airborne asbestos fibres and cutting of the cement sheets with saws and angle grinders are particularly able to release fibres from inside the AC. Similarly, mechanical cleaning of dry surfaces of AC sheets are also known to release substantial numbers of airborne asbestos fibres (Burdett 2007).

A typical example of a chrysotile bundle present in a sample of AC material following breakage is shown in **Figure 3.3**. Although the matrix material will 'cement' particles together, and some of the exposed fibres will have cement particles adhered to the fibres, the bundles of chrysotile fibre contain many fibres and fibrils, which are not in direct contact with the cement matrix and may not have cement fragments adhered to the surface (Burdett 2007).

Primarily, the weathering of an AC sheet is based on its major component (90% cement). As it weathers the more resistant asbestos is left increasingly free of the cement matrix. Therefore, weathered asbestos cement often has the potential to release more fibres from the surface than unweathered asbestos cement due to the much greater numbers of loosely bound fibres exposed on the surface. In more extreme cases, weathering may cause the surface to flake or crack, giving an even greater area from which asbestos may be released into the air (Burdett 2007).

Asbestos fibres are typically resistant to weathering, however, the AC product is expected to be affected by weathering. The nature of the weathering may affect the potential for loose asbestos fibres to be present that may move into the air. Where materials have undergone significant weathering from water or acidic materials (or leaching) there is the potential for asbestos fibres to be exposed and remain on the surface of the AC material (refer to **Figure 3.4**) (Campopiano et al. 2009). Other forms of weathering may result in asbestos fibres and bundles being exposed (refer to **Figures 3.5 and 3.6**), some of which may include particles of concrete adhered to the fibres, but there may be some fibres where no concrete is adhered (Burdett 2007; Campopiano et al. 2009).

More detailed review of the asbestos fibres from these weathered AC materials indicates some have a coating (mainly calcium) and many of the individual fibres have attached cement particles, while others do not (Burdett 2007). These are further illustrated in **Figure 3.7**.

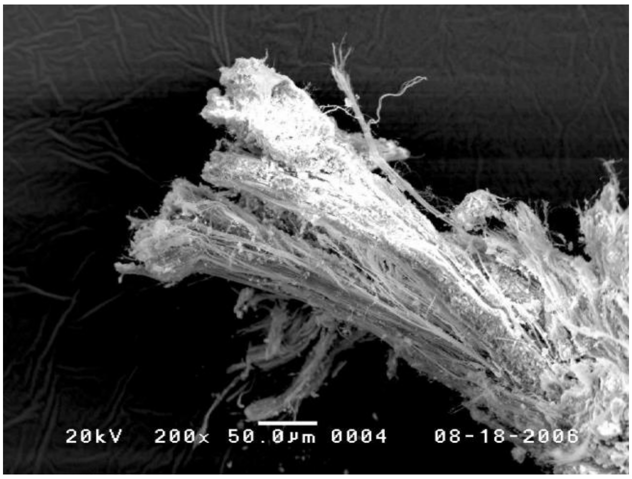


Figure 3.3: Chrysotile fibre bundle projecting from broken section of AC material (scanning electron microscopy [SEM] image at approx. x 200) (Burdett 2007)

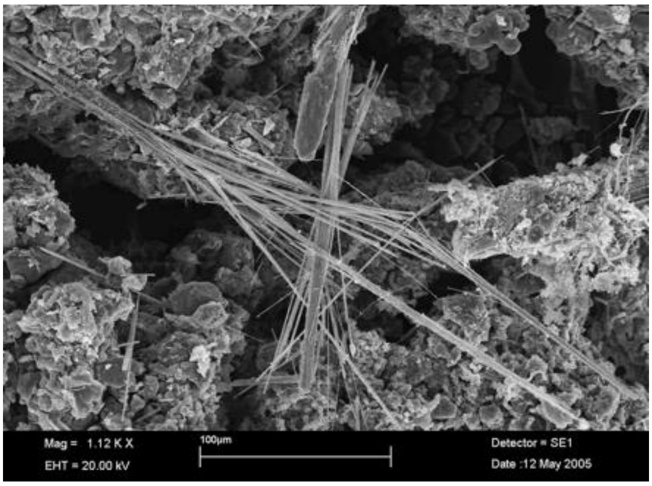


Figure 3.4: Amosite fibres exposed or detached from cement sheeting following weathering (SEM image) (Campopiano et al. 2009)

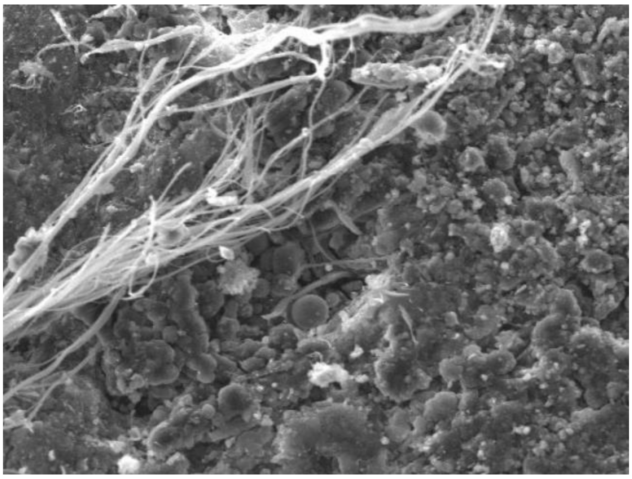


Figure 3.5: Chrysotile fibres exposed on the surface of weathered AC material (SEM image at approx. x 600) (Burdett 2007)

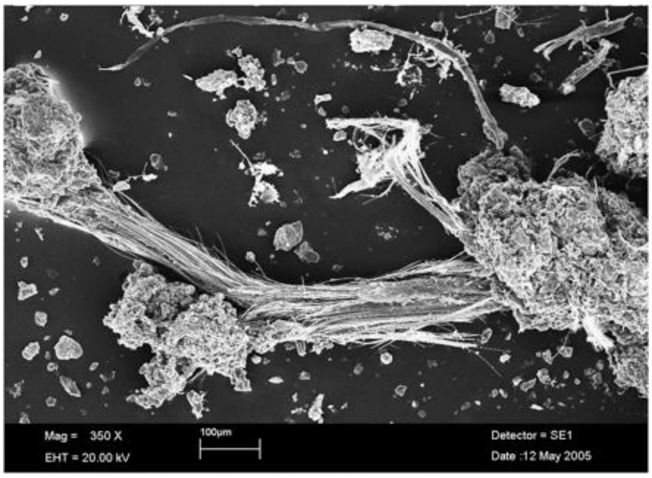
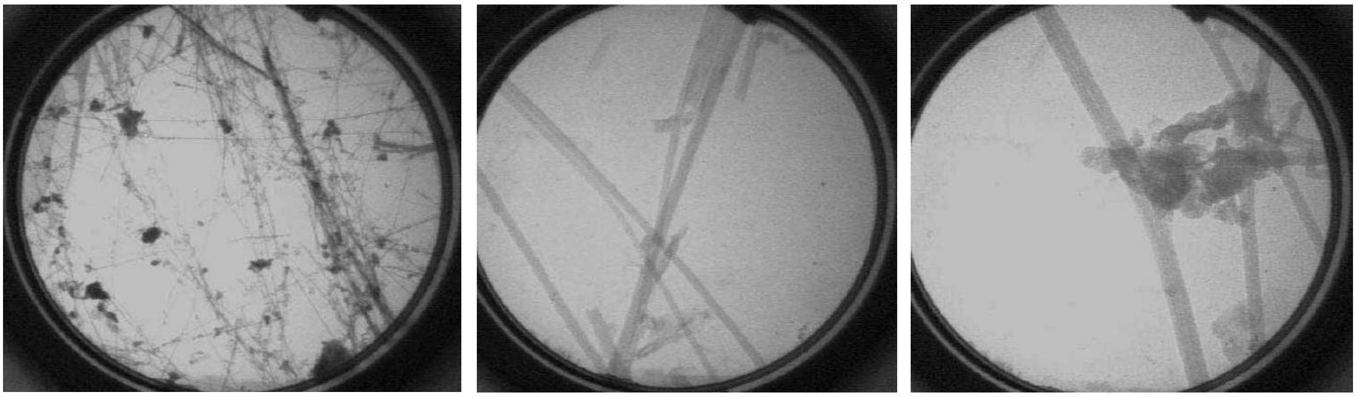


Figure 3.6: Chrysotile fibres detached from weathered AC material (SEM image)



A **B** **C**

Figure 3.7: Chrysotile fibres from weathered AC material, A: showing small cement particles attached to the fibres, B: Fibres at high magnification showing no evidence of coating or many attached particles, C: High magnification example of particle attached to fibre (Burdett 2007)

Overall, it appears that the vast majority of fibres are uncoated and there is no evidence to support the claim that all the chrysotile has been chemically or structurally altered (Burdett 2007).

Further review of asbestos fibres in air (derived from these weathered materials) identified that the fibres had only a few small particles of cement attached or were free of any coating or particles, as illustrated in **Figure 3.8**. This may suggest that the presence of cement particles on asbestos in weathered material may reduce the potential for asbestos fibres to be present in air, with only fibres with small amounts of cement particles or no cement particles moving into the air phase.

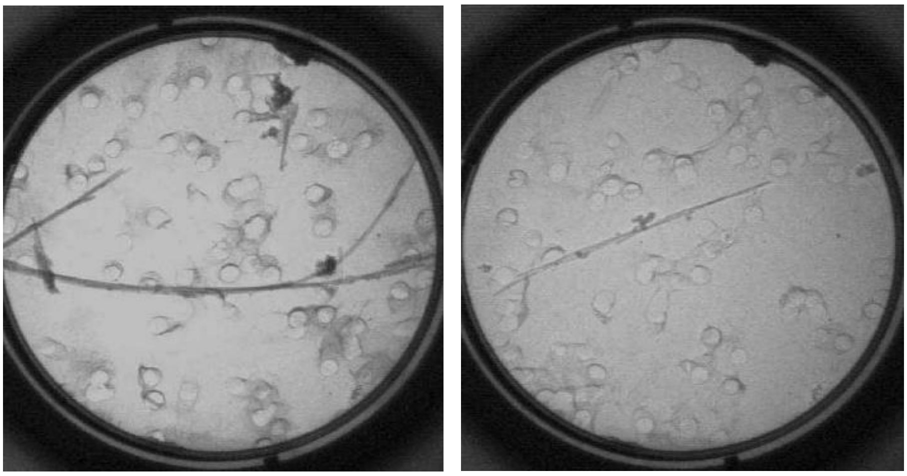


Figure 3.8: Examples of magnified airborne chrysotile fibres from weathered AC material, showing a few small particles attached to fibres and fibres free of particles (Burdett 2007)

The fibres found in the air samples essentially showed no significant alteration and would be able to be distinguished as asbestos fibres using standard methods (Burdett 2007).

In relation to the inhalation of asbestos fibres derived from the weathering or damage to AC materials, there are no differences in the carcinogenic potencies between 20 year old weathered chrysotile asbestos fibres from the surface of AC sheets and friable chrysotile asbestos fibres (Spurny 1989; Tilkes & Beck 1989).

Human epidemiology has shown that chrysotile asbestos cement manufacture is low risk compared to other asbestos products. The low risk is largely due to the lower levels of fibre emissions in the manufacturing industry, as much of the asbestos production is carried out using wet processes and when dry the asbestos is locked into a resilient cement matrix. There was also increasing use of dust controls in western production plants (Burdett 2007).

Teichert (Teichert 1986b, 1986a) concluded that despite evidence of “considerable erosion”, only “very low” (i.e. in most cases undetectable) asbestos fibre emissions were observed from AC roofing. A strength of this work was that fibre concentrations were related to the prevailing weather conditions at the time of measurement. The proportion of released fibres in the external air that were asbestos in nature were reported to be very low at 1.1 % for shorter fibres of 2.5 µm to 5.0 µm in length and less than 0.2% for fibres greater than or equal to 5.0 µm in length (Teichert 1986b).

In a review of their previous work Spurny (Spurny 1989) concludes that AC corrodes in response to “aggressive” atmospheric pollution (e.g. to acids arising for sulfur dioxide and other industrial gases). The extent of corrosion is dependent on several factors including the concentrations of these pollutant gases, the relative time of exposure and the prevailing weather conditions. Spurny (1989) indicates, however, that only about 20% of free asbestos is released into the air. The remaining 80% is hypothesised to be removed by rain. It is not known if these northern European findings can be directly related to the drier conditions found in Australia (ASCC 2008).

Overall, the broad consensus from the available information is that the release of asbestos fibres is exceedingly small from non-friable asbestos materials (AC) as a result of aging, weathering and/or corrosion (ASCC 2008; Burdett 2007). This is partly due to:

- The relatively lower amount of asbestos used in this product compared to others; and
- The hard resistant nature of the cement matrix which makes it more difficult to release airborne fibres (as noted above);

AC is considered non-friable and has a low hazard except when physically damaged or handled (e.g. by using power tools and other machinery). Where released to air, fibres from these materials are no less hazardous than those released from friable asbestos.

3.4 Background exposure

Natural sources are important, because asbestos minerals are widely spread throughout the earth's crust and are not restricted to the few mineable deposits. In particular, chrysotile is present in most serpentine rock formations. Emissions from these sources are due to natural weathering and can be enhanced by man's activities, such as quarrying or street building. Very little, however, is known about the amounts emitted from natural sources (WHO 2000). Man-made emissions originate from activities in the following categories:

a) mining and milling
b) manufacture of products
c) construction activities
d) transport and use of asbestos-containing products
e) disposal.

Indoor asbestos fibre concentrations can be considerably higher than outdoor concentrations.

Asbestos fibres normally constitute only a relatively small fraction of the total number of fibres in ambient air. The biologically more important so-called "critical" fibres are those equal to or longer than 5 µm and having diameters up to 3 µm with an aspect ratio equal to or greater than 3:1 (WHO 2000) as already discussed.

Table 3.1 presents a summary of the available data on background levels of asbestos in air in urban, rural and industrial areas. In addition, the table includes calculated lifetime burdens, i.e. the number of asbestos fibres inhaled over a lifetime in urban and rural areas compared with workplace exposures. This shows that all members of the population are always exposed to asbestos in air, with significant (a million to many millions) numbers of fibres inhaled over a lifetime, even where no exposure occurs in a workplace. In spite of this, the general population (non-occupationally exposed population) does not contract asbestos related disease in any significant numbers. The background rate of mesothelioma is noted to be less than 1.5 per million per year.

Table 3.1 Summary of background levels of asbestos reported in the environment

Exposure	Concentrations reported ($f/cm^3 = f/mL$)	Reference
Urban air (typically 10 times higher than rural)	0.000003 to 0.0198 for multiple countries 0.00004 to 0.05 (0.0011 mean) in US 0.0016 to 0.0037 (0.0016 mean) for 1990's US 0.0001 to 0.001 lowest background	(Krakowiak et al. 2009) (Abelmann et al. 2015) (ASCC 2008) (WHO 2000) (IARC 2012)
Rural air	0.0003 to 0.0218 for multiple countries 0.0000048 to 0.013 (0.00039 mean) in US 0.000014 to 0.000092 (0.000018 mean) in 2000's in US 0.00001 to <0.0001 lowest background	(Krakowiak et al. 2009) (Abelmann et al. 2015) (ASCC 2008) (WHO 2000) (IARC 2012)
Industrial air	<0.0006 to 91.4	(Krakowiak et al. 2009)
Heavy traffic road crossing or freeway	0.0009 to 0.0033	(WHO 2000)
Indoors	<0.001 buildings with no ACM <0.001 to 0.01 buildings with friable asbestos 0.00003 to 0.006 in homes, schools etc 0.00012 (mean) in US	(WHO 2000) (IARC 2012) (ATSDR 2001) (Lee & Van Orden 2008)
Outdoor ambient levels or background	0.00003 to 0.0047 in the US	(Glynn et al. 2018)

Exposure	Concentrations reported ($f/cm^3 = f/mL$)	Reference
Lifetime burdens	**Urban population** exposed to 0.00003 to 0.0002 f/cm^3, exposure for 70 years = ~1.5 x 10^7 to 10^8 accumulated fibres	(WHO 2000)
	Rural population exposed to 0.00001 f/cm^3, exposure for 70 years = 10^5 to 10^6 accumulated fibres	(WHO 2000)
	Asbestos workers exposed to 0.1 to 1 f/cm^3 Exposure for 50 years = 10^{10} to 10^{11} fibres Exposure for 0.7 year (incidental exposure) = 5x10^7 fibres	(WHO 2000)

Comments on exposure and risk

Different types of asbestos pose different levels of risk to workers and the community. The level of risk posed by asbestos will depend on the nature of the materials in which asbestos is present, and the nature and duration of exposure.

High Risks – This relates to asbestos that may be present as friable asbestos, that can easily move into air where exposure may occur. The greater the duration of exposure to scenarios where these fibres are present in air in elevated numbers, the greater the risk. The presence of friable asbestos in building and demolition waste is expected to be negligible where these materials are properly removed in accordance with existing regulatory requirements and guidelines that require these materials to be removed by a licenced contractor prior to any demolition.

Low Risk – This relates to asbestos that remains bound or bonded in products, where there is a very low potential for asbestos fibres to be released to air, even where weathering may have occurred.

Risks may be increased where these materials are heavily weathered or mechanically damaged, and asbestos fibres may be available to move into the air. The movement of asbestos to air may be more limited from these materials. However, once in air, the hazards posed by airborne asbestos fibres remain unchanged.

The background presence of asbestos, relevant to all members of the community in urban and rural areas means that the concept of zero asbestos or zero asbestos exposure and risk is meaningless.

While it is accepted that zero tolerance is part of NSW asbestos waste regulations and community expectations, the concept is meaningless in technical terms. Everyone is exposed to fibres from natural sources. Such sources are not targeted for management by regulation or policy.

These background exposures have been further considered in relation to the concept of trivial in **Section 6**.

Section 4. Asbestos guidelines – Australia

4.1 General

There is scientific uncertainty regarding the dose–response relationships for asbestos – i.e. how many fibres are needed to cause the various effects. There is also considerable public concern about unwilling exposure to asbestos fibres. As a consequence, regulators typically adopt a conservative approach to policy and guidelines in relation to asbestos.

4.2 Regulation of asbestos in Australia

Exposures to asbestos in the past were very high in some Australian industries and occupations. For example, there has been as much as 25 million particles per cubic foot (150 fibres/mL) in asbestos pulverisers and disintegrators in the asbestos cement industry (Roberts and Whaite, 1952 quoted in Leigh et. al. (Leigh et al. 2002)), and up to 600 fibres/mL in baggers at Wittenoom (Major, 1968 in Leigh et.al. 2002). However, the recognition of the associated health risks led to a series of regulations being adopted nationally in the late 1970s. Exposure limits of 0.1 fibres/mL for crocidolite and amosite; and 1.0 fibres/mL for chrysotile were imposed. In July 2003, a revised national exposure standard for chrysotile asbestos of 0.1 fibres/mL was declared by the National Occupational Health and Safety Commission (NOHSC).

The asbestos air-quality limit for protecting the public around contaminated sites is 0.01 fibres per millilitre (f/mL) (using the membrane filter method) as endorsed by the enHealth Council (enHealth 2005; NOHSC 2005).

In 2001 NOHSC declared a prohibition on all uses of chrysotile asbestos from 31 December 2003, subject to a very limited range of exemptions, and confirmed earlier prohibitions on the use of amosite and crocidolite asbestos. The prohibition of chrysotile was adopted simultaneously under regulations in each Australian OHS jurisdiction, as well as Australian Customs, on 31 December 2003. The prohibition does not extend to ACMs that were in situ at the time prohibition took effect (i.e. part of existing buildings) and is subject to a very limited range of exemptions. Since 1988, NOHSC and then the ASCC, has provided detailed guidance material to minimise occupational exposures to asbestos. This material was revised in 2005, and most recently in 2018 and 2020 and includes national codes of practice for the safe removal of asbestos (Safe Work Australia 2018) and for the management and control of asbestos in the workplace (Safe Work Australia 2020). It also includes a Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres 2nd Edition [NOHSC:3003(2005) (NOHSC 2005)].

4.3 Australian guidelines for asbestos in contaminated sites

The ASC NEPM (NEPC 1999 amended 2013a) sets out soil levels for asbestos for different site uses below which no effects would be expected. These are derived from guidance developed by the Western Australian Department of Health (WA DOH 2009).

The asbestos in soil guideline values have been based on preventing the entrainment of asbestos fibres into the breathing zone of sensitive receptors from normal activities relevant to different long-term uses of land. In the derivation of soil guidelines, the WA Department of Health and the NEPM (Assessment of Site Contamination) use a risk-based and, where necessary, conservative approach to the uncertainties associated with protecting the public from asbestos-contaminated sites and employ the following general contamination criteria:

- The investigation criterion or clean-up goal is 0.001% asbestos in soil on a weight for weight basis (w/w) for free fibre-related materials including fibrous asbestos and free fibre itself. It should be noted that this criteria is 10 times lower than the original criteria (0.01%) derived by the Dutch (Swartjes & Tromp 2008) to account, in part, for the drier Western Australian soil;
- Depending on site use, at least a 10-fold higher criteria is applied to asbestos-containing materials (ACM) (i.e. bonded) in sound condition, such as commonly found asbestos cement fragments, since these pose much lower risks to human health; (NEPC 1999 amended 2013a; WA DOH 2009).

The derived health screening levels for asbestos in soil, as adopted in the ASC NEPM are listed in **Table 4.1** (NEPC 1999 amended 2013a).

Table 4.1: Summary of NEPM screening levels for asbestos in soil (NEPC 1999 amended 2013a)

Health Screening Levels for Relevant Land use Settings (w/w)				
Form of asbestos	**Residential A[1]**	**Residential B[2]**	**Recreational C[3]**	**Commercial/ Industrial D[4]**
Bonded ACM	0.01%	0.04%	0.02%	0.05%
FA and AF[5] (friable asbestos)	0.001%			
All forms of asbestos	No visible asbestos for surface soil			

Notes:
1. Residential A with garden/accessible soil also includes children's day care centres, preschools and primary schools.
2. Residential B with minimal opportunities for soil access; includes dwellings with fully and permanently paved yard space such as high-rise buildings and apartments.
3. Recreational C includes public open space such as parks, playgrounds, playing fields (e.g. ovals), secondary schools and unpaved footpaths.
4. Commercial/industrial D includes premises such as shops, offices, factories and industrial sites.
5. The screening level of 0.001% w/w asbestos in soil for FA and AF (i.e. non-bonded/friable asbestos) only applies where the FA and AF are able to be quantified by gravimetric procedures. This screening level is not applicable to free fibres.

The available soil criteria detailed above are based on the protection of human health (all workers and members of the public) associated with long-term (chronic[1]) exposure for commonly undertaken activities for the various land uses (NEPC 1999 amended 2013a).

It is noted that the ability of National Association of Testing Authorities (NATA) accredited laboratories, using Polarized Light Microscopy (PLM) as specified in available methods, to quantify asbestos in such low concentrations in bulk soil samples is limited to a reporting limit of 0.01% (w/w)

[1] Chronic exposure refers to exposures that may occur over at least a year. Within the NEPM chronic exposures relates to exposures over 25 years for residents and users of public open space areas and 30 years for workers

(Standards Australia 2004). Regulators may request that an attempt is made to quantify asbestos contamination at levels below 0.01% (w/w) but this is technically difficult.

4.4 Air guidelines

There are currently no ambient air quality criteria for asbestos in any state in Australia. It is noted that the WA DoH guidelines for asbestos in soil (which has been utilised in the development of the soil guideline discussed in **Section 4.3**) adopts the WHO air quality guideline value of 0.001 f/mL.

Lifetime exposure to asbestos-in-air at 0.0001 f/mL of air (>5 microns in length) has been estimated to produce about 2–4 excess cancer deaths (lung cancer plus mesothelioma) per 100,000 people.

The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA 2016b) provides methods for the assessment of air pollutants from stationary sources[2] in NSW. This applies to new as well as existing facilities where there are emissions to air. The document includes guidance on the interpretation of the modelling results and includes assessment criteria for air pollutants that should not be exceeded at or beyond the site boundary. This guidance includes assessment criteria for asbestos in air as: 0.18 mg/m^3 over a 1 hour averaging period (refer to Table 7.2a of NSW EPA 2016a). This means that asbestos can be lawfully released directly to air from new and existing stationary sources in NSW provided the concentration in air at or beyond the site boundary is below the assessment criteria.

It is noted that the NSW assessment criteria for asbestos is presented in mg/m^3, which is not comparable with other data and guidelines. Based on the most common measurement technique (phase contrast light microscope) the conversion adopted in this assessment is 30 f/ml per mg/m^3 (NRC 1984; USEPA 1986). Using this conversion, the assessment criteria is 5.4 f/ml as a 1 hour average concentration. If this criteria is converted to a long-term average (i.e. an annual average) (Ontario MfE 2004) the assessment criteria would be 0.43 f/ml. This is a long-term air criteria that is significantly elevated (by many orders of magnitude) above the WHO health based air guidelines and background levels (as detailed in **Section 3.4**).

The above essentially means that NSW guidance currently allows for significant emissions to air of asbestos from new and existing stationary sources at levels that would be considered to pose a significantly elevated (and arguably unacceptable) risk to community health.

4.5 NSW asbestos regulation

Asbestos is regulated in NSW by SafeWork NSW, the Environment Protection Authority (EPA), councils, emergency service organisations and the NSW Department of Planning and Environment (DPE).

The Heads of Asbestos Coordination Authorities (HACA) was established in 2011 to ensure that NSW government agencies and councils effectively coordinate the safe management of asbestos to help reduce the incidence of asbestos related diseases in NSW. The HACA is chaired by SafeWork NSW with senior representatives from: Department of Industry, Department of Planning and

[2] Stationary sources are defined (NSW EPA 2016a) as "any premises-based activity; does not include motor vehicles".

Environment, Dust Diseases Authority, Environment Protection Authority, Local Government NSW, Ministry of Health, Office of Emergency Management, Office of Local Government.

HACA published an Asbestos Blueprint in 2011. The Blueprint was updated most recently in 2017 (SafeWork NSW 2017). The Asbestos Blueprint is designed to provide clarity and improved coordination of asbestos regulation in NSW, leading to better protection of the health and wellbeing of the community and workers. Improved coordination of regulatory services also leads to better services for the public. The Blueprint also provides the public with a clear description of the regulatory landscape.

Figure 4.1 provides an overview of the complex inter-governmental agency interactions and responsibilities in relation to all phases of asbestos management in NSW. **Table 4.2** provides a summary of asbestos legislation and regulations in NSW. These are taken from the Asbestos Blueprint (SafeWork NSW 2017).

In the ground	Naturally occurring asbestos	DPE/Councils
	Mineral extraction, abandoned mines	DPE
	Declared contaminated land	EPA
	Non-declared contaminated public land	EPA/Councils
	Non-declared contaminated non-workplace land	EPA/Councils
	Non-declared workplace - contaminated land	SafeWork NSW
	Asbestos remediation work	SafeWork NSW
	Illegal dumping	EPA
Supply	Illegal import/export	SafeWork NSW through DIBP
	Illegal supply	SafeWork NSW
Buildings and vehicles	Licensed asbestos assessors	SafeWork NSW
	At workplaces	SafeWork NSW
	At non-workplaces	Councils
Removal	Licensed removal work and asbestos assessors	SafeWork NSW
	At workplace not requiring a licensed removalist	SafeWork NSW
	At all locations by a PCBU or worker	SafeWork NSW
	At non-workplaces — all other cases	Councils
Emergencies	Response to emergency incidents	Fire & Rescue NSW (HAZMAT)
	Major recovery operations	Fire & Rescue NSW (HAZMAT)
	Routine recovery operations	Councils
	Waste export	EPA through DIBP
Transport and disposal	Transport by vehicle	EPA
	Landfill facilities	EPA
	Scheduled waste storage and disposal facilities	EPA
	Waste transport — interstate	EPA
	Temporary on-site waste storage — workplaces	SafeWork NSW
	Laundering facilities	SafeWork NSW

Figure 4.1: Regulatory responsibilities based on asbestos mineral life cycle (SafeWork NSW 2017)

Table 4.2: Asbestos Legislation and Regulations in NSW (SafeWork NSW 2017)

Topic	Legislation
Work health and safety	*Work Health and Safety Act 2011 (WHS Act 2011)* *Work Health and Safety Regulation 2017 (WHS Regulation 2017)* *Work Health and Safety (Mines and Petroleum Sites) Act 2013* *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014*
Environmental protection	*Protection of the Environment Operations Act 1997* *Protection of the Environment Operations (General) Regulation 2009* *Protection of the Environment Operations (Waste) Regulation 2014* *Contaminated Land Management Act 1997* *Environmental Trust Act 1998* *Dangerous Goods (Road and Rail Transport) Regulation 2009*
Planning	*Environmental Planning and Assessment Act 1979* *Environmental Planning and Assessment Regulation 2000* *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* *State Environmental Planning Policy (Infrastructure) 2007* *State Environmental Planning Policy (State and Regional Development) 2011* *State Environmental Planning Policy No 55 – Remediation of Land*
Local government	*Local Government Act 1993*
Consumer safety	*Fair Trading Act 1987* *Property, Stock and Business Agents Act 2002* *Home Building Act 1989* (For LFAI) *Conveyancing (Sale of Land) Regulation 2017* (for LFAI) *Residential Tenancies Regulation 2010* (for LFAI)
International trade	*Customs Act 1901* *Customs (Prohibited Imports) Regulations 1956* *Customs (Prohibited Exports) Regulations 1958* *Hazardous Waste (Regulation of Exports and Imports) Act 1989* *Industrial Chemicals (Notification and Assessment) Act 1989* *Industrial Chemicals (Notification and Assessment Regulations 1990*
Emergency response	*State Emergency and Rescue Management Act 1989* *Fire Brigade Act 1989*
Compensation	*Workers' Compensation (Dust Diseases) Act 1942* *Dust Diseases Tribunal Act 1989* *Dust Diseases Tribunal Regulation 2007* *Dust Diseases Regulations 2006* *Dust Diseases Tribunal (Standard Presumptions – Apportionment) Order 2007* *James Hardie (Civil Penalty Compensation Release) Act 2005* *James Hardie Former Subsidiaries (Winding up and Administration) Act 2005* *James Hardie Former Subsidiaries (Winding up and Administration) Amendment Act 2009* *James Hardie Former Subsidiaries (Winding up and Administration) Regulation 2007* *James Hardie (Civil Liability) Act 2006*

4.6 Workplaces

The control of asbestos in the workplace is regulated under the *WHS Act* and the *WHS Regulation*. SafeWork NSW administers the legislation for all workplaces with the exception of mine and petroleum sites which are administered by the Department of Industry (SafeWork NSW 2017). The asbestos requirements specified in these regulations apply to all workplaces, including workplaces at waste disposal sites or sites where temporary storage of materials is required.

Some of the key aspects of the *WHS Regulation 2017* that relate to asbestos are as follows (also refer to **Section 7.2** for further discussion):

- All asbestos or ACM at the workplace must be identified by a competent person. If the material cannot be identified, it must be assumed that the material is asbestos
- If asbestos is identified at the workplace, the person with management or control of a workplace must ensure that an asbestos register and asbestos management plan are prepared.
- A person conducting a business or undertaking (PCBU)/licensed asbestos removalist (holding a licence suitable for the removal of friable and/or non-friable asbestos) must ensure that asbestos waste is contained and labelled before the waste is removed from an asbestos work area, and disposed of as soon as practicable at a site authorised to accept asbestos waste.
- The licensed asbestos removalist must ensure that when the licensed asbestos removal work is completed, a clearance inspection of the asbestos removal area is carried out by a competent person or licensed asbestos assessor, and the person must issue a clearance certificate before the asbestos removal area at the workplace is re-occupied.
- A licence is not required for the removal of small volumes (<10 m^2) of non-friable asbestos (ACM) and there are significantly fewer controls on this work, with no requirements for reporting or the conduct of a clearance inspection and certification.

4.7 Waste

Where asbestos is transported or disposed, this is regulated by the NSW EPA.

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* No 156 (POEO Act) includes the following key aspects in relation to asbestos and waste:

<u>Definitions:</u>

> ***Waste*** *includes -*
>
> *(a) any substance (whether solid, liquid or gaseous) that is discharged, emitted or deposited in the environment in such volume, constituency or manner as to cause an alteration in the environment, or*
>
> *(b) any discarded, rejected, unwanted, surplus or abandoned substance, or*
>
> *(c) any otherwise discarded, rejected, unwanted, surplus or abandoned substance intended for sale or for recycling, processing, recovery or purification by a separate operation from that which produced the substance, or*
>
> *(d) any processed, recycled, re-used or recovered substance produced wholly or partly from waste that is applied to land, or used as fuel, but only in the circumstances prescribed by the regulations, or*
>
> *(e) any substance prescribed by the regulations to be waste.*
>
> *A substance is not precluded from being waste for the purposes of this Act merely because it is or may be processed, recycled, re-used or recovered.*

waste facility *means any premises used for the storage, treatment, processing, sorting or disposal of waste (except as provided by the regulations).*

Asbestos *means the fibrous form of those mineral silicates that belong to the serpentine or amphibole groups of rock-forming minerals, including actinolite, amosite (brown asbestos), anthophyllite, chrysotile (white asbestos), crocidolite (blue asbestos) and tremolite.*

Asbestos waste *means any waste that contains asbestos.*

Building and demolition waste *means unsegregated material (other than material containing asbestos waste or liquid waste) that results from—*

(a) the demolition, erection, construction, refurbishment or alteration of buildings other than -

(i) chemical works, or

(ii) mineral processing works, or

(iii) container reconditioning works, or

(iv) waste treatment facilities, or

(b) the construction, replacement, repair or alteration of infrastructure development such as roads, tunnels, sewage, water, electricity, telecommunications and airports, and includes materials such as -

(i) bricks, concrete, paper, plastics, glass and metal, and

(ii) timber, including unsegregated timber, that may contain timber treated with chemicals such as copper chrome arsenate (CCA), high temperature creosote (HTC), pigmented emulsified creosote (PEC) and light organic solvent preservative (LOSP),

but does not include excavated soil (for example, soil excavated to level off a site prior to construction or to enable foundations to be laid or infrastructure to be constructed).

Section 144AAB - Re-use and recycling of asbestos waste prohibited. A person must not cause or permit asbestos waste in any form to be re-used or recycled (with penalties outlined).

The POEO Act provide penalties for the unlawful disposal of asbestos.

Protection of the Environment Operations (Waste) Regulation 2014

The NSW *Protection of the Environment Operations (Waste) Regulation 2014* includes (by definition) any processed, recycled, re-used or recovered substance produced wholly or partly from waste that is intended to be applied to land or used as a fuel. Part 7 specifically relates to the transportation and management of asbestos waste.

POEO Amendment (Waste) Regulation 2018

The *POEO Amendment (Waste) Regulation 2018* includes the following key aspects:

Provides requirements for the transport and disposal (to landfill) of asbestos waste.

Part 8A is specific to C&D waste facilities where the following definition is provided:

> ***construction waste*** *means:*
>
> *(a) material that results from the construction of buildings or infrastructure (such as roads, tunnels, airports and infrastructure for sewage, water, electricity and telecommunications) and includes materials such as:*
>
> > *(i) bricks, concrete, paper, plastics, glass and metal, and (ii) timber, including unsegregated timber, that may contain timber treated with chemicals, and*
> >
> > *(iii) soil or other excavated material (but not virgin excavated natural material within the meaning of Schedule 1 to the Act), and*
> >
> > *Note. Construction waste includes all building and demolition waste within the meaning of Schedule 1 to the Act.*
>
> *(b) material processed from any material to which paragraph (a) applies,*
>
> *(c) waste that contains any material to which paragraph (a) or (b) applies.*

It is a condition of an environment protection licence for a scheduled waste facility that is a construction and demolition waste facility that the requirements set out in the Standards for managing construction waste in NSW are complied with at the facility.

The NSW EPA Standard on managing construction waste (EPA 2019) requires each load of construction waste that enters a C&D waste facility to undergo inspection. This requires visual inspections at 2 points:

- Inspection point 1 – top of load in truck from an elevated location or using a video camera
- Inspection point 2 – tip and spread in an inspection area, with inspection by trained personnel (visual inspection).

The Standard requires rejection of the entire load where asbestos waste is identified at either of the inspection points.

This standard does not include further risk assessment or testing for friable asbestos fibres. Such fibres are not visible so the inspection process as outlined would not detect these. The standard also does not include any additional definitions of asbestos or asbestos waste.

Dangerous Goods (Road and Rail Transport) Regulation 2014

The *Dangerous Goods (Road and Rail Transport) Regulation 2014* adopts uniform national requirements for the transport of dangerous goods including the requirements of the Australian Dangerous Goods Code ('the Code'). Asbestos is categorised by the Code as a Class 9 dangerous good; however, most asbestos waste is subject to special provision 168.

Special provision 168 – exemptions from the dangerous goods code:

Asbestos which is immersed or fixed in a natural or artificial binder (such as cement, plastics, asphalt, resins or mineral ore) in such a way that no escape of hazardous quantities of respirable asbestos fibres can occur during transport is not subject to this Code. Manufactured articles containing asbestos and not meeting this provision are nevertheless not subject to this Code when packed so that no escape of hazardous quantities of respirable asbestos fibres can occur during transport.

The tracking threshold is 100 kg or 10 m^2 for “transporters of asbestos”.

Comments on the definition of asbestos

The definition of asbestos in the POEO Act, which is adopted throughout all of the NSW regulations and is consistent with the definitions adopted in other states (refer to **Section 4.11**) is very general. Similarly, the definition of asbestos waste is very general and appears to have resulted in the zero-tolerance approach adopted in NSW, where the concept of any asbestos means it is an asbestos waste.

The use of such a general definition does not enable risk to be considered, nor the characteristics of asbestos, namely fibres of a particular length and width that are of importance to the hazards that asbestos poses (refer to **Section 2**). In addition, the definition does not allow any distinction between risks posed by ACM (i.e. likely to be visible (i.e. bonded or in products)), which are low risk, and asbestos fibres that can easily move into the air, which are high risk (refer to **Section 3**).

This lack of regulatory definition, and link with the characteristics of asbestos that are hazardous, results in misunderstanding and misinformation that the hazards relate to the general term asbestos, and how these relate (or not) to the toxicological studies (Case et al. 2011).

Without clarity on the definition of asbestos waste, any facility operating in NSW would carry significant liabilities when dealing with any product, as asbestos may be present in any material from background sources, in addition to being derived from some waste materials.

Further this definition of asbestos is at odds with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (NSW EPA 2016b), that establishes guidelines that allow for new and existing stationary sources to release asbestos to air at and beyond their site boundary at levels that would pose a risk to community health.

4.8 Local Councils

Local councils are responsible for managing asbestos in the community through educating residents, regulating land use and development, and managing waste disposal.

Specifically, this relates to the following (SafeWork NSW 2017):

- Contaminated land:
  - Record known asbestos site contamination on Section 149 certificates where practicable and, for council workplaces, record on council’s asbestos register.

    - Regulate asbestos contaminated land that is not declared 'significantly contaminated' under the *CLM Act 1997* (excluding oversight of removal or remediation work which is the role of SafeWork NSW).
- Demolition:
    - Approve demolition under the *EP&A Act*.
    - Council certifiers may approve development as complying development under the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008*.
- Residential premises:
    - Respond to any public health risks (risks to council workers and wider public) relating to the removal of asbestos containing materials or asbestos work at residential properties that does not involve a business or undertaking.
    - Respond to complaints about unsafe development activities at a residential property.
    - Respond to public health risks posed by derelict properties or asbestos materials in residential settings.
    - Include properties listed on the Loose-fill Asbestos Insulation Register on section 149 (2) planning certificates.
    - In areas where loose-fill asbestos insulation has been identified, include a notation on all section 149(5) planning certificates regarding the potential for loose-fill asbestos insulation in properties that are not listed on the Register.
- Waste:
    - Manage waste facilities in accordance with environmental protection legislation.
    - Respond to illegal storage, illegal dumping and orphan waste.
    - Regulate transport and disposal of asbestos containing materials

4.9 Department of Planning and Environment

The Department of Planning and Environment's (DPE) primary role in the management of asbestos relates to administration of State Environmental Planning Policies, and the *EP&A Act* (and associated Regulation).

While the DPE does not have an operational role in the management of asbestos, it has a regulatory function and provides policy support relating to asbestos and development. In assessing proposals for development under the *EP&A Act*, consent authorities are required to consider the suitability of the subject land for the proposed development. This includes consideration of the presence of asbestos and its environmental impact (SafeWork NSW 2017).

Where asbestos represents contamination of the land (i.e. it is present in excess of naturally occurring levels), *State Environmental Planning Policy No. 55 — Remediation of Land* imposes obligations on developers and consent authorities in relation to remediation of the land and the assessment and monitoring of its effectiveness.

The *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* enables exempt and complying development across the state. While this includes demolition and the removal of asbestos, the *EP&A Regulation* specifies particular conditions that must be contained in a complying development certificate in relation to the handling and lawful disposal of both friable and non-friable asbestos material under the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008*.

4.10 NSW guidance on construction and demolition waste recycling 2010

Asbestos contamination in construction and demolition materials for recycling has been recognised as an issue for a long period of time.

In 2010, WorkCover NSW published a guide on the management of asbestos in recycled construction and demolition waste (WorkCover NSW 2010). This guidance clearly stated that products containing asbestos containing materials (ACM) are prohibited from being sold or used as recycling materials.

The guidance was intended to provide practical assistance to the construction and demolition waste recycling industry to minimise the potential risk of asbestos contamination in recycled C&D materials – e.g. concrete and brick.

It outlines the procedures to manage ACM that may enter a recycling facility. This guide covers the receipt, processing and management of construction and demolition (C&D) materials at construction and demolition (C&D) facilities.

The guidance links with regulatory obligations for the management, control and removal of asbestos.

This guidance provides for the following:

- The definition of asbestos is consistent with that provided in the POEO Act (refer to **Section 4.7** above)
- Site required to advise suppliers that asbestos and ACM will not be accepted, incorporate “no asbestos” clause in contracts, visible signs, trained staff.
- The primary control point for the removal of asbestos is prior to demolition (i.e. not at the waste facility). Buildings and structures normally undergo regulated and comprehensive asbestos removal programs and stringent clearance inspections before they are demolished. If licensed demolishers conduct the demolition, and the waste has ACM removed and separated at the source, the probability of ACM being present should be low.
- However, it is not unusual for mixed waste from unknown sources, or from small-scale demolition or refurbishment activities that place their waste into skip bins, to contain amounts of ACM waste. These sources should be considered high risk.
- An inspection process should be implemented when waste materials are received at the C&D facility. It should be a two-stage process undertaken by trained personnel.
- The first stage takes place on receipt of the load, the second when the load is tipped out (and before it is included in a mass stockpile).
- If friable asbestos is detected, the load should be immediately rejected.
- If bonded ACM is detected, it should be removed in accordance with the *Code of practice for the safe removal of asbestos* and stored appropriately for later disposal. If friable ACM is detected, the load must be isolated and kept wet during the course of further inspection.

- If ACM is detected, the load should be either:
  - assessed by an occupational hygienist
  - rejected and reloaded onto the delivery truck
  - isolated until removal is arranged.

The process is summarised in **Figure 4.2**.

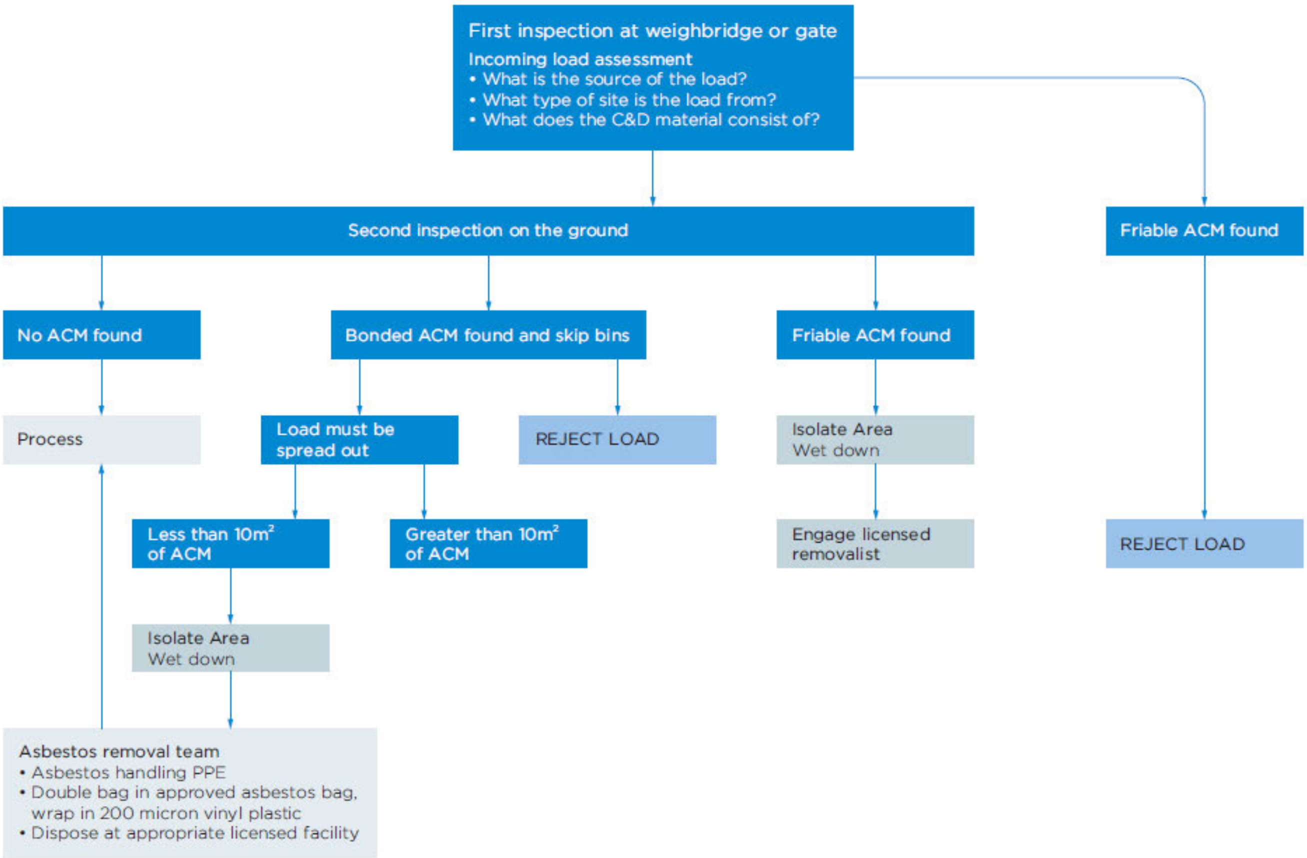


Figure 4.2: ACM inspection process from 2010 guidance (WorkCover NSW 2010)

2014

In 2014, the NSW EPA (NSW EPA 2014) provided a draft protocol on the management of asbestos during resource recovery for C&D waste.

The document states that the protocol has been developed by NSW EPA and WorkCover NSW, in consultation with industry, to:

- prevent asbestos entering a recycling facility
- improve workplace safety at recycling facilities

- outline the management requirements for asbestos where it is discovered in waste, whether unprocessed, processed or supplied to a third party.

The protocol provides practical procedures for verifying that ACM does not contaminate material intended for resource recovery and thereby meets construction industry and community expectations.

The definition of asbestos is consistent with that provided in the POEO Act (refer to **Section 4.7** above).

The protocol follows a similar process as detailed in 2010, with inspection required at the gate (preliminary inspection) and following tipping and inspection (detailed inspection)

Following completion of the detailed inspection:

- Where no asbestos, or suspected asbestos, is observed, the waste can be moved into the storage/processing area or stockpile.
- Where asbestos is sighted or suspected, the entire waste load must be rejected and details of the load entered into the Rejected Load Register.

If asbestos is observed, the load should be immediately wetted down.

The recycling facility operator must maintain an Asbestos Inspection Register where the details of each load of waste inspected in the designated inspection area are recorded.

Where suspected asbestos is observed in a waste stockpile at a recycling facility or in waste-derived materials supplied to a third party or off site, and the facility can satisfy the EPA that it has complied with the requirements of the protocol, a risk-based approach to assessing the waste can be permitted. This means that the waste must be sampled, classified and managed in accordance with this protocol by an occupational hygienist or qualified professional approved by the EPA or WorkCover NSW. The final regulatory decision is a matter for the EPA.

Removal of asbestos, or suspected asbestos, from stockpiles or waste-derived materials supplied to a third party by ‘emu-picking’ or processing of any other kind is not permitted.

Where asbestos is observed in a waste stockpile at a recycling facility or in waste-derived materials supplied to a third party, and the facility cannot demonstrate compliance with the requirements of the protocol to the satisfaction of the EPA, all of the waste material involved is required to be classified and removed to a facility that can lawfully receive it.

Figure 4.3 provides a summary of the steps required in the draft Protocol.

The 2014 draft protocol has never been finalised, and it is understood that the draft document was withdrawn by the EPA in 2019.

Appendix I: Steps for sampling and removing asbestos waste from stockpiles and supplied waste-derived materials

Note: Handling, storage, transport and disposal of asbestos waste must be in accord with the requirements of the Protection of the Environment Operations (Waste) Regulation 2005.

Scenario
One or more pieces of ACM (or suspected ACM) is identified in a stockpile or supplied waste-derived materials

Step 1
Immediately cease adding to or removing from the stockpile or supplied waste-derived material (except in line with the steps below) and manage as per Section 6.1 of the protocol, including notifying the EPA on 131 555. Where approved by the EPA, remove from the stockpile or waste-derived material each piece of ACM and one cubic metre of the stockpile surrounding it. This cubic metre is deemed to have a minimum waste classification of Special Waste (asbestos waste) (or any higher class as determined in accord with the EPA *Waste Classification Guidelines*) and must be disposed of to a landfill that can lawfully receive that waste.*, **

Step 2
Segregate from the stockpile or supplied waste-derived material the 20 cubic metres immediately adjacent to and surrounding each cubic metre removed in Step 1. Move this 20 cubic metres to an area that is not contaminated with asbestos, divide it into four separate 5-cubic metre sections and spread them to a height of not more than 100 mm, ideally on a hardstand (such as a concrete pad) and inspect for visible ACM.

No visible ACM detected

Step 3a
Regroup the 20-cubic metre section of waste into a single separate pile and collect one 10-litre sample for analysis. The sample must be sent to an accredited NATA laboratory and analysed for asbestos in accord with the requirements of AS4964-2004: *Method for the qualitative identification of asbestos in bulk samples.*

Visible ACM detected

Step 3b
The separated 20 cubic metres is deemed to have a minimum waste classification of Special Waste (asbestos waste) (or any higher class as determined in line with the EPA *Waste Classification Guidelines*) and must be disposed of to a landfill that can lawfully receive that waste.*, **

Asbestos not detected

Step 4a
The 20 cubic metres of waste can lawfully be managed in accord with its usual waste classification. It can be returned to the original stockpile once Steps 1–3 have been followed for all pieces of ACM identified in the original stockpile.
The entire stockpile of waste or supplied waste-derived materials can now lawfully be managed in accordance with its usual waste classification.

Asbestos detected by lab analysis

Step 4b
40 cubic metres of the stockpile or supplied waste-derived materials surrounding and immediately adjacent to this 20 cubic metres must be tested and managed as in Steps 2 and 3a or 3b.

Step 4c
If ACM and/or asbestos is detected in the 40 cubic metres separated for visual assessment and testing in Step 4b, repeat that step on 40-cubic-metre quantities until it can be demonstrated that the waste material is free of asbestos or ACM.

* In accord with Section 6.2 of the protocol, submit an Asbestos Survey and Sampling Report to the EPA prior to the removal of any Special Waste (asbestos waste) from the facility.
** Within seven days of the disposal of the waste, submit an Asbestos Disposal Report to the EPA which meets all of the requirements of Section 6.3 of the protocol.

Figure 4.3: Procedures for managing asbestos in C&D materials as per Draft Protocol (NSW EPA 2014)

2020

It is understood that the NSW EPA is developing a new or updated Asbestos Unexpected Find Procedure which aims to provide an approach to managing what is termed “unexpected finds” at resource recovery facilities. This procedure is being developed in consultation with industry and it is understood that the basis of the procedure remains the concept of zero tolerance.

4.11 Guidance in other Australian states and territories

Victoria

Key legislation in relation to C&D waste includes:

- *Environment Protection Act 1970* (The Act)
- *Environment Protection (Industrial Waste Resource) Regulations 2009* (IWR Regs)
- *Environment Protection (Scheduled Premises and Exemption) Regulations 2007* (Sched. Prem. Regs)
- State Environment Protection Policy (Prevention and Management of Contamination of Land) (PMCD SEPP)
- National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM).

The definition of asbestos adopted in Victoria is consistent with that used in NSW.

Guidance on recycling C&D material in Victoria is provided in a WorkSafe Victoria document (WorkSafe Victoria 2007).

This guidance material provides information to assist industry to meet its obligations under the *Occupational Health and Safety (Asbestos) Regulations 2003* (the Asbestos Regulations). The guidance material describes an auditable procedure to verify that asbestos-containing material has been removed from C&D materials prior to recycling.

The Asbestos Regulations require that a licensed asbestos removalist be engaged to remove asbestos from workplaces, other than in a few very limited circumstances. Following removal of the asbestos, the person who commissioned the removal work must obtain a Clearance Certificate from an independent person prior to the site being re-occupied. This is not required where the asbestos-containing material removed was non-friable and less than 10 square metres.

The guidance uses a risk based approach to classifying C&D waste. The guidance requires inspection at the gate, with a Material Risk Classification Matrix used to classify the materials. Where asbestos is sighted the load should be rejected. Inspection is also required when unloading with the type of inspection dependent on the risk level relevant to the load. This may include sampling of the waste.

This remains consistent with the approach outlined in the EPA Victoria toolkit for C&D waste (EPA Victoria 2017).

The *Occupational Health and Safety Regulations 2007* note that regulations around asbestos handling “do not apply to construction and demolition material -

a) produced in accordance with an auditable process, determined by the Authority, to verify that asbestos-containing material has been removed from that material; and
b) of which less than 0·001% is asbestos-containing material measured using a method determined by the Authority."

This allows for the use of a definition of asbestos in C&D waste.

Queensland

Queensland has no specific guidance on the potential presence of asbestos in the C&D waste recycling industry.

Sections 452 and 453 of the *Work Health and Safety Regulation 2011* require asbestos to be removed before demolition commences so far as reasonably practicable.

The tracking threshold for asbestos is 175 kg non-friable for transport in Queensland.

Queensland does not track asbestos-contaminated soils (or other contaminated soils). However, it does define where waste is asbestos waste to be regulated (>0.01% w/w) based on the contaminated land criteria.

South Australia

South Australia has no specific guidance on the potential presence of asbestos in the C&D waste recycling industry. However, it did conduct a review of the re-use and recycling of clean fill and building and demolition waste (SA EPA 2001). Guidance is available on wastes containing asbestos (SA EPA 2017). A Standard for the production and use of waste derived fill (WDF) includes requirements in relation to asbestos (SA EPA 2013) and includes C&D waste. The following relates to asbestos in these materials:

- The EPA supports the removal of asbestos from the environment and expects that, to the maximum extent possible, persons involved in construction, demolition and recycling take specific measures to ensure that no asbestos is incorporated into WDF. This position is based on the precautionary principle for best practice waste management. This approach aims to continue to reduce the overall risk of exposure to asbestos by preventing pollution and continually removing it from the environment and ensuring its secure and safe disposal at authorised facilities. The EPA does not endorse any safe level of asbestos for use in WDF.
- Any waste proposed for use as WDF that is derived from materials potentially containing asbestos, must be subject to representative analysis in order to demonstrate the material is free of asbestos if it is to be considered as meeting the waste fill criteria.
- If the proponent believes there is a suitable beneficial use that will not pose any risks to human health or the environment, use as fill may be possible at specific sites and under specific conditions. These include:
    - remove all asbestos from the fill to the maximum extent possible and achievable
    - conduct a thorough, scientifically sound and robust quantitative human health risk assessment (refer to information below)

- submit a site management plan endorsed by a site contamination auditor, engaged for that purpose in accordance with EPA requirements, in which the auditor provides the opinion that, based on the knowledge available at the time including appropriate assessment of the site, the WDF is suitable for use, will not pose an unacceptable risk of causing harm and the land will be suitable for its proposed use at the completion of the project. An audit report for the destination of the WDF containing asbestos (ACM) in this regard must be produced at the completion of the project and must be attached to the title of the land in accordance with questions under Form 1 as required by section 7 of the LBSC Regulations
- adhere to all conditions of the site management plan and audit report
- not use the WDF at a destination with a sensitive use.

Any risk assessment would need to comply with the ASC NEPM.

South Australia acknowledges that asbestos waste can be a concern in C&D Wastes, and refers to the above as well as the NSW Draft guidance (NSW EPA 2014) for additional information.

Western Australia

Western Australia have guidelines on the recycling of C&D waste (DEC 2012). These guidelines note the following:

- Recycling C&D waste is important for reducing the demand for virgin materials, diverting waste from landfill and salvaging valuable resources.
- Asbestos is a hazardous material.
- While regulations and procedures are in place to identify and remove asbestos and asbestos-containing materials (ACM) from buildings prior to demolition, there is still a small risk that some asbestos or ACM will be contained in C&D waste that is directed to recycling facilities.
- The operation of C&D waste recycling facilities and landfills accepting asbestos waste are regulated under Part V of the Environmental Protection Act 1986 (the Act).
- The objectives of these guidelines are to document the procedures DEC expects C&D waste recyclers to implement to:
  1. Minimise the risk of asbestos being received and processed at the premises;
  2. Minimise the potential risk of asbestos in emissions within and from their recycling premises; and
  3. Minimise the potential risk of asbestos contamination in recycled construction and demolition (C&D) materials and products.

The procedures outlined in the guidance are summarised as follows:

- If suspect FA or AF are detected, the load must be isolated, kept wet and once appropriately contained and redirected to an appropriately authorised disposal facility.
- Where suspect ACM is identified within a load and is not capable of being easily removed by hand, the load must be rejected and should be isolated, kept wet and once appropriately contained, and redirected to an appropriately authorised disposal facility.

- Where suspected ACM fragments capable of being easily removed by hand are identified in a load, the suspect ACM must be removed from the load and either:
  1. Appropriately isolated and covered for asbestos testing. If testing of representative samples confirms the material is ACM, it must be redirected to an appropriately authorised disposal facility. If testing confirms the material is not ACM, the waste can be added to the stockpile awaiting further processing; or
  2. Assumed to be ACM and redirected to an appropriately authorised disposal facility.
- ACM and FA are subject to visual inspection and sampling procedures since they are larger in size (>7 mm). AF (<7 mm) is assessed by submitting samples for laboratory analysis.
- Each sample collected must be at least 10 litres in volume and then be divided into 2 size fractions (>7 mm and <7 mm) in the field by sieving though a 7 mm screen or spread out for inspection on a contrasting colour fabric. The >7 mm fraction should be examined for any suspect asbestos material and this should be retained to calculate the level of contamination. The <7 mm fraction will need to be a minimum 500 mL, be wetted, and submitted for laboratory analysis. This sample size is considered necessary to improve the limit of detection for asbestos in the analysis procedure.

Sample Analysis Method >7 mm sample fractions as follows:

- Asbestos concentrations (for ACM and FA) should be calculated in accordance with the methods detailed in section 4.1.7 of Department of Health (DoH), 2009, Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia.
- As detailed in the DoH Guidelines, averaging asbestos levels across the stockpile is not appropriate and asbestos levels within each sample should be reported.
- Each <7 mm sample fraction must be analysed for FA and AF. Asbestos analysis must be undertaken by an independent NATA certified laboratory and comply with Australian Standard Method for the Qualitative Identification of asbestos in bulk samples (AS4964–2004) or be demonstrated to be able to achieve the equivalent level of results to this Australian Standard. AS4964-2004 is currently the only method in Australia that has NATA certification and the practicable level of detection for this standard polarized light microscopy method (PLM) and dispersion staining (DS) is 0.01% w/w. It is possible, however, to measure asbestos contamination at or lower than 0.001% w/w where an increased sample size is used, however, DEC recognises that any reporting of concentrations below 0.01% w/w will be outside the conditions set by NATA.
- Therefore, to determine whether recycled products meet the product specification for asbestos content, samples must be a minimum of 500 mL in size. Proponents must adopt one of the following analytical approaches:
  - Detected/non-detected – where any quantity of asbestos is detected by the PLM method it must be assumed, without further analysis, to be in concentrations above the product specification limit of 0.001%w/w. A weight of evidence approach may be adopted i.e. the frequency and occurrence of other positive results in the stockpile can be taken into account, to determine whether the stockpile being assessed is considered to meet the product specification or not; or

- Where any quantity of asbestos is detected by the PLM method, the sample is subject to further testing in the form of a semi-quantitative method with a lower level of detection for asbestos.
- A number of laboratories have developed such semi-quantitative methods for the analysis of low levels of asbestos. Techniques include:
  - The extraction and weighing of fibre bundles or fibre cement material from the total sample; and
  - Measuring the width and length (i.e. volume) of individual fibre by Phase Contrast Microscopy (PCM) and calculating the weight of fibres in the extracted sub-sample.

If the visual inspection, sieve sample or analytical results identify asbestos above or possibly above the 0.001% w/w criteria then that stockpile or product process should be deemed potentially contaminated and considered for off-site disposal as asbestos waste, or subject to further actions to remediate it or to demonstrate its acceptability by further assessment. A record should be made of the decision making and action taken e.g. off-site disposal, further assessment undertaken etc, in relation to that stockpile.

The WA guidelines allow for the hand-picking or emu-picking of ACM materials from the waste (with details provided on how this can be done effectively).

4.12 Australian review

A report was completed in 2011 which included a review of issues relating to C&D waste across Australia (Hyder 2011). The following is a summary of the key findings from that review:

> *Asbestos contamination is a critical issue in C&D recycling, and Federal intervention may be required to produce a workable solution for all stakeholders. Best Practice Guidelines for screening incoming loads to minimise contamination risk, coupled with adoption of a small allowable limit of <0.001% contamination in end products, may provide a solution.*
>
> *Due to the widespread use of asbestos material over many years, resource recovery operators who adopt the most stringent acceptance and testing regimes cannot fully guarantee there are no asbestos fibres in materials coming into their sites and in their final products. In some jurisdictions there is a zero tolerance approach to asbestos, while others have allowable limits of < 0.001% of asbestos in products.*
>
> *In NSW, consultation for this review has highlighted that the presence of asbestos contamination presents one of the most problematic issues for the C&D waste recovery market. Due to widespread use of asbestos material in the NSW construction market over many years, even resource recovery operators who adopt the most stringent testing regimes and make all possible effort to avoid any asbestos coming onto their sites cannot fully guarantee there is no asbestos fibres in their final products. However, the NSW regulator currently has zero tolerance of asbestos in recovered materials.*
>
> *The current situation is extremely problematic, with the potential to completely destroy the C&D resource recovery sector. So long as there is zero allowable limit of asbestos in end products, and no way for even the most diligent operators to guarantee this outcome, all*

operators carry continual risk of being in breach of legal requirements. All stakeholders expressed a view that the current situation is unsustainable.

One example provided in the review concerned a recent project where 600 tonnes of recycled material was supplied to a client at around $20/tonne (total value approximately $12,000), and a small amount of asbestos material was found in the material (less than 1 kg). The cost for the company to remove all material and clean up the site was estimated at more than $150,000.

Industry participants point to the adoption of allowable levels of asbestos in Victoria and WA as a workable solution to this potentially debilitating issue. The allowable limit adopted in Victoria and WA is <0.001% (as discussed in ***Section 4.11****). While this is a very small percentage, it should be noted that, due to the high volumes of end products coming out of the C&D recycling sector, this could equate to a considerable amount of asbestos being legally allowed into the marketplace. In the example above involving 600 tonnes of products, an allowable limit of 0.001% could equate to 6 kg of asbestos at the project site.*

An alternative solution that has been discussed by some industry operators is to close their operations altogether and cease attempting to recover resources from C&D waste streams. While wholesale abandonment of existing operations by established and profitable organisations is certainly an extremely unlikely outcome, it should be noted that the issue of asbestos does have the potential to completely close down the C&D resource recovery market in NSW.

WorkCover NSW produced a guide for the Management of asbestos in recycled construction and demolition waste (SafeWork NSW 2010). The document was produced in consultation with industry, and is considered a best practice guide to minimising the risk of asbestos contamination in recovered C&D material. The use of this guide, combined with the adoption of some very small allowable limit of asbestos in C&D products, as implemented in Victoria and WA, is worthy of serious consideration. However, the human health, environmental, legislative and political complexities surrounding asbestos in NSW mean that and any change to the government's approach on this issue would require careful management.

The management of asbestos in C&D waste recovery and recycling will require the engagement of the State's WorkCover Authority or health department. In Victoria, this approach was taken in collaboration with environmental agencies and the unions representing employee interests, to achieve an outcome that was satisfactory to all parties.

Asbestos contamination is one of the most critical issues in the NSW market. Victoria and WA have adopted small allowable limits of asbestos to solve this issue. NSW is unlikely to independently progress toward a similar solution.

The recycling of wastes, in particular C&D waste, is acknowledged by the Australian Government to be hampered by cross-contamination, with asbestos identified as a well documented problem (NSW EPA 2014).

A national Asbestos Safety and Eradication Agency (ASEA) was established under the Asbestos Safety and Eradication Agency Act 2013 to administer the National Strategic Plan (ASEA 2019) which aims to prevent exposure to asbestos fibres in order to eliminate asbestos-related disease in Australia. Website: https://www.asbestossafety.gov.au/

A review commissioned by the Asbestos Safety and Eradication Agency (ASEA) (ASEA 2016; Blue Environment 2017) identified that the management of asbestos varies across the states of Australia. This includes differences in the definitions of asbestos waste.

There is no threshold for asbestos in waste (i.e. any concentration of asbestos is classified as asbestos waste) in NSW, ACT, NT, QLD, SA.

The *Occupational Health and Safety Regulations 2007* note that regulations around asbestos handling “do not apply to construction and demolition material – (b) of which less than 0.001% is asbestos containing material measured using a method determined by the Authority”.

The WA *Environmental Protection (Controlled Waste) Regulations 2004* define material containing asbestos as “material which contains 0.001% or more of asbestos fibres weight/weight”. This is likely to dictate thresholds in asbestos waste.

Different states also have different threshold requirements for tracking asbestos waste.

- NSW, Vic, Qld and SA track ACM through waste generator, transporter and receiver to ensure it is disposed of in a facility that will appropriately manage the risks posed by asbestos waste to human health
- SA and Vic both require the tracking of asbestos waste by commercial asbestos waste companies for any amount of asbestos, but do not require tracking of domestic self-haul regardless of the tonnage. SA does not record the fate of the waste asbestos – only the name of the receiving facility.
- The ACT, NT, Tas, and WA do not track asbestos transport for either commercial asbestos companies or domestic self-haul asbestos transport.

For asbestos contaminated wastes (asbestos contaminated soils, C&D wastes):

- Vic, SA, track asbestos contaminated wastes.
- ACT, NSW, NT, Tas, WA do not track asbestos contaminated wastes.
- Qld does not track asbestos contaminated soils under their hazardous waste tracking system, but does have another permitting system for contaminated soils movements.

Comments on approaches adopted in other states

Victoria and Western Australia provide a definition of an acceptable level of asbestos, as measurable fibres, in waste that is consistent with risk-based guidance in the ASC NEPM. The criteria of 0.001% is also consistent with the detection limits that may be achievable for the analysis. Including the requirement to analyse for fibres addressed the key risk related to asbestos – the inhalation of fibres that are not visible so cannot be addressed by current control measures. The WA guidance also allows for the removal of visible ACM by emu-picking, which provides a workable approach to dealing with low risk asbestos in these materials.

South Australia and Queensland are largely silent on an acceptable level of asbestos in C&D waste.

Section 5. International approaches to asbestos in C&D recycling

5.1 General

This section provides an overview of guidelines available in other countries that specifically relate to the C&D industry.

5.2 UK

Asbestos waste is “Hazardous Waste” when it contains more than 0.1% asbestos – definition adopted in England and Wales, with the same criteria for “Special Waste” as adopted in Scotland. It is not permitted to mix asbestos waste with other waste to get below 0.1%.

CL:AIRE CAR-SOIL™ , Control of Asbestos Regulations 2012, Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials: Industry guidance (CL:AIRE 2016), where the following is noted:

> *The aim of the guidance is to set out what is good practice for assessing and managing risks from asbestos in soil and C&D materials.*
>
> *'Asbestos' is the general term used for the fibrous silicates listed in regulation 2(1) of CAR 2012. Guidance provided in ACoP L143 states, in respect of the determination of asbestos in bulk materials, that any mixture containing one or more of these fibrous silicates at more than “**trace**” amounts, as defined in Appendix 2 of the first edition of HSG248, Asbestos: The analysts' guide for sampling, analysis and clearance procedures (‘The Analysts’ Guide’), is within the definition.*
>
> *HSG248 provides a definition for ‘trace’ amounts of asbestos in bulk samples, below which the Regulations do not apply. It is important for the purpose of this guidance to define what an ‘asbestos-containing material’ is in the context of soil and/or C&D materials that may have been contaminated by asbestos and, therefore, the point at which the Regulations will apply*
>
> *For representative bulk samples of fragments of suspect materials thought to contain asbestos and submitted for asbestos identification analysis, HSG248 recommends that ‘asbestos not detected’ is reported when no asbestos fibres are found after careful searching of the sample under the stereo microscope for 10 minutes and searching a minimum of two preparations mounted in suitable Refractive Index (RI) liquid at high magnification by Phase Light Microscopy (PLM)/Phase Contract Microscopy (PCM) for a further 5 minutes.*
>
> *HSG248 goes on to say that if during the search only one or two fibres are seen and identified as asbestos, the term “**asbestos [fibres] identified at the limit of detection**” may be used. This is taken to be the equivalent of ‘trace’ asbestos, for bulk materials.*
>
> *A ‘Blue Book’ method describes the quantification of the mass of asbestos in soil, construction materials and products, or associated materials, using a gravimetric method for ACM and fibre bundles, plus dispersion and fibre counting for free fibres using Phase*

Contrast Microscopy (PCM), including calculations for the concentration of Total Fibres and Regulatory Fibres as counted using Annex 1 of HSG248, as appropriate.

Analysis of soil and/or C&D materials in accordance with the 'Blue Book' method requires prior identification analysis by the asbestos identification method described in HSG248. The Limit of Quantification of the 'Blue Book' method is given as 0.001% w/w, based on a practical Limit of Detection of 0.0001%.

*For samples of soil and C&D materials where no fragments of ACMs are isolated and fewer than three asbestos fibres are identified during detailed and extended identification and gravimetric analysis procedures combined, the mass concentration of asbestos fibre is likely to be many orders of magnitude below the 0.0001% w/w Limit of Detection; this generally will be taken to mean '**trace**' asbestos fibre contamination.*

In such circumstances, therefore, on the basis that the potential risk from exposure to such trivial concentrations of asbestos in the external environment is likely to be very low to negligible, it is practical to conclude that such material, whilst containing very few isolated asbestos fibres, is not strictly an ACM that falls under the definition of asbestos in the Regulations.

Prohibitions on the manufacture, supply and use of asbestos and asbestos-containing articles and materials are not contained in CAR 2012. They can be found in direct-acting EU legislation, the Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations (REACH), which applies in the UK and other EU Member States. For the convenience of the reader some information on REACH and its application to asbestos-containing aggregate materials is presented below.

*REACH prohibits the manufacture, placing on the market and use of any article or product to which asbestos has been **intentionally added.***

Recycled aggregates, which fall under the definition of 'articles' under REACH, where asbestos is found to be present are deemed to have had asbestos intentionally added, "subject to evidence to the contrary being adduced in any proceedings.

Caution must be exercised, therefore, to ensure that the mixing of asbestos and inert demolition wastes does not occur if asbestos and/or ACMs have not first been removed from a building prior to its demolition.

5.3 EU

The EU recognises that contamination with asbestos of C&D materials to be recycled is an issue due to the nature of the materials being managed. This is noted to be a key risk to the C&D waste recycling industry (EC 2018).

Asbestos cannot be readily isolated from other components in the mineral fraction of demolition waste. For this reason, the only practical means of guaranteeing the absence of asbestos is to ensure thorough removal prior to demolition, and this, in turn, requires a comprehensive survey of the fabric of the structure to identify occurrences of this material.

The EU has a C&D waste management protocol. This outlines the need for proper removal of asbestos so that it does not contaminate materials for reuse and recycling. Hazardous C&D waste is defined as containing asbestos-based materials in the form of breathable fibres (EC 2016). Hazardous C&D waste is required to be separated from other waste and disposed to an appropriate facility. No more specific detail is provided on the management of asbestos within the protocol.

The EU Council Decision of 19 December 2002 established criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (2003/33/EC). This states that construction materials containing asbestos and other suitable asbestos waste may be landfilled at landfills for non-hazardous waste without testing.

The EU Commission Decision of 16 January 2001 amending Decision 2000/532/EC as regards the list of wastes (2001/118/EC) defines that construction materials containing asbestos were classified as hazardous waste. **Asbestos waste is any waste which contains more than 0.1% w/w asbestos**.

The Nordic Council of Ministers have end-of-waste guidance for C&D waste (Norden 2016) which provides criteria under which specified waste fractions are no longer considered to be waste. The criteria include values for a range of metals and other chemicals but do not include a value for asbestos. The Nordic countries (Denmark, Finland, Norway and Sweden) already have procedures for selective demolition, depollution of buildings and on-site sorting of C&D waste/concrete that, if they are followed and properly inspected, probably will be sufficient to ensure a good quality input material. This includes procedures to effectively reduce contamination from asbestos. Most Nordic countries state that there is a total ban on asbestos in C&D materials.

5.4 United States

Asbestos and ACM is required to be removed during demolition and renovations by an approved contractor and must be properly disposed as asbestos waste.

In the US, most C&D waste is regulated at the state level, with around half the states applying specific C&D regulations. However, when C&D waste contains hazardous materials such as lead-based paint, asbestos, or elements such as lead, mercury, cadmium, PCBs and arsenic, disposal is regulated under the Federal Resource Conservation and Recovery Act (RCRA).

Some states and cities have implemented policies to encourage C&D recycling, including the following:

- Demolition contractors are required to pay a deposit in order to receive a building permit – the deposit is refunded if the contractor can demonstrate that the C&D waste was taken to a certified recovery facility.
- Contractors are required to produce a complete site plan prior to receiving a building permit – the site plan must detail recycling of rubble (concrete/asphalt), land-clearing debris, corrugated cardboard, metals and wood.
- State solid waste legislation specifies recycling goals for counties, and a certain amount of C&D waste is allowed to count toward those goals.

The USEPA provides a document on the characterisation of building-related C&D debris in the US (USEPA 1998). This provides a summary of various state waste requirements. Most do not accept any asbestos materials in C&D debris or waste.

5.5 Canada

Canada provides the following definitions of asbestos[3]:

Airborne asbestos fibre: Asbestos fibres that are longer than 5 µm (micrometres) with an aspect ratio equal to or greater than 3:1 and that are carried by the air.

Asbestos: actinolite, amosite, anthophyllite, chrysotile, crocidolite and tremolite in their fibrous form.

Asbestos-containing material (ACM): means

- Any article that is manufactured and contains 1% or more asbestos by weight at the time of manufacture or that contains a concentration of 1% or more asbestos as determined in accordance with Method 9002 set out in the document entitled NIOSH Manual of Analytical Methods published by the National Institute for Occupational Safety and Health, as amended from time to time, or in accordance with a scientifically proven method used to collect and analyse a representative sample of the material; and
- Any material that contains a concentration of 1% or more asbestos as determined in accordance with Method 9002 set out in the document entitled NIOSH Manual of Analytical Methods published by the National Institute for Occupational Safety and Health, as amended from time to time, or in accordance with a scientifically proven method used to collect and analyse a representative sample of the material.

Zero airborne asbestos concentration: The concentration of “zero” airborne asbestos fibres in COHSR 10.19 (1.1, 3) corresponds to a recognized asbestos analytical method, such as NIOSH Method 7400 or NIOSH Method 7402, used to analyse an asbestos sample that returns a result that is below the limit of detection (LOD) of the analytical method. The LOD of NIOSH Method 7400 and of NIOSH Method 7402 is less than 0.01 f/mL (cm^3). After a qualified person conducts asbestos air sampling, when a result is below the limit of detection for that method, the asbestos sample can be effectively considered to be “none detected” or “zero”. The specific value of the LOD is set by the technological limits of the analytical equipment required in the analytical method, rather than being chosen by a person.

In relation to consumer products (which would be expected to include recycled products), Canada has regulations that prohibit the import, sale and use of processed asbestos fibres. Asbestos is a commercial term applied to six different varieties of minerals: chrysotile, amosite, crocidolite, anthophyllite, tremolite and actinolite. Based on current scientific data, human health risks associated with exposure to trace amounts of naturally occurring asbestos are expected to be low.

[3] https://www.canada.ca/en/employment-social-development/services/health-safety/reports/asbestos-exposure-management-programs.html

Hence Environment and Climate Change Canada and Health Canada have defined what are considered to be **trace amounts of asbestos**, as follows[4]:

- Trace amounts of asbestos are those below 0.1% when measured using a suitable standard analytical method with polarized light microscopy (PLM).
- At present, test results identifying asbestos at 0.1% or more, with fibres that demonstrate both of the following characteristics, will be considered by Environment and Climate Change Canada and Health Canada as evidence of the presence of asbestos in more than a trace amount:
    - Fibres longer than 5 µm, with a mean aspect ratio greater than 3:1. Aspect ratios should be determined for fibres, not bundles.
    - Very thin fibrils, less than 3 µm in width.

Ontario laws in relation to C&D waste (R.R.O. 1990, Regulation 347[5]), define asbestos waste as follows:

"**asbestos waste**" means the following solid or liquid waste that contains asbestos in more than a **trivial** amount:

1. Waste that results from the removal of asbestos-containing construction or insulation materials.
2. Waste that results from the manufacture of asbestos-containing products.
3. Waste that results from the removal of asbestos-containing components from a motor vehicle.
4. Waste that results from the removal or handling of waste or materials described in paragraphs 1, 2 and 3, including personal protective equipment, tools that cannot be decontaminated and cleaning materials.

The law does not define "trivial", but Section 17 includes details on the management of asbestos waste.

[4] https://www.canada.ca/en/environment-climate-change/services/management-toxic-substances/list-canadian-environmental-protection-act/asbestos/trace-asbestos-consumer-products-guidance.html

[5] https://www.ontario.ca/laws/regulation/900347

Comments on international approaches

Most international jurisdictions are clear that the effective and complete removal of asbestos at a site, prior to demolition is key to managing asbestos in C&D waste. Some jurisdictions adopt the concept of zero asbestos in waste.

The UK and Canada go further and allow for trace amounts of asbestos to remain. The UK adopts the reporting limit for the detection of fibres (using a specified method). Canada provides a definition of trace levels that is higher than in the UK. Ontario references the term trivial but does not define trivial. Further discussion on trivial is provided in **Section 6**.

Canada also provides a definition of zero asbestos in air, which is essentially the reporting limit of the method (with the analysis method stated).

The concept of zero asbestos is meaningless (refer to **Section 3**), as we are all exposed to background levels of asbestos all of the time, and with anything that requires measurement, a non-detection never means zero.

Being able to define what is meant by “zero” or allowing consideration of trivial levels of asbestos and defining what is trivial enables these concepts to be better understood by industry and the community.

Section 6. Contamination: Trivial or not

In Australia (referent to **Section 4**), the definitions of asbestos are very general. In addition, with the exception of Victoria and Western Australia, there are not quantitative amounts of asbestos that may be present in waste for recycling in C&D waste. Where states such as NSW have a "zero tolerance" approach, there is no definition of what "zero" means. Internationally, there are a number of jurisdictions where the concept of trivial or trace levels are permitted and defined, with Canada also providing a definition of what is meant by "zero". Most of these levels or definitions relate to the detection limit for a particular method (with the method specified).

Whenever something is measured, the concept of zero is meaningless as it depends on the measurement method used, which has a unique detection limit or practical quantitation limit. There is no way to measure zero for any chemical. The ASC NEPM (NEPC 1999 amended 2013e) indicates that the term non-detect should be used rather than zero or not present when reporting results in relation to contamination.

The concept of trivial levels of contamination or pollution is used in NSW legislation.

The NSW EPA does not use licensing to regulate every potential pollutant that could be contained in a discharge or activity. This is because some pollutants are present at such low levels in a discharge that they are highly unlikely to pose a reasonable risk of harm to human health or the environment. Also, some activities are conducted in such a way that discharges to the environment are avoided – such as where an intensive agricultural activity uses an engineered runoff retention basin.

The POEO Act 1997 (Part 5.7, Section 147) in relation to duty to notify pollution incidents defines that "*harm to the environment is material if – (i) it involves actual or potential harm to the health or safety of human beings or to ecosystems that is **not trivial***,".

In addition, "***land pollution** or **pollution of land** means placing in or on, or otherwise introducing into or onto, the land (whether through an act or omission) any matter, whether solid, liquid or gaseous - (a) that causes or is likely to cause degradation of the land, resulting in actual or potential harm to the health or safety of human beings, animals or other terrestrial life or ecosystems, or actual or potential loss or property damage, that is **not trivial**,"*

In relation to pollution of water, the NSW EPA licencing fact sheet[6] states that:

- It is the responsibility of licence holders to:
    - be aware of the pollutants that are discharged to waters from their premises
    - be aware of the environmental impacts that pollutants discharged from their premises have on the environment
    - ensure that their licence specifically regulates the discharge from their premises of all those pollutants that pose a risk of **non-trivial** harm to human health or the

[6] https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/epa/130119eplswater.ashx

environment – where the premises discharges a pollutant that is not regulated by the licence, the licence holder does not have a defence against the pollution of waters offence for the discharge of that pollutant.

- Licence holders are unlikely to be complying with their licence or the POEO Act if a discharge from their premises:
  - does not comply with the concentration limits for each pollutant specified in condition L3.3 of the licence, or
  - contains pollutants other than those specified in condition L3.3 of the licence and those pollutants are at levels that are **not trivial** – '**trivial**' here relates to both the concentration of the pollutant as well as its risk to the environment.
- The EPA Prosecution Guidelines set out how the EPA decides what regulatory action to take, ensuring that all relevant matters are considered, and the action is proportional to the offence (the **EPA does not act on trivial matters**).

The concept of trivial is also adopted by SA EPA (SA EPA 2008, 2019) in the *Environment Protection Act 1993* (*EP Act*) in relation to site contamination – Section 5B:

> *(1) For the purposes of this Act, site contamination exists at a site if— (a) chemical substances are present on or below the surface of the site in concentrations above the background concentrations (if any); and (b) the chemical substances have, at least in part, come to be present there as a result of an activity at the site or elsewhere; and (c) the presence of the chemical substances in those concentrations has resulted in— (i) actual or potential harm to the health or safety of human beings that is* ***not trivial****, taking into account current or proposed land uses; or (ii) actual or potential harm to water that is* ***not trivial****; or (iii) other actual or potential environmental harm that is* ***not trivial****, taking into account current or proposed land uses.*

To assist in determining 'actual or potential harm' and 'not trivial', as stated in each point of section 5B(1)(c) of the EP Act, the application and use of published investigation criteria or trigger levels is considered appropriate. In assisting consultants and auditors to make consistent determinations of the existence of site contamination, the SA EPA has reviewed available national and international guidance and adopted published criteria. Those that are recognised as appropriate criteria by the EPA are specified in Appendix 2 of the site contamination guideline (SA EPA 2019). Appendix 2 includes the ASC NEPM health screening levels for asbestos contamination in soil.

The description of trivial also includes the concept of background (SA EPA 2008) – **concentrations consistent with background are considered trivial**.

Comments on trivial

The concept of defining pollution based on its potential to cause harm and whether or not it is non-trivial is already within NSW legislation and guidance. The concept of non-trivial, however, is not defined, particularly in terms of asbestos, where it gets caught up in the definitions of asbestos in the POEO Regulation which effectively mean zero-tolerance.

The SA EPA also adopts the concept of trivial and has included consideration of background, which is important for asbestos (refer to **Section 3**) and references the health based guidelines on asbestos in the ASC NEPM to assist in understanding what is considered trivial.

Given the concept of trivial is already relevant in NSW, it would be appropriate to provide a definition of what is non-trivial in terms of asbestos in C&D recycling industry. Defining such levels could be undertaken such that it reflects the reporting limits for asbestos (refer to **Section 4.10**) and the level of risk posed by the materials likely to be present in C&D waste (refer to **Section 3**) and require management.

To further evaluate the concept of trivial, the background concentrations of asbestos in air presented in **Section 3.2** have been further considered.

Based on a background outdoor dust concentration of 0.039 mg/m^3 (NEPC 1999 amended 2013b), and an assumption of 0.0001 f/mL background level of asbestos in air (low value for urban air and reasonable for rural air as per **Table 3.1**), this relates to a soil concentration of 0.0077% w/w, calculated using the following equation.

$$\text{Soil criterion} = \frac{\text{Asbestos in air x mass}}{\text{Dust concentration}} \qquad \text{(mg asbestos/mg soil)}$$

where:
Air concentration = 0.0001 f//mL
Mass of an asbestos fibre = 3 x 10^{-8} mg/f (USEPA 1986)[1]
Dust concentration = Concentration of soil (dust) in the air (mg/mL = mg/m^{3}x10^{-6})

This is higher than the asbestos guideline for friable asbestos in soil adopted in the NEPM (**Section 4.3**) and, also, higher than the guideline adopted for asbestos in C&D recycling in Victoria and Western Australia (**Section 4.11**). The soil concentration that relates to an air concentration is dependent in the level of dust generated, however, the above is presented to illustrate that achieving a 0.001% w/w criteria in soil or waste results in air or exposure concentrations of asbestos below background.

Where background exposures are considered, the value of 0.001% could be considered trivial (refer to **Section 6**).

Section 7. Current C&D recycling processes in NSW

7.1 General

This section provides a description of the current C&D recycling processes, including the procedures adopted to identify and manage asbestos. This section also provides a list of the current issues with the existing regulatory system for the management of asbestos. Some of the information presented in this section has been provided by the C&D industry.

7.2 General description of the C&D recycling process

C&D recycling can be broken down into three distinct waste streams:

1. Mixed waste such as demolition materials, building site clean-up waste and skip bin collected waste;
2. Source separated concrete, brick, and asphalt; and
3. Unprocessed soils.

There are other C&D waste streams such as source separated timber and plasterboard but these are not included in this report.

It must be emphasised that the first and key phase of managing asbestos materials in C&D waste occurs "upstream" well before materials leave a site and may be transported as C&D waste. NSW, along with all other states and territories, require the removal of asbestos waste at the source – i.e. at the building, prior to demolition or other works. In NSW, these requirements are detailed in Chapter 8 of the *Work Health and Safety Regulation 2017 (WHS Regulation 2017)*.

Friable asbestos, and any fire damaged asbestos material, is required to be removed by a licenced[7] asbestos removalist, prior to demolition or any other works. The requirement to use a licenced asbestos contractor for these materials reflects the level of risk these materials pose to workers and the public, should they not be removed and disposed properly. Where this process is undertaken properly, then no friable asbestos or fire damaged asbestos, would be present in C&D waste.

Small quantities (up to 10 m^2) of non-friable asbestos are permitted to be disposed by householders and contractors with no asbestos licence. This is the source of waste that poses the greatest risk for C&D waste in terms of the potential presence of asbestos.

The removal of more than 10 m^2 of non-friable asbestos[7] is required to be undertaken by a licenced asbestos removalist.

There are a range of requirements detailed in the *WHS Regulation 2017* that must be followed for the removal of asbestos by a licenced removalist, including completion of a clearance inspection and issuing a clearance certificate. The clearance requires no visible asbestos residue from

[7] The contractor must hold a Class A licence that permits the removal of any amount of friable asbestos. A Class B licence does not permit removal of friable asbestos but allows for the removal of any quantity of non-friable asbestos. Refer to NSW *WHS Regulation 2017* and SafeWork Australia guidance for further detail.

asbestos removal work in the area, or in the vicinity of the area and airborne fibre levels less than 0.01 f/ml.

It is noted that the *WHS Regulation 2017* requirements in relation to asbestos do not apply to soil where (Clause 419 (5)):

i. there is no visible ACM or friable asbestos, or
ii. if friable asbestos is visible – does not contain more than trace levels of asbestos determined in accordance with AS 4964:2004.

AS4964:2004 details the method for qualitative identification of asbestos in bulk samples and includes a method for determining trace levels, which uses polarised light microscopy. This method has a detection limit of 1 in 10000 parts by weight or 0.1 g/kg or 0.01% w/w. This means it is permitted for waste to contain trace amounts of asbestos when it leaves a demolition/construction site.

Processes and procedures at C&D waste recycling facilities

The procedures at the facilities include:

1. The mixed waste streams use specialised purpose-built sorting plants that separate the different waste materials generally by shredding, screening and density separation. The aim is to separate the waste into the following:
   - Clean masonry fraction to meet the requirements of the Recovered Aggregates Resource Recovery Order
   - Clean soil to meet the Recovered Fines Resource Recovery Order
   - Steel for recycling by others
   - Non-ferrous for recycling by others
   - Wood suitable for reuse complying with the Compost or Mulch Resource Recovery Orders or as alternate fuels in approved facilities
   - Other materials such as plasterboard, green waste, and cardboard for recycling by others
   - Residual waste either for further processing at other facilities or for landfill.
   - A typical percentage split of materials produced from the mixed C&D waste recycling process is:
     - Soil = 35-45%
     - Masonry =20-30%
     - Wood =10-15%
     - Ferrous & Non-Ferrous metal = 3-5%
     - Other = 1-2%
     - Residual waste = 15-25%
2. Source separated concrete, brick and asphalt material is recycled using crushing and screening equipment and the products produced are manufactured to the relevant Resource Recovery Orders. Ferrous and non-ferrous metal is produced for recycling by others during this process. Only a very small percentage of residual waste is produced when processing source separated concrete and brick (<0.1%).

The products produced are used in drainage works, behind retaining walls, electrical trenches, temporary ground cover on building sites, under concrete slabs, pipe backfill and in various landscaping applications. Many products are additionally manufactured to comply with specifications from the Transport for NSW, Sydney Water Corporation, electricity supply utilities and local councils and as such are extensively used in road construction.

3. Soils are typically processed at C&D recycling facilities via screening to produce recovered fines, masonry for subsequent crushing and screening to make recovered aggregates, and residual waste.

7.3 Current processes/procedures used to identify and manage asbestos

Under current EPA legislation, a C&D recycling facility must comply with the requirements set out in the EPA's document "*Standards for managing construction waste in NSW".*

This Standard imposes minimum procedures including various stages of inspection during the receival and processing stages.

The requirement of the Standard is to undertake **visual** inspections at the weighbridge, upon discharge of the load and upon spreading of the load prior to it being incorporated into a stockpile for processing. Visual inspections are also required of product stockpiles after processing and prior to despatch from the premises.

The important fact here is that the inspections required are visual only and consequently only pieces of asbestos containing material (ACM) will be observed as asbestos fibres are not visible to the naked eye.

Many facility operators have equipped their facilities with a "Micro Phazir" (or similar) portable asbestos analysis device to assist in the identification of material as ACM. It is noted that these devices are not NATA certifiable or 100% accurate in the detection of ACM. In addition, these devices cannot identify if any fibres may be present in waste.

Under the current Standard, any load of waste that has even a single piece of ACM (regardless of size) MUST be rejected by the facility and the details recorded in a register as per the Standard.

7.4 Current issues with the existing system for the management of asbestos in this industry

By way of background, the long-term recycling facilities in the Sydney waste industry have been managing asbestos through inspection of incoming loads since the early 2000's. These facilities have their own written procedures that they follow. In 2010 Workcover produced a Guide titled *'Management of asbestos in recycled construction and demolition waste'.* The industry groups WMRR (formerly WMAA) and WCRA contributed to this document by aggregating their members inspection procedures. This document was extensively adopted by Workcover in their Guide.

In 2019 the EPA released their document "*Standards for managing construction waste in NSW"*. The fundamentals are the same as the Workcover Guide, however, its more prescriptive regarding how to manage stockpiles.

These new Standards mandate the inspection and rejection protocols, however, make it extremely onerous when a piece of asbestos is found in a stockpile of material that has previously been inspected and cleared.

The EPA (some staff, as noted by industry) appear to be of the view that the Standards will totally prevent ACM being found at a recycling facility but this is not achievable due to the nature of the waste received and the range of possible sizes of ACM.

The current situation is that, if ACM is observed at a facility, then the facility will likely be put into a lockdown situation and much investigation work required to resolve the issue prior to reopening the facility, invariably with significant time delays and costs. This will be triggered primarily due to waste materials from sites that had only small quantities of ACM which were permitted to be managed by non-licensed people. For wastes from sites that had large amounts of ACM, the strict requirements for occupational hygienists/licenced removalists should ensure that it is unlikely that such waste will contain visible pieces of ACM.

It is understood that the EPA is currently working with the industry to develop a procedure to manage an "unexpected find" of ACM so that it does not place undue/unnecessary strain on the facility both for its continued operation and financially risking its continued operation. This is a logical approach provided requirements for removing ACM at the point of demolition is undertaken to the same standard as required to be met at the waste facility, and then any ACM find should truly be an "unexpected find".

The following provides a list of issues identified by the industry with the existing system:

- There appears to be no practical understanding of how difficult it is to inspect mixed waste to be able to guarantee there is no ACM present. If there is a large quantity of ACM in the load it will be obvious. It's not possible, however, to see small fragments of ACM (say < 2-3 mm in size) mixed in with a variety of wastes such as plastic, plasterboard, timber, cardboard, soils etc.
- There is no understanding that ACM may be stuck to the underside of concrete or encapsulated in the concrete. This material cannot be found easily through visual inspection.
- Most large demolitions have asbestos clearances prior to the demolition of the walls and slabs. These are visual inspections and it is entirely possible for small pieces or fibres to remain mixed with the waste. This then becomes the responsibility of the recycler if these small amounts are found in products.
- Asbestos clearances are allowed to be issued even though trace amounts of asbestos material may remain in the waste which means the waste recyclers bear responsibility for material that has been passed as appropriate in another section of the industry
- Currently the EPA is proposing that when ACM is found in stockpiles or processing plants, that the facility stops operating and engages a hygienist to determine the way forward. This would include removing a quantity of stockpiled material to landfill as asbestos waste. Emu picking ACM out of stockpiles is not permitted by the EPA. This is not viable as the hygienist is not always immediately available and the facility may be closed for a number of days until the matter is finalised. Emu picking is allowed by other states in Australia once appropriately risk assessed e.g. QLD and WA.

- If ACM is found in recycled products supplied to a building site, the EPA provides no guidance other than to say any waste containing asbestos is asbestos waste and asbestos can’t be recycled. This leaves the site in the difficult position as to what to do with the ACM material/recycled product. If they have one piece of ACM in 1 tonne it is easy to take it all to landfill. If there are 10 pieces found on the surface of a road where 1000 t has been supplied placed and compacted that’s a more difficult problem to determine what to do.
- The regulatory framework as it relates to asbestos and the lack of a due diligence defence for facility operators. This is a critical driver as to whether businesses choose to continue operating within a 'system' that has such exposure to prosecution.

Many of these issues can be solved with a workable “Unexpected Finds’ procedure that is robust and does not pose unacceptable environmental or health risks. There is a need to develop a sensible solution to ensure the viability of the C&D waste recycling industry.

Comments on the current processes

The current processes in NSW place all onus on the C&D facility to ensure there is “zero” asbestos, with these operators taking on significant legal risk in receiving waste from various sources.

The *WHS Regulation 2017* details requirements for the removal of asbestos “upstream” of the C&D recycling facility. It is entirely reasonable that an operator of a C&D recycling facility should be able to rely on works being undertaken in accordance with this regulation to ensure asbestos is removed from the waste being delivered. The key issues identified in that process are as follows:

- The removal of asbestos from buildings and structures as detailed in the *WHS Regulation 2017* does NOT require achieving and demonstrating “zero” asbestos. The *WHS Regulation 2017* has guidance on what comprises clearance (following asbestos removal) and allows for trace levels to remain in soil/waste. Neither of these requirements are consistent with “zero” asbestos. In fact, the definition of trace levels in relation to soil results in the use of detection limits that are consistent with the NEPM criteria (NEPC 1999 amended 2013a) for ACM for residential land use, but higher than the criteria for friable asbestos.
- The *WHS Regulation 2017* (and associated SafeWork Australia guidance) allows for the removal and disposal of up to 10 m^2 of non-friable ACM by individuals with no asbestos licence. The *WHS Regulation 2017* requires such materials be removed by a competent person, however, there are no requirements for clearance inspections to occur or certificates to be issued. This aspect poses the greatest risk to C&D recycling facilities as the proper removal and disposal of up to 10 m^2 does not require reporting or verification. Hence waste sent to C&D recycling facilities may include ACM from these sites.

As the processes currently applied to upstream generators of waste do not and cannot result in “zero” asbestos in the waste, the onus to achieve “zero” asbestos in waste being received at a waste facility appears to fall on the operator of the facility, at the gate. This is a significant disconnect or inconsistency.

If the C&D recycling facility can only receive waste with “zero” asbestos and the waste they receive must be cleared by people licenced by SafeWork NSW, then they should be able to rely on the procedures in the upstream waste generation stream to achieve that goal. So the on-site procedures should be sufficient to produce waste containing trivial or zero asbestos

To further compound the disconnect/inconsistency, other aspects of waste regulated in NSW, specifically contaminated soil and air emissions, certainly do not require “zero” asbestos as they allow for asbestos to be present at some level. In the case of air emissions, significant levels of asbestos in air can be lawfully discharged from a stationary source (refer to **Section 4.4**).

Many international jurisdictions make it clear that it is the responsibility of upstream waste generators to ensure that asbestos is removed from waste being delivered to C&D recycling facilities (refer to **Section 5**).

The current procedures do not appear to have any flexibility in allowing the facility to adopt appropriate practices for the identification and management of asbestos, utilising qualified asbestos experts and enabling risk-based decisions to be made in relation to the likely nature of asbestos that may be present, and how to manage those materials. This appears to result in the classification of large amounts of waste and recycled product (at times) as asbestos waste (as defined under the POEO Act). It also appears that the operator of such a facility is required to bear the cost and liability of this waste and the consequences of the waste containing "any asbestos" (or not achieving "zero asbestos") as is currently the situation even though they have no control over the production of the material for recycling and regulations exist to ensure such producers of waste for recycling provide appropriate materials. In addition, asbestos can also be present in such waste due to it being naturally present in soils – i.e. not due to any human activities.

The likelihood of friable asbestos being present in C&D waste is low. The form of asbestos most likely to be present in C&D waste is non-friable ACM which is of low risk in relation to worker and community health (refer to **Section 3.2**). To ensure this material remains low risk, procedures to remove this material prior to any significant mechanical disturbance (the key process by which fibres may be released) should be adopted. This would be at the point of removal (i.e. upstream) and upon receipt at a facility.

Section 8. Outcomes

This review has focused on understanding the complexities of dealing with asbestos contamination in waste that is accepted, handled and managed in the C&D recycling industry in NSW. The recycling of waste, including C&D waste is a key aspect of the waste management system in NSW, to reduce the volume of waste sent to landfill.

This review has considered the current legislation and guidance in NSW as well as approaches adopted in other states of Australia and Internationally, on the identification and management of asbestos contamination in these materials. The C&D recycling industry has identified a range of issues related to the way in which asbestos is managed at recycling facilities that have posed significant difficulties.

The review has identified a number of key outcomes which are summarised below:

Hazards posed by asbestos

- It is clear that there are a range of hazards posed by the potential presence of asbestos in any environment. The key hazards relate to asbestos fibres that are of biological concern, i.e. those equal to or longer than 5 μm and having diameters up to 3 μm with an aspect ratio equal to or greater than 3:1, that can move into the air and be inhaled. When assessing asbestos, there are a range of different methods that can be used to quantify asbestos fibres, some of which enable characterisation of the fibres with characteristics that have the potential to pose hazards to human health when inhaled. The selection of the quantification method is important as each will report different aspects in relation to asbestos exposure and risk. Hence guidelines are often tied to specific analytical methods.
- Different types of asbestos pose different levels of risk to workers and the community. Asbestos that is bonded in materials (or cement sheeting) poses the lowest risk, while loose fibres, such as those present in friable asbestos, that can easily move into the air pose the highest risk.
- In relation to potential risks posed by C&D waste:
    - There is a low potential for friable asbestos to be present in C&D waste where these materials are effectively managed at the point of removal from buildings and structures (i.e. upstream)
    - The most likely form of asbestos is bonded asbestos, which is of low risk, except where the bonded material is mechanically damaged. When this occurs, there is the potential for some fibres to be released to air, where exposure may occur. This material can be more easily identified and managed in waste materials. The most effective way to manage the potential for this damage to occur is for it to be effectively removed upstream or identified at the gate.
- The background presence of asbestos fibres in air, which is relevant to all members of the community in urban and rural areas means that the concept of zero asbestos or zero asbestos exposure is meaningless.
- While it is accepted that zero tolerance is part of NSW asbestos waste regulations and community expectations, the concept is meaningless in technical terms. Everyone is exposed to fibres from natural sources. Such sources are not targeted for management by

regulation or policy. In addition, the concept of 'zero' for anything that requires any form of measurement is meaningless as its detection depends on the reporting limit of the method. It is never possible to determine "zero", only that something cannot be detected.

Definition of asbestos

- The definition of asbestos in the POEO Act, which is adopted throughout all of the NSW regulations and is consistent with the definitions adopted in other states is very general. In addition, the definition of asbestos waste is very general and appears to have resulted in the zero-tolerance approach adopted in NSW, where the concept of any asbestos means it is an asbestos waste.
- The use of such a general definition does not enable risk to be considered, nor the characteristics of asbestos, namely fibres of a particular length and width that are of importance to the hazards that asbestos poses (refer to **Section 2**). In addition the definition does not allow any distinction between risks posed by ACM likely to be visible (i.e. bonded or in products), which are low risk, and asbestos fibres that can easily move into the air, which are high risk.
- This lack of regulatory definition, and link with the characteristics of asbestos that are hazardous, results in misunderstanding and misinformation that the hazards relate to the general term asbestos, and how these relate (or not) to the toxicological studies

Current asbestos guidance

Current guidance on asbestos in NSW is mixed and is the cause of many of the issues identified by the C&D recycling industry. There is a requirement for this industry to have "zero" asbestos in waste received and managed at a facility, and "zero" tolerance on the presence of asbestos in recycled products produced.

While the concept of "zero" asbestos is meaningless, the requirement is also disconnected from other regulations and guidance in NSW:

- The key disconnect relates to the *WHS Regulation 2017*, that relates to the requirements for removing and managing asbestos from buildings and structures prior to demolition (the process that produces the waste received by a C&D facility). The *WHS Regulation 2017* does not require "zero asbestos" post asbestos removal and allows for soil to include trace levels of asbestos, which is defined as <0.01% w/w. In addition, removal of small amounts of ACM (<10 m^2) poses the greatest risk of being present in such wastes.
- NSW utilises the NEPM (NEPC 1999 amended 2013a) for the assessment and management of contaminated soil, where risk-based guidelines for the presence of asbestos that may remain in soil in different land use settings is defined.
- NSW allows for emissions to air of asbestos from stationary sources (NSW EPA 2016a), at levels that may result in significant airborne asbestos exposures within the community, well above background levels and well above WHO air guidelines.

The requirement for "zero" asbestos appears to only apply to the C&D recycling facilities. Such a requirement is not workable where the waste being delivered does not have a requirement to have "zero" asbestos when it leaves the place where such waste was produced. This places the onus and liability (of prosecution) of managing asbestos to a zero-tolerance level on the operators of the C&D facilities alone and not onto the producers of the waste being recycled.

Current NSW EPA Standard (EPA 2019)

These documents relate to visual identification of ACM.

- ACM, where bonded in materials which would be visible is considered to be low risk in terms of health and can be easily removed from soil or waste using an emu-picking approach (noted to be permitted in the 2010 Worksafe guidance, but not in 2019).
- The greatest risk, however, relates to loose asbestos fibres. As discussed in **Sections 2, 3** and **4**, the key risk for workers and the community (including consumers) relates to the inhalation of fibres. The potential for friable asbestos to be present in C&D waste is low, and the release of any fibres from bonded asbestos can be minimised by the effective removal of these materials prior to mechanical damage.

Other Australian States

- South Australia and Queensland are silent on the management of asbestos in C&D waste.
- Victoria and Western Australia provide a definition of an acceptable level of asbestos, as measurable fibres, in waste that is consistent with risk-based guidance in the ASC NEPM. The criteria of 0.001% is also consistent with the detection limits that may be achievable for the analysis. This guidance includes the requirement to analyse for fibres addressed the key risk related to asbestos – the inhalation of fibres that are not visible so cannot be addressed by current control measures. The WA guidance also allows for the removal of visible ACM by emu-picking, which provides a workable approach to dealing with low risk asbestos in these materials.

International approaches

- Most international jurisdictions are clear that the removal of asbestos at a site, prior to demolition is key to managing asbestos in C&D waste. Some jurisdictions adopt the concept of zero asbestos in waste.
- The UK and Canada go further and allow for trace amounts of asbestos to remain. The UK adopts the reporting limit for the detection of fibres (using a specified method). Canada provides a definition of trace levels that is higher than in the UK. Ontario references the term trivial but does not define trivial.
- Canada also provides a definition of zero asbestos in air, which is essentially the reporting limit of the method (with the analysis method stated).
- The concept of zero asbestos is meaningless, as we are all exposed to background levels of asbestos all of the time, and with anything that requires measurement, a non-detection never means zero.
- Being able to define what is meant by “zero” or allowing consideration of trivial levels of asbestos and defining what is trivial enables these concepts to be better understood by industry and the community.

Trivial

- The concept of defining pollution based on its potential to cause harm and whether or not it is non-trivial is already within NSW legislation and guidance. The concept of non-trivial, however, is not defined particularly in terms of asbestos, where it gets caught up in the definitions of asbestos in the POEO Regulation which effectively mean zero-tolerance.
- The SA EPA also adopts the concept of trivial and has included consideration of background, which is important for asbestos. They reference the health based guidelines on asbestos in the ASC NEPM to assist in understanding what is considered trivial.
- Where background exposures to dust and asbestos are considered, adopting a soil or waste guideline of 0.001% w/w for friable asbestos (which is consistent with NEPC guidance on contaminated land, and also consistent with the criteria for asbestos in C&D waste in Victoria and Western Australia) would result in inhalation exposures that are below background in urban and rural areas, and could be considered to be trivial.
- Given the concept of trivial is already relevant in NSW, it would be appropriate to provide a definition of what is non-trivial in terms of asbestos in C&D recycling industry.

To be able to effectively manage asbestos contamination that may be present in C&D materials taken to facilities for the purpose of recycling, there are some fundamental aspects of legislation and policy in NSW that have to be changed, including:

- Changes to the *WHS Regulation* to ensure that waste generated from the demolition of structures with asbestos (friable and non-friable) adopt the same threshold or definition of “zero” asbestos as required to be adopted by the C&D recycling industry. Only where requirements in relation to the presence (or otherwise) of asbestos is the same for the generators of the waste and the C&D recycling industry can future protocols relating to “unexpected finds” be relevant and applicable.
- Rework the definition of asbestos, so that it is better linked with the characteristics of asbestos that pose hazards to human health, and can be matched with measurement methods.
- Providing a definition of zero asbestos in the context of measurement (i.e. reporting limits for methods) and background or non-trivial exposures and risks.
- Allowing for the hand-picking or emu-picking of visible ACM prior to transport to a facility, and at receipt at a facility as this is the material most likely to be present in C&D waste and this material is of low risk. There are numerous examples of procedures that can be used to ensure this is done effectively and safely.

Without the above legislative changes, it will be very difficult to establish a workable protocol or procedure for C&D waste recycling that does not result in significant liabilities remaining with the owners of these facilities in relation to the presence of asbestos.

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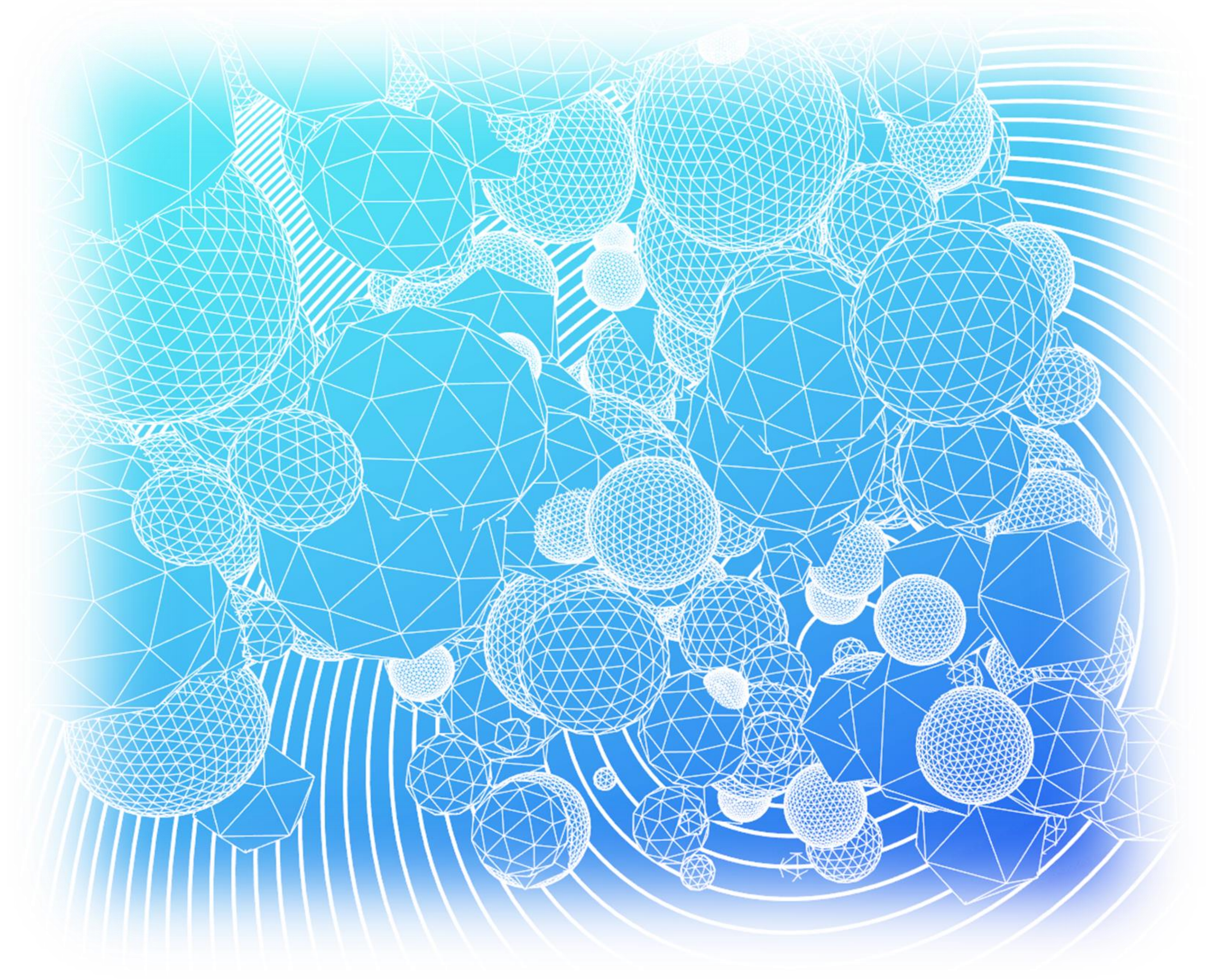

Independent review: Asbestos in Construction and Demolition Recycling

Prepared for: Beatty Legal Pty Limited

20 October 2020

Document History and Status

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Limitations

Environmental Risk Sciences has prepared this report for the use of Beatty Legal Pty Limited in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in the **Section 1** of this report.

The methodology adopted and sources of information used are outlined in this report. Environmental Risk Sciences has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

This report was prepared between June and October 2020 and is based on the information provided and reviewed at that time. Environmental Risk Sciences disclaims responsibility for any changes that may have occurred after this time.

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Glossary of terms

Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).
Exposure Assessment	The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.
Exposure Pathway	The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as chemical leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.
Guideline Value	Guideline value is a concentration in soil, sediment, water, biota or air (established by relevant regulatory authorities such as the NSW Department of Environment and Conservation (DEC) or institutions such as the National Health and Medical Research Council (NHMRC), Australia and New Zealand Environment and Conservation Council (ANZECC) and World Health Organisation (WHO)), that is used to identify conditions below which no adverse effects, nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter- and intra-species variations and uncertainty factors. Separate guidelines may be identified for protection of human health and the environment. Dependent on the source, guidelines will have different names, such as investigation level, trigger value, ambient guideline etc.
HHRA	Human Health Risk Assessment
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way (see route of exposure).
Inhalation	The act of breathing. A hazardous substance can enter the body this way (see route of exposure).
Point of Exposure	The place where someone can come into contact with a substance present in the environment (see exposure pathway).
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
Receptor Population	People who could come into contact with hazardous substances (see exposure pathway).
Risk	The probability that something will cause injury or harm.
Route of Exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin (dermal contact)
Toxicity	The degree of danger posed by a substance to human, animal or plant life.
Toxicology	The study of the harmful effects of substances on humans or animals.

Executive summary

ES.1 Introduction

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by Beatty Legal Pty Limited to undertake an independent review of the technical information around the potential presence and risks posed by asbestos that may be present in construction and demolition (C&D) waste to be recycled.

As noted by enHealth in 2013 (enHealth 2013)

"We are all exposed to low levels of asbestos in the air we breathe every day."

Consequently, it is no surprise that it is possible that asbestos may be found in C&D waste being brought in for recycling. Asbestos may be present in such waste due to:

- mixing in of small amounts of bonded asbestos from demolition with concrete for recycling or
- it being naturally occurring in the soil on which a building is being demolished or constructed (i.e. soil containing asbestos gets mixed into the waste) or
- settling of asbestos fibres generally present in the atmosphere (i.e. source of fibres is off-site).

Since around 2007, the C&D recycling industry has been working with the NSW EPA to develop an appropriate protocol/procedure for understanding the issues arising from the potential for asbestos to be present in construction and demolition waste and how best to manage that during the recycling process. This procedure has not yet been finalised.

In 2019 a court case changed the understanding of the law in NSW around asbestos containing wastes (Environment Protection Authority v Grafil Pty Ltd)**.** The court case determined that 1 fibre of asbestos in a stockpile makes the stockpile asbestos waste.

This change in understanding has the real potential to affect the viability of the C&D recycling industry which would have significant impacts on the amount of waste that requires landfilling. Given the limited landfilling volume available in NSW, this matter requires serious consideration.

To better understand the health and environmental risks of asbestos in C&D recycling, a detailed independent technical review has been undertaken and presented in this report.

ES.2 Objectives

The objectives of the review presented in this report are:

- Undertake independent review and provide a summary document detailing:
    - what is asbestos (where it comes from; how it is present in our environment; how it moves around the environment)
    - general technical basis for managing asbestos including toxicology, risk assessment, sampling and analysis and ambient levels

  - hazard based versus risk based guidelines
  - management frameworks for other chemicals in wastes in Australian jurisdictions – similarities and differences for asbestos
  - management frameworks for asbestos containing waste in NSW and other jurisdictions including international jurisdictions. This will include information about the basis for these frameworks [i.e. risk based], where available, and the situations where these get applied (e.g. WHS or contaminated land or waste)
  - concept of trivial versus non-trivial when assessing environmental changes
  - general description of C&D recycling process including products produced and where they are used
  - current issues with the existing system for the management of asbestos in this industry
  - definitions in relation to asbestos containing wastes (existing and changes due to court case in 2019) including what is technically feasible to measure (including sampling methods)
  - technical basis of asbestos guidelines used for waste and for other industries (like contaminated land)
- Based on the review undertaken, outline a best practice approach to managing asbestos within C&D recycling processes, noting where these measures may require additional work, or revision or changes to current guidelines, policy or regulation.

ES.3 Outcomes

The review presented in this report has identified a number of key outcomes which are summarised below:

Hazards posed by asbestos

- It is clear that there are a range of hazards posed by the potential presence of asbestos in any environment. The key hazards relate to asbestos fibres that are of biological concern, i.e. those equal to or longer than 5 μm and having diameters up to 3 μm with an aspect ratio equal to or greater than 3:1, that can move into the air and be inhaled. When assessing asbestos, there are a range of different methods that can be used to quantify asbestos fibres, some of which enable characterisation of the fibres with characteristics that have the potential to pose hazards to human health when inhaled. The selection of the quantification method is important as each will report different aspects in relation to asbestos exposure and risk. Hence guidelines are often tied to specific analytical methods.
- Different types of asbestos pose different levels of risk to workers and the community. Asbestos that is bonded in materials (or cement sheeting) poses the lowest risk, while loose fibres, such as those present in friable asbestos, that can easily move into the air pose the highest risk.
- In relation to potential risks posed by C&D waste:
  - There is a low potential for friable asbestos to be present in C&D waste where these materials are effectively managed at the point of removal from buildings and structures (i.e. upstream)

  - The most likely form of asbestos is bonded asbestos, which is of low risk, except where the bonded material is mechanically damaged. When this occurs, there is the potential for some fibres to be released to air, where exposure may occur. This material can be more easily identified and managed in waste materials. The most effective way to manage the potential for this damage to occur is for it to be effectively removed upstream or identified at the gate.
- The background presence of asbestos fibres in air, which is relevant to all members of the community in urban and rural areas means that the concept of zero asbestos or zero asbestos exposure is meaningless.
- While it is accepted that zero tolerance is part of NSW asbestos waste regulations and community expectations, the concept is meaningless in technical terms. Everyone is exposed to fibres from natural sources. Such sources are not targeted for management by regulation or policy. In addition, the concept of 'zero' for anything that requires any form of measurement is meaningless as its detection depends on the reporting limit of the method. It is never possible to determine "zero", only that something cannot be detected.

Definition of asbestos

- The definition of asbestos in the POEO Act, which is adopted throughout all of the NSW regulations and is consistent with the definitions adopted in other states is very general. In addition, the definition of asbestos waste is very general and appears to have resulted in the zero-tolerance approach adopted in NSW, where the concept of any asbestos means it is an asbestos waste.
- The use of such a general definition does not enable risk to be considered, nor the characteristics of asbestos, namely fibres of a particular length and width that are of importance to the hazards that asbestos poses. In addition the definition does not allow any distinction between risks posed by ACM that are likely to be visible (i.e. bonded or in products), which are low risk, and asbestos fibres that can easily move into the air, which are high risk.
- This lack of regulatory definition, and link with the characteristics of asbestos that are hazardous, results in misunderstanding and misinformation that the hazards relate to the general term asbestos, and how these relate (or not) to the toxicological studies.

Current asbestos guidance

Current guidance on asbestos in NSW is mixed and is the cause of many of the issues identified by the C&D recycling industry. There is a requirement for this industry to have "zero" asbestos in waste received and managed at a facility, and "zero" tolerance on the presence of asbestos in recycled products produced.

While the concept of "zero" asbestos is meaningless, the requirement is also disconnected from other regulations and guidance in NSW:

- The key disconnect relates to the *WHS Regulation 2017*, that relates to the requirements for removing and managing asbestos from buildings and structures prior to demolition (the process that produces the waste received by a C&D facility). The *WHS Regulation 2017* does not require "zero asbestos" post asbestos removal and allows for soil to include trace

levels of asbestos, which is defined as <0.01% w/w. In addition, removal of small amounts of ACM (<10 m^2) poses the greatest risk of being present in such wastes.
- NSW utilises the NEPM (NEPC 1999 amended 2013a) for the assessment and management of contaminated soil, where risk-based guidelines for the presence of asbestos that may remain in soil in different land use settings is defined.
- NSW allows for emissions to air of asbestos from stationary sources (NSW EPA 2016a), at levels that may result in significant airborne asbestos exposures within the community, well above background levels and well above WHO air guidelines.

The requirement for "zero" asbestos appears to only apply to the C&D recycling facilities. Such a requirement is not workable where the waste being delivered does not have a requirement to have "zero" asbestos when it leaves the place where such waste was produced. This places the onus and liability (of prosecution) of managing asbestos to a zero-tolerance level on the operators of the C&D facilities alone and not onto the producers of the waste being recycled.

Current NSW EPA Standard (EPA 2019)

These documents relate to visual identification of ACM.

- ACM, where bonded in materials which would be visible is considered to be low risk in terms of health and can be easily removed from soil or waste using an emu-picking approach (noted to be permitted in the 2010 Worksafe guidance, but not in 2019).
- The greatest risk, however, relates to loose asbestos fibres. As discussed in **Sections 2, 3** and **4**, the key risk for workers and the community (including consumers) relates to the inhalation of fibres. The potential for friable asbestos to be present in C&D waste is low, and the release of any fibres from bonded asbestos can be minimised by the effective removal of these materials prior to mechanical damage.

Other Australian States

- South Australia and Queensland are silent on the management of asbestos in C&D waste.
- Victoria and Western Australia provide a definition of an acceptable level of asbestos, as measurable fibres, in waste that is consistent with risk-based guidance in the ASC NEPM. The criteria of 0.001% is also consistent with the detection limits that may be achievable for the analysis. This guidance includes the requirement to analyse for fibres addressed the key risk related to asbestos – the inhalation of fibres that are not visible so cannot be addressed by current control measures. The WA guidance also allows for the removal of visible ACM by emu-picking, which provides a workable approach to dealing with low risk asbestos in these materials.

International approaches

- Most international jurisdictions are clear that the removal of asbestos at a site, prior to demolition is key to managing asbestos in C&D waste. Some jurisdictions adopt the concept of zero asbestos in waste.
- The UK and Canada go further and allow for trace amounts of asbestos to remain. The UK adopts the reporting limit for the detection of fibres (using a specified method). Canada

provides a definition of trace levels that is higher than in the UK. Ontario references the term trivial but does not define trivial.
- Canada also provides a definition of zero asbestos in air, which is essentially the reporting limit of the method (with the analysis method stated).
- The concept of zero asbestos is meaningless, as we are all exposed to background levels of asbestos all of the time, and with anything that requires measurement, a non-detection never means zero.
- Being able to define what is meant by “zero” or allowing consideration of trivial levels of asbestos and defining what is trivial enables these concepts to be better understood by industry and the community.

Trivial

- The concept of defining pollution based on its potential to cause harm and whether or not it is non-trivial is already within NSW legislation and guidance. The concept of non-trivial, however, is not defined particularly in terms of asbestos, where it gets caught up in the definitions of asbestos in the POEO Regulation which effectively mean zero-tolerance.
- The SA EPA also adopts the concept of trivial and has included consideration of background, which is important for asbestos. They reference the health based guidelines on asbestos in the ASC NEPM to assist in understanding what is considered trivial.
- Where background exposures to dust and asbestos are considered, adopting a soil or waste guideline of 0.001% w/w for friable asbestos (which is consistent with NEPC guidance on contaminated land, and also consistent with the criteria for asbestos in C&D waste in Victoria and Western Australia) would result in inhalation exposures that are below background in urban and rural areas, and could be considered to be trivial.
- Given the concept of trivial is already relevant in NSW, it would be appropriate to provide a definition of what is non-trivial in terms of asbestos in C&D recycling industry.

ES.4 Recommendations

To be able to effectively manage asbestos contamination that may be present in C&D materials taken to facilities for the purpose of recycling, there are some fundamental aspects of legislation and policy in NSW that have to be changed, including:

- Changes to the *WHS Regulation* to ensure that waste generated from the demolition of structures with asbestos (friable and non-friable) adopt the same threshold or definition of “zero” asbestos as required to be adopted by the C&D recycling industry. Only where requirements in relation to the presence (or otherwise) of asbestos is the same for the generators of the waste and the C&D recycling industry can future protocols relating to “unexpected finds” be relevant and applicable.
- Rework the definition of asbestos, so that it is better linked with the characteristics of asbestos that pose hazards to human health, and can be matched with measurement methods.
- Providing a definition of zero asbestos in the context of measurement (i.e. reporting limits for methods) and background or non-trivial exposures and risks.

- Allowing for the hand-picking or emu-picking of visible ACM prior to transport to a facility, and at receipt at a facility as this is the material most likely to be present in C&D waste and this material is of low risk. There are numerous examples of procedures that can be used to ensure this is done effectively and safely.

Without the above legislative changes, it will be very difficult to establish a workable protocol or procedure for C&D waste recycling that does not result in significant liabilities remaining with the owners of these facilities in relation to the presence of asbestos.

Section 1. Introduction

1.1 General

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- it being naturally occurring in the soil on which a building is being demolished or constructed (i.e. soil containing asbestos gets mixed into the waste) or
- settling of asbestos fibres generally present in the atmosphere (i.e. source of fibres is off-site).

Since around 2007, the C&D recycling industry has been working with the NSW EPA to develop an appropriate protocol/procedure for understanding the issues arising from the potential for asbestos to be present in construction and demolition waste and how best to manage that during the recycling process. This procedure has not yet been finalised.

In 2019 a court case changed the understanding of the law in NSW around asbestos containing wastes (Environment Protection Authority v Grafil Pty Ltd). The court case determined that 1 fibre of asbestos in a stockpile makes the stockpile asbestos waste.

This change in understanding has the real potential to affect the viability of the C&D recycling industry which would have significant impacts on the amount of waste that requires landfilling. Given the limited landfilling volume available in NSW, this matter requires serious consideration.

To better understand the health and environmental risks of asbestos in C&D recycling, a detailed independent technical review has been undertaken and presented in this report. This review presents the technical background for asbestos (including information about the toxicology and risks posed by different types of asbestos, the analysis of asbestos as well as background levels of asbestos (ambient levels) commonly present in air that the community is exposed to); description of the C&D recycling process, how asbestos might be present and how it asbestos is currently managed; a description of how other jurisdictions manage asbestos containing wastes; and proposing a practical, technically feasible framework for managing asbestos containing wastes into the future.

This document could then be used in discussions with NSW EPA and other relevant stakeholders and the general public (or interested groups).

1.2 Objectives

The objectives of the review presented in this report are:

- Undertake independent review and provide a summary document detailing:
  - what is asbestos (where it comes from; how it is present in our environment; how it moves around the environment)
  - general technical basis for managing asbestos including toxicology, risk assessment, sampling and analysis and ambient levels
  - hazard based versus risk based guidelines
  - management frameworks for other chemicals in wastes in Australian jurisdictions – similarities and differences for asbestos
  - management frameworks for asbestos containing waste in NSW and other jurisdictions including international jurisdictions. This will include information about the basis for these frameworks [i.e. risk based], where available, and the situations where these get applied (e.g. WHS or contaminated land or waste)
  - concept of trivial versus non-trivial when assessing environmental changes
  - general description of C&D recycling process including products produced and where they are used
  - current issues with the existing system for the management of asbestos in this industry
  - definitions in relation to asbestos containing wastes (existing and changes due to court case in 2019) including what is technically feasible to measure (including sampling methods)
  - technical basis of asbestos guidelines used for waste and for other industries (like contaminated land)
- Based on the review undertaken, outline a best practice approach to managing asbestos within C&D recycling processes, noting where these measures may require additional work, or revision or changes to current guidelines, policy or regulation.

1.3 Approach

The approach taken for the assessment of potential risks to human health is in accordance with guidelines / protocols endorsed by Australian regulators, including:

- enHealth, Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth 2012a);
- enHealth, Australian Exposure Factor Guide (enHealth 2012b);
- NEPM (1999 amended 2013) National Environmental Protection Measure – Assessment of Site Contamination including:
  - Schedule B1 Investigation Levels for Soil and Groundwater (NEPC 1999 amended 2013a)
  - Schedule B4 Guideline on Health Risk Assessment Methodology(NEPC 1999 amended 2013c)
  - Schedule B7 Guideline on Health-Based Investigation Levels (NEPC 1999 amended 2013d)

  - Toolbox Note – Key principles for the remediation and management of contaminated sites
- Relevant Standard Methods including:
  - Australian Standard 2004, Method for the qualitative identification of asbestos in bulk samples, Method No. 4964 (Standards Australia 2004);
  - NOHSC 2005, Guidance note on the membrane filter method for estimating airborne asbestos fibres, 2nd Edition, National Occupational Health and Safety Commission (NOHSC 2005)
- Environmental Health Standing Committee (enHealth), Asbestos: A guide for householders and the general public, Australian Health Protection Principal Committee, Canberra, 2013 (enHealth 2013);
- Environmental Health Standing Committee (enHealth), Management of asbestos in the non-occupational environment, Australian Health Protection Principal Committee, Canberra, 2005 (enHealth 2005);
- NSW Approved Methods for Modelling and Assessment of Air Pollutants in NSW (NSW EPA 2016a);
- National Waste Policy (2018);
- NSW Waste Avoidance and Resource Recovery Strategy (2014-2021); and
- SafeWork Australia and SafeWork NSW guidance on asbestos in the workplace and asbestos in and on soil.

Other guidelines adopted in the preparation of this report are referenced throughout this report.

Section 2. Hazards: Asbestos

2.1 General

This section provides a summary of the properties and hazard of asbestos.

Hazard identification examines the capacity of an agent to cause adverse health effects in humans and other animals. It is a qualitative description based on the type and quality of data, complementary information (such as structure-activity analysis, genetic toxicity and pharmacokinetics) and the weight of evidence from these various sources (enHealth 2012a). The hazard assessment can also consider the available data and determine a dose-response relationship that can be used to define quantitative guidelines or toxicity reference values for use in a risk assessment. The dose-response relationship is key to being able to quantify hazards and therefore risks.

The presence of a hazard does not, by itself, automatically result in adverse health effects. It is the dose or level of exposure that is important to making decisions about the potential for health effects (i.e. the risks).

Risk assessment incorporates the understanding of hazard with information related to exposure to determine if the dose or exposure is sufficiently elevated to result (or potentially result) in adverse health effects.

2.2 What is asbestos

Asbestos is the generic name given to the fibrous variety of six naturally occurring minerals. These minerals have been used in a wide range of commercial products. The minerals are hydrated silicates including a serpentine mineral (*chrysotile*) (also known as 'white asbestos'), and five amphibole minerals (*actinolite, amosite* (also known as 'brown asbestos'), *anthophyllite, crocidolite* (also known as 'blue asbestos'), and *tremolite*) (enHealth 2005, 2013; IARC 1973; USGS 2001).

The structure of these silicate minerals depends on the conditions under which they were formed. They may be long, thin fibres or they may take a range of other shapes. It is when they are in the form of the long, thin fibres that they are of most concern. The terms 'asbestos' or 'asbestiform minerals' refer only to those silicate minerals that occur in these long, thin fibres and as polyfilamentous bundles. The bundles are composed of extremely flexible fibres with a relatively small diameter and a large length. These fibre bundles have splaying ends, and the fibres are easily separated from one another (HSE 2005; USGS 2001).

Most asbestos used for commercial purposes was the serpentine mineral – chrysotile. Chrysotile is the only one of the three principal serpentine silicate minerals that can present in a fibrous form. Of the amphibole silicate minerals, amosite and crocidolite occur only in the asbestiform habit, while tremolite, actinolite and anthophyllite occur in both asbestiform and non-asbestiform habits (i.e. as fibres and as other shapes which do not require the same sort of evaluation) (enHealth 2005, 2013; HSE 2005; NTP 2005; USGS 2001).

Asbestos fibres are strong (e.g. high tensile strength, wear and friction characteristics), flexible (e.g. the ability to be woven), heat resistant (e.g. heat stability; thermal, electrical and acoustic insulation) and they have insulating properties and they are resistant to chemical, thermal and biological degradation (enHealth 2005, 2013; HSE 2005; NTP 2005; USGS 2001).

The fibres are light and their shape means they do not settle out onto surfaces very quickly unlike larger particles or particles of different shapes so they remain airborne for some time (enHealth 2013).

2.3 Sources of asbestos

Asbestos is widely distributed in the Earth's crust, and chrysotile, which accounts for more than 95% of global mining and use, occurs in virtually all serpentine minerals. Asbestos deposits have served as commercial sources in more than 40 countries, but the largest natural deposits are located in Canada, South Africa, China, and Russia. Amosite and crocidolite have been mined from South Africa, while crocidolite was once mined in Western Australia.

Asbestos fibres are basically chemically inert. They do not evaporate, dissolve, burn, or biodegrade, making them environmentally stable and cumulative. Asbestos fibres can be released into the air as a result of mechanical and natural disruption of asbestos containing materials (ACM) during use and disposal. Because of the widespread use of asbestos and their natural occurrence, the fibres are ubiquitous in the environment. Asbestos-containing materials that do not result in respirable fibres pose virtually no risk to health similar to other inert materials.

Asbestos fibres are present in normal urban air. Such fibres are present due to historic uses including in brake pads in cars. They are also present because this is a naturally occurring material, where fibres can be disturbed from rocks containing the mineral deposits (enHealth 2013).

Man-made asbestos containing products (ACM) can be divided into two types – bonded and friable asbestos. In good condition, bonded asbestos products such as asbestos cement sheet do not pose a risk because the asbestos fibres are bound together in solid cement. Friable asbestos products produce airborne fibres and so do pose a risk. It should be noted that bonded asbestos products can be damaged to become friable (enHealth 2013).

2.4 Health effects associated with asbestos exposure

2.4.1 General

Although the link between occupational exposure to asbestos and lung diseases such as mesothelioma was suspected over a century ago, it wasn't until the 1960's that the link was well established. Most evidence of the adverse health effects of asbestos (IARC 2012) comes from epidemiological studies of groups with known occupational exposures to asbestos such as those employed in the asbestos mining, processing or production industries or in the building trade. However, it is also clear that environmental (e.g. living near an asbestos mine) or para-occupational exposures (e.g. household contact with exposed workers) can result in asbestos related diseases.

Additionally, the background level of asbestos related disease may be related to the ubiquity of this naturally occurring mineral fibre. The annual mesothelioma rate in adults with no history of asbestos exposure is about 1.5 per million people (McDonald, J. & McDonald 1977; Peto 1984). This is considered low. The etiology (i.e. the cause) of these cases is unknown. Low-level environmental exposure to asbestos and asbestiform minerals has been postulated as a factor in these cases

(Omenn GS 1986). Berry et al (Berry, GR, AJ. Pooley, FD. 1989) reported that the lung burden of amosite and crocidolite fibres in 37 'unexposed' mesothelioma cases ranged up to 8.1 million fibres per gram of dry lung tissue (median 0.31). In summary, asbestos fibres are widespread in the environment, but the incidence of asbestos-related disease is extremely low, except in cases of high occupational or para-occupational exposure. This means everyone breathes in asbestos fibres during their lifetime. The small burden of fibres resulting from this background exposure appears to be tolerated.

Extensive epidemiological research on asbestos shows clear associations between asbestos exposure and asbestosis, lung cancer, and mesothelioma. The epidemiological evidence for other types of cancer is less extensive than it is for lung cancer and mesothelioma, but is still considerable for some. Epidemiological evidence shows a high incidence of lung cancer among workers exposed to chrysotile, amosite, anthophyllite, and with mixed fibres containing crocidolite, and tremolite. Pleural and peritoneal mesotheliomas were reported to be associated with occupational exposures to crocidolite, amosite, and chrysotile. Gastrointestinal tract cancers were reported to have been demonstrated in groups occupationally exposed to amosite, chrysotile or mixed fibres containing chrysotile. An excess of cancer of the larynx in occupationally exposed individuals has also been noted. In summary, all types of commercially available asbestos are well known to cause fibrosis of the lung and pleura as well as cancer of the lung, mesothelium and possibly the gastrointestinal tract in humans (IARC 2012).

Asbestos-related health effects result primarily from chronic exposures to asbestos, but relatively brief, high-level and low-level neighbourhood exposures in the vicinity of a crocidolite mine or mill, can also cause these diseases. The increased risk of mesothelioma is dose-dependent (enHealth 2005). Short-term exposures to low concentrations of airborne asbestos are likely to be associated with very low health risks (i.e. unlikely to result in disease) (enHealth 2005).

The four main asbestos-related conditions are pleural plaques, asbestosis, lung cancer and mesothelioma (HACA 2016):

- Pleural plaques are areas of white, smooth, raised scar tissue on the outer lining of the lung, internal chest wall and diaphragm. Pleural plaques are uncommon, and their occurrence is usually associated with exposure to asbestos. Most people with pleural plaques have no symptoms. Refer to **Section 2.4.2** for further discussion.
- Asbestosis is a chronic lung disease caused by inflammation or scarring in the lungs. It is associated with asbestos exposure and causes breathlessness, coughing, and permanent lung damage. Refer to **Section 2.4.2** for further discussion.
- Lung cancer is a tumour that develops in the lungs. People who are exposed to asbestos and smoke or have pre-existing lung disease have a higher chance of developing lung cancer. Refer to **Section 2.4.3** for further discussion.
- Mesothelioma is a cancer of the tissue that lines the body cavities, particularly the chest and abdominal cavities. It is almost exclusively caused by exposure to asbestos and usually takes a very long time to develop. Refer to **Section 2.4.4** for further discussion.

Asbestos-related diseases can take a long time to develop. Asbestosis can take 10 to 20 years to develop after initial exposure, whereas mesothelioma may take 30 to 45 years to develop (HACA 2016).

2.4.2 Asbestosis and pleural disease

Asbestosis and asbestos pleural disease are non-malignant asbestos diseases (i.e. not cancer) that are slowly progressive.

Asbestosis is a chronic inflammatory and fibrotic medical condition affecting the parenchymal tissue of the lungs caused by the inhalation and retention of asbestos fibres. Sufferers may experience severe dyspnoea (shortness of breath) and are at an increased risk for certain malignancies, including lung cancer but especially mesothelioma. The characteristic pulmonary function finding in asbestosis is a reduction in lung volumes, particularly the vital capacity (VC) and total lung capacity (TLC). In the more severe cases, the drastic reduction in lung function due to the stiffening of the lungs and reduced TLC may induce right-sided heart failure.

The onset of visible fibrosis rarely occurs earlier than 15–20 years from first exposure to high concentrations of respirable fibres. Not all individuals exposed to high levels of asbestos fibre develop asbestosis. There may be a threshold for asbestosis development of between 25 to 100 fibres-years/mL, effectively a high exposure. This compares to the current occupational time weighted average (TWA) exposure for asbestos fibres of 0.1 fibres/mL (which would require 10 years exposure at 0.1 fibres/mL to equate to 1 fibre-year/mL) (enHealth 2005).

In a review of the epidemiologic evidence for an asbestosis exposure response relationship, the World Health Organization Task Group on Environmental Criteria for Chrysotile Asbestos (WHO 1998) concluded that “the risk at lower exposure levels is not known.” There is evidence of an increased incidence of asbestosis in smokers which may be due to a number of issues such as smoking effects on lung function and defence mechanisms, however, no specific ‘dose’ of tobacco that caused this enhanced incidence could be determined (ATSDR 2001). Lung fibre retention is expected to play a role in the development of asbestosis with trapped asbestos fibres having a prolonged lung residence time. Therefore, the progression of asbestosis may continue for many years after exposure (ATSDR 2001).

Asbestos pleural disease is a non-malignant disease caused by inhalation of asbestos fibres that scar the pleura. The pleura is the thin membrane lining the lung and chest cavity. If the scarring is diffuse and extends along the chest wall, it is called pleural thickening. If the scarring is more focused and well defined, it is called pleural plaques. Asbestos pleural disease results in a similar scarring process as the one that occurs inside the lung with asbestosis; however, it occurs in the lining of the lungs rather than in the lungs themselves (ATSDR 2001). In regards to pleural plaques, enHealth (2005) provides the following:

> *The relationship between dose and response for pleural plaques is much weaker than for asbestosis. A good correlation has been shown between pleural plaques and asbestos fibres in the lungs; however, there is large variation.*

As these diseases generally occur only after heavy industrial exposure they are of limited relevance to this review and have not been specifically discussed further.

2.4.3 Lung cancer

National and international health agencies have classified asbestos as a known human carcinogen. This includes classifications available from IARC (IARC 2012) and the USEPA (USEPA 2020).

Asbestos, by itself or acting synergistically with tobacco smoke, causes lung cancer. Lung cancer can occur many years after initial exposure (10–40 years). Lung cancer has been identified in people exposed to respirable asbestos in occupational environments and has been associated with exposure to both amphibole and chrysotile asbestos (ATSDR 2001). The causal association between asbestos exposure and lung cancer is generally well recognised, but there are still substantial controversies on how the risk might vary by exposure to different fibre types and sizes, and whether there is a risk at low levels of exposure (i.e. environmental/community exposures).

There is some evidence that chrysotile asbestos may be less potent for the induction of lung cancer than the amphibole forms of asbestos (e.g. crocidolite, amosite and tremolite). This “amphibole hypothesis” (Cullen 1996; McDonald, JC. 1998; Stayner, Dankovic & Lemen 1996) is based on the observation from experimental studies that chrysotile asbestos is less biopersistent (i.e. has a shorter half-life) in the lung than the amphiboles. IARC (IARC 2012) noted that the lower biopersistence of chrysotile in the lung does not necessarily imply that it would be less potent than amphiboles for lung cancer.

2.4.4 Mesothelioma

Mesothelioma is a cancer of the lining of the chest cavity (the pleura) or, less commonly, the lining of the abdominal cavity (the peritoneum).

It is generally, but not always, associated with continued occupational or other high exposure to respirable asbestos. Fairly consistent and strong epidemiological evidence indicates that approximately 70% to 90% of mesothelioma cases can be related to asbestos exposure (Youakim 2005), and hence it is commonly accepted that asbestos exposure is the cause.

The ability to link asbestos exposure to the development of mesothelioma is subject to sufficient time elapsing since the exposure occurred, to permit the disease to have initiated and developed. Mesothelioma generally does not occur until 20–50 years after exposure. Mesothelioma has been associated with all types of asbestos. However, the evidence for causality is strongest for amphiboles. Unlike lung cancer, mesothelioma occurrence does not appear to be affected by smoking history.

Mesothelioma can occur with low asbestos exposure; however, very low background environmental/community exposures carry only an extremely low risk. The dose necessary for effect appears to be lower for asbestos-induced mesothelioma than for pulmonary asbestosis or lung cancer (ATSDR 2001).

The incidence rates of malignant mesothelioma have been increasing in Australia since 1965 and it is clear that these rates of mesothelioma are related to the use and production of asbestos in Australia in previous decades. There is no indication of when the incidence rates of mesothelioma will start to decline although a recent update of Wittenoom workers stated that by the end of 2008, the number of mesothelioma deaths related to direct exposure at Wittenoom had reached 4.7% for all the male workers and 3.1% for the females and predicted that about another 60 to 70 deaths with mesothelioma may occur in men by 2020 (Berry, G et al. 2012).

The link between asbestos exposure and the incidence of lung cancer and mesothelioma has been assessed in more than 20 epidemiological studies of occupational exposure in traditional asbestos industries. There is much less evidence of a link between non-occupational or para-occupational exposures and asbestos related disease. In the first published study to show exposure-response relationships between incidence of mesothelioma and environmental/community exposure to any form of asbestos, the incidence rate of mesothelioma for Wittenoom residents with household contact with crocidolite miners or neighbourhood exposure to crocidolite tailings has been estimated to be 260 per million person-years (Hansen et al. 1998). The incidence of mesothelioma increased significantly with increasing time following first residence at Wittenoom and with increased level of exposure to crocidolite. The incidence of mesothelioma increased from about 210 per million person-years (pmpy) at 20–29 years since first exposure, to over 1,600 pmpy at 40 or more years from first exposure. This rate is substantially higher than the 1998 Western Australian rate of 50 pmpy for men and 8 pmpy for women. The corresponding figures for the Wittenoom workers' cohort were approximately 900 and 7,000 pmpy. (Hansen et al. 1998).

The background incidence rate of mesothelioma in people without occupational, domestic or neighbourhood exposure to asbestos and with normal lung fibre content is about one or two annual deaths per million of population, which translates broadly to a lifetime risk of 8 to 16 per 100,000 for either sex although recent data indicates this could be as high as 25 per 100,000. Whether this background level is in fact caused by naturally occurring asbestos, or asbestos-like materials in the natural environment, by other causes or by a mixture of causes, is not known (WATCH 2002-2012).

2.5 Asbestos mode/mechanism of action

2.5.1 General

The quantitative assessment of potential risks to human health for any chemical requires the consideration of the health end-points and, where carcinogenicity is identified; the mechanism of action needs to be understood. The IARC (IARC 2012) review concluded that "*The mechanistic basis for asbestos carcinogenicity is a complex interaction between crystalline mineral fibres and target cells in vivo. The most important physicochemical properties of asbestos fibres related to pathogenicity are surface chemistry and reactivity, surface area, fibre dimensions, and biopersistence*."

In addition to the degree of exposure (magnitude or intensity, frequency and duration), the physical properties of the fibres, including fibre type, size and shape are important determinants of asbestos related diseases. The physical and chemical properties, persistence in the lungs and capacity to translocate across membranes are factors that underpin the intrinsic toxicity of the various asbestos types.

2.5.2 Fibre dimensions

Fibre dimension determines the likelihood that a fibre will enter the body insofar as the size and shape influence the respirability and clearance of the fibres as well as the potential for translocation across cells and biological membranes. In terms of shape, fibres >8 µm long and <0.25 µm diameter, with an aspect ratio (length/width) ≥10 appear to be most dangerous. In terms of length, fibres >20 μm and <100 μm long tend to be more carcinogenic. Fibres >100 μm long are not respirable (cannot reach the lungs) and hence do not pose a risk, unless they are first broken down into shorter fibres.

Asbestosis has been associated with fibres longer than 2 μm, mesothelioma with fibres longer than 5 μm, and lung cancer with fibres longer than 10 μm (Lippmann 1988, 1990). Fibres <5 μm are considered to be much less potent than longer fibres, however, in typical occupational environments, fibres shorter than 5 μm outnumber the longer fibres by a factor of 10 or more (Dement & Wallingford 1990). As noted, studies report that longer thinner fibres are more carcinogenic but do not identify a precise fibre length that did not have biological activity (Berman & Krump 2008; Stanton & Wrench 1972). Studies looking at human tissues have also found that the majority of asbestos fibres in mesothelial tissues were shorter than 5 μm in length, thus indicating the ability of the shorter fibres to reach the tumour site, remain there, and have an unspecified role in the etiology of disease (Dodson, Ronald F et al. 2001; Suzuki & Yuen 2002). There is clear evidence that short fibres predominate in the lung, thoracic lymph nodes and mesothelial tissue following asbestos exposure (Dodson, Ronald F. et al. 2003). Furthermore, short fibres appear to more readily migrate to the pleura and are present in substantial amounts in pleural plaques, pleural fibrotic tissue and mesotheliomas.

2.5.3 Fibre respirability

Fibre diameter is an important determinant of carcinogenic potency, as it influences fibres' aerodynamic diameter, a contributing factor for pulmonary deposition. Specifically, the diameter of fibres impacts their deposition rate and clearance rate from the lungs and the body overall, and thus the amount of time they have to interact with biological systems.

The following general conclusions can be made about particle respirability (USEPA 2003):

- Fibres that are deposited in the lung are usually thinner than approximately 0.7 μm and are almost always thinner than 1 μm.
- Long, thin fibres are deposited in the lung with greater efficiency.
- Because of physical/chemical differences, short, thick chrysotile structures will be deposited more efficiently in the lung than corresponding (i.e., short, thick) amphibole structures and longer, thinner amphibole structures are typically deposited more efficiently than corresponding chrysotile structures.
- Curly chrysotile structures are less likely to reach the lung than are straight amphibole (or chrysotile) structures.

2.5.4 Fibre clearance

Once inhaled, asbestos fibres can be removed from their site of deposition (WHO 2000) by:

- Mucociliary clearance
- Translocation within alveolar macrophages
- Uptake by epithelial cells.

These mechanisms usually remove 95-98% of deposited fibres, as most of the fibres have lengths less than <5 μm. Fibres less than 15 μm are often engulfed by macrophages. Longer fibres may be more pathogenic because they are harder to clear from the lungs. Most reports have shown that fibre accumulation is proportional to measured exposure for amphiboles, but this is not generally true for chrysotile. For amosite and crocidolite, estimated clearance half-times are measured in years to decades, whereas for chrysotile, the available, rather indirect, data suggest that the vast majority of fibres are cleared within months, although some fibres may be sequestered and only cleared very slowly. Although both chrysotile and amphibole asbestos are generally insoluble, within the lungs, chrysotile fibres can subdivide into constituent fibrils that will partially dissolve and those that don't dissolve at all. Overall, these studies suggest that the differences between amphibole and chrysotile fibre burdens in man reflect much faster clearance of chrysotile fibres, rather than a failure of chrysotile deposition.

Clearance rates partially determine biopersistence, that is, the degree to which fibres remain or persist in the body. Biopersistence is influenced by fibre size which in turn dictates respirability, deposition, as well as clearance from the lung. Chrysotile has been shown to be rapidly removed from the lung following inhalation exposure in experimental animals (Bernstein, Chevalier & Smith 2005), while lung analyses from humans (Albin et al. 1994) who were primarily exposed to chrysotile fibres show low levels of chrysotile compared to amphibole fibres even when amphibole exposure represented a trace impurity of overall exposure (Rowlands, Gibbs & McDonald 1982).

In summary, there is clear support for the view that the epidemiological literature and mechanistic animal studies show a strong correlation between fibre length and carcinogenic potency for asbestos (ATSDR 2001). Risk assessments should thus give greater importance to fibres greater than 10 μm in length while accepting that shorter fibres may also play a role in asbestos cancer etiology.

2.5.5 Fibre type

There is some uncertainty around the types or severity of illness attributable to the different mineralogical types of commonly encountered asbestos. The asbestos industry has supported research and published various studies claiming that chrysotile is much less toxic than the amphibole forms such as crocidolite and amosite.

For example, arguments have been presented that:

- mesothelioma incidence associated with chrysotile exposure is actually attributable to relatively low concentrations of other asbestos fibre types
- chrysotile is less potent than other asbestos fibres in the induction of asbestosis and lung cancer based upon observed differences in fibre persistence, morphology, composition and lung fibre burdens
- there is a threshold for chrysotile fibre exposure below which pathological effects will not occur or will be undetectable in epidemiological studies.

However, strong experimental support for reduced chrysotile toxicity on a mechanistic basis remains lacking. WHO (WHO 2014) states that: *'The scientific evidence is clear. The firm conclusion of the WHO and IARC assessments is that chrysotile causes cancer of the lung, larynx and ovary, mesothelioma and asbestosis, whether or not it is less potent than amphibole types of asbestos in doing so. Assertions about differing physicochemical properties, the question of whether or not historical epidemiological studies may have been dealing with chrysotile contaminated with* *amphibole types of asbestos, and the physical containment of chrysotile in modern high-density cement (at the time of manufacture) do not alter this finding.'*

The WA Rationale states that *'While it is reasonable to anticipate differences in toxicity according to the mineralogy and dimensions of asbestos fibres, current scientific knowledge is not yet able to provide meaningful distinction. In addition, it is evident that the influence of confounding environmental exposure factors on asbestos toxicity may be significant, particularly in non-occupational settings. From a regulatory perspective, the assumption that the potential health impacts posed by different asbestos fibre types and dimensions are equivalent is therefore considered both conservative and reasonable.'*

Based on the existing data, most regulators adopt different risk levels for the different types of asbestos based on some large meta-analyses (Berman & Krump 2008; Hodgson, J & Darnton 2000). Some of these risk levels have recently been re-appraised. (Hodgson, JT & Darnton 2010) updated their meta-analysis of the potency of chrysotile asbestos fibres to cause mesothelioma and revised their potency estimate upward (i.e. higher risk).

2.5.6 Human susceptibility to asbestos-related disease

Studies have also demonstrated that not all people are similarly affected by exposure to the same levels of asbestos as is the case for many diseases. Multiple diseases are associated with asbestos exposure and other environmental or genetic factors may interact e.g. there is a synergistic effect between cigarette smoking and lung cancer.

Several populations that may be unusually susceptible to asbestos exposure have been identified (ATSDR 2001). The long-term retention of asbestos fibres in the lung and the long latency period for the onset of asbestos related disease suggests that those exposed earlier in life (as children) may be at greater risk. Early developmental differences may also lead to increased childhood susceptibility. An association has been noted between certain genotypes and increased risks of mesothelioma, cancers and non-malignant respiratory disease (Neri et al. 2008). In Cappadocia, Turkey, certain families in specific villages show an autosomal dominant susceptibility to developing mesothelioma after exposure to erionite, a naturally occurring mineral that shares the same structure as asbestos (Ascoli et al. 1998; Huncharek, Klassen & Christlani 1995).

Animal studies suggest that those who are immunologically deficient may experience increased severity of pulmonary lesions in response to asbestos exposure. Further studies indicate that genetic differences in immunological capabilities may be a predisposing factor for asbestos related disease. Some human studies have suggested that individuals infected with Simian Virus 40 may be at increased risk of developing mesothelioma.

2.5.7 Mode of action

Fibres that persist within the lung or the mesothelium are capable of producing fibrogenic and tumorigenic effects in these tissues. Although the precise mechanisms by which asbestos fibres cause toxic injury have not been determined, there are several proposed modes of action including both direct interaction between fibres and cellular components and induced cell-mediated pathways (ATSDR 2001).

- *Direct action*: Asbestos fibres can adsorb to a variety of cellular macromolecules (e.g., proteins, membrane lipids, RNA, DNA), an interaction mediated by surface charge. Fibres can also bind to fibronectin, a glycoprotein found in abundance in the alveolar lining fluid. Fibre binding can alter protein shape, stiffen membranes and interfere with chromosome segregation.
- *Active oxygen mechanism:* In response to asbestos fibres, alveolar macrophages produce reactive oxygen species in an attempt to digest the fibre. The reactive oxygen species include hydrogen peroxide and superoxide radical anion which can interact to produce potent hydroxyl radicals. Cell membrane lipids have been shown to undergo peroxidation, resulting in increased membrane permeability in rat lung fibroblasts cultured with asbestos. Overall, cytotoxic and oxidative responses indicative of oxidative stress in a variety of lung tissues have been observed following asbestos exposure.
- *Other Cell-Mediated Mechanisms*: In addition to the release of active oxygen species, alveolar macrophages and other cells, including pleural mesothelial and lung cells, release a number of cellular factors in response to asbestos exposure. These factors are mediators of a number of cellular reactions including inflammation, macrophage recruitment and cell proliferation.

2.6 Quantification of hazard

Asbestos is considered to act with a non-threshold dose response relationship (WHO 2000, 2014). This means that there is no safe dose for asbestos exposure, however, the risk of asbestos-related disease increases with increasing dose or exposure.

The WHO (2000) provides unit risk values relevant to the assessment of asbestos exposure, and mesothelioma, based on data from a number of studies. The WHO best estimate (which notes a number of uncertainties) is a risk of 2×10^{-5} for exposure to 100 f/m^3. This assessment has been used in the derivation of the NEPM guidelines for asbestos in soil (NEPC 1999 amended 2013a; WA DOH 2009)

The WHO (WHO 2000) further indicates that, with a lifetime exposure to 1000 f/m^3 (0.0005 f/ml or 500 f/m^3, optically measured) in a population of whom 30% are smokers, the excess risk due to lung cancer would be in the order of 10^{-6}–10^{-5}. For the same lifetime exposure, the mesothelioma risk for the general population would be in the range 10^{-5}–10^{-4}.

The USEPA currently adopts an inhalation unit risk of 0.23 (f/mL)$^{-1}$ and the most recent review (USEPA 2020) has proposed an inhalation unit risk of 0.16 (f/mL)$^{-1}$ for chrysotile asbestos exposures.

2.7 Asbestos fibre measurement

The inhalation of micron-scale asbestos fibres is the major exposure pathway for this material. Consequently, the determination of risk and occupational exposure limits is based, in large part, on the accurate determination of fibre concentrations in the air. However, all measurement procedures are complicated by the considerable variation in physical structure and chemical composition that are found with the different forms of asbestos.

Regulatory definitions specify mineral species identification based on chemistry and crystal structure, but can also specify physical parameters, such as length and width, which apply to and define particles that meet specific counting rules. This is frequently done by identifying approved analytical methods, such as ISO 10312 (ISO 2019) or NIOSH 7400 (NIOSH 2019), that clearly define for the analyst which particles should and should not be counted.

Historically, the most commonly used definitions (e.g., those used by the Occupational Safety and Health Administration [OSHA], National Institute for Occupational Safety and Health [NIOSH], and World Health Organization [WHO]) for a regulated form of “asbestos” are limited to those structures longer than 5 μm and with a defined length-to-width (aspect) ratio of 3:1 or sometimes 5:1; rarer definitions (e.g., AHERA as used by the U.S. Environmental Protection Agency [EPA]) include different length parameters.

Most regulations are based on numbers of countable particles per unit volume of air. Generally, the regulatory definitions have evolved historically for practical reasons related to the analytical sensitivities of the instruments used in regulatory measurements. As such, they may include categories that do not produce health effects or, conversely, may exclude some that do (Case et al 2011).

Three main forms of microscopy have been used for measuring asbestos: ordinary light microscopy (OLM); phase contrast microscopy (PCM); and transmission electron microscopy (TEM).

Ordinary light microscopy **(OLM)** is the most limited method as there can be no distinction made between mineralogies or morphologies. OLM is generally limited to detecting particles that are much larger than those detected using phase contrast and electron microscopy, which makes it the least useful of the readily available methods.

In the 1980s, the USEPA developed an approach for assessing asbestos risks (USEPA 1986) which assumes no differences between the potencies of different asbestos types (amphibole and chrysotile). At the time, the most likely analytical method used for asbestos analysis was Phase contrast microscopy (PCM).

Phase contrast microscopy **(PCM)** using the membrane filter method has been used for many years as the standard procedure for the determination of asbestos fibres in air in Australia. The Australian National Occupational Health and Safety Commission (NOHSC) has published a Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres (2nd. Ed.) (NOHSC 2005).

“Countable fibres” are defined as any fibrous objects having a maximum width less than 3 μm, a length greater than 5 μm and a length/width ratio greater than 3:1. These guidelines do not place a requirement on the quantification of fibres below 5 μm in length in occupational settings even though the available evidence indicates that such fibres represent the majority of fibres released from asbestos building materials (Spurny 1989; Teichert 1986b).

The detection limit of this method is 0.01 f/mL level. Laboratories are present in Australia that are NATA accredited for analysis using PCM.

This methodology has been adapted from occupational hygiene practice in the asbestos industries in the 1970's and 1980's and has been adapted for use on sites involving asbestos removal from the 1980's. The PCM methodology is somewhat limited in all but high public risk situations because almost all data are recorded as below detection limit (e.g. <0.01 f/mL or <10,000 fibres per cubic metre of air). The method does not provide an air quality dataset that may be able to be used on a daily basis to understand emerging changes in risk during site remediation and identify any warning signs that elevated levels could occur.

Unlike OLM, PCM is able to measure smaller asbestos structures and also determine their shape. However, PCM can only measure particles greater than 0.25 μm in diameter and 0.5 μm in length. This can result in underestimation of narrow asbestos particles, which may be important for accurately quantifying asbestos cancer risk (Berman, D & Crump, K 2008; Berman, DW & Crump, KS 2008). It has been shown in previous studies that PCM significantly underestimates asbestos fibre concentration in air when compared to TEM, primarily because of poor resolution (Perry 2004). Other limitations of PCM include the inability to distinguish between particle mineralogy and, in some instances, the inability to distinguish between asbestiform and non-asbestiform particles. Depending on the sample matrix, this inability to clearly identify only asbestos fibres could potentially result in overestimation of the concentration of asbestos present on a filter. The possibility of either underestimation from poor resolution, or overestimation from misidentification of non-asbestiform particles, causes PCM to be an inaccurate method for estimation of asbestos concentrations.

***Transmission electron microscopy* (TEM) or scanning electron microscopy (SEM)** – Analytical Method 7402 –Asbestos measured by TEM (Baron & Platek 1990) quantifies the asbestos fibre fraction of all fibres in air samples when there is any uncertainty as to the composition of the samples. Unlike other analytical techniques used for asbestos analysis, TEM/SEM is able to distinguish different fibre mineralogies. TEM is able to reveal fibres that are less than 0.01 μm in diameter and SEM is able to reveal fibres down to 0.05 μm in diameter. As a consequence, different fibre size classes of both amphibole and chrysotile asbestos can be differentiated. TEM is slower and more expensive and may be able to achieve lower detection limits than PCM. It is noted, however, that the detection limit is affected by the small portion of the sample that can be observed under high magnification.

In general, there is a lack of standardised methods for TEM/SEM and an absence of proficiency testing. Few laboratories have been identified in Australia that can conduct TEM/SEM analysis. Review of the NATA website indicates that only one laboratory in Australia is NATA accredited for asbestos and inorganic fibre identification using SEM.

Overall

PCM is the predominant method used in all workplace determinations principally because of its relative ease of use and cost advantage. There are limitations with each of these procedures. For example, PCM may underestimate the concentration of relevant fibres as this visual procedure cannot accurately determine fibres below 0.2 μm in diameter. Importantly, all of the asbestos types can produce fibres below this size which cannot be easily determined by optical resolution (Brown 2000). In addition, PCM procedures routinely count only fibres longer than 5 μm in length. The conventional PCM method is adequate for monitoring the breathing zone of workers (wearing respiratory protection) so that the level of protection to workers near asbestos sources are quantitatively monitored. Static asbestos-in-air monitoring at the boundary of sites undergoing remediation etc. using the conventional membrane filter method will typically produce ‘below limit of detection’ data.

PCM techniques are not able in some situations to accurately distinguish morphologically non-asbestos fibres from asbestos fibres. Fibres below 5 μm in length may still be very relevant to asbestos mediated health effects in humans (Suzuki, Yuen & Ashley 2005; Tossavainen, Karjalainen & Karhunen 1994) and are best evaluated using electron microscopy methods. However, the more sensitive analytical methods utilizing electron microscopy are time and labour intensive and suffer from standardisation problems between laboratories (Wagner 2002).

Currently, environmental laboratories offering asbestos in soil analysis can provide a variety of methods, some of which are accredited and some are not:

- Gross visual screen, often performed as soils are mixed and weighed out for other analyses – this will only detect ACM – no quantification
- Detailed screen using a x10 – x40 standard optical microscope – this will detect ACM and most free fibres – no quantification
- Identification of asbestos type by Phase Contrast Optical Microscopy (PCOM) or Polarised Light Microscopy (PLM) – no quantification
- Quantification by gravimetric measurement – visible pieces or large bundles are picked out manually and weighed – this will only detect ACM to 0.1%
- Quantification by sedimentation and fibre measurement using PCOM or PLM (fibres) – this will detect fibres to 0.001%
- Quantification and identification by Transmission Electron Microscopy – this is a high resolution method which will detect fibres to 0.0001%, but the equipment is extremely expensive and only available in a very small number of laboratories

Comments on hazards and measurement

It is clear that there are a range of hazards posed by the potential presence of asbestos in any environment. The key hazards relate to asbestos fibres that are of biological concern, i.e. those equal to or longer than 5 μm and having diameters up to 3 μm with an aspect ratio equal to or greater than 3:1, that can move into the air and be inhaled.

Asbestos is naturally occurring in many areas and is also present as a result of historical uses of asbestos materials, hence asbestos is expected to always be present in the environment.

When assessing asbestos, there are a range of different methods that can be used to quantify asbestos fibres, some of which enable characterisation of the fibres with characteristics that have the potential to pose hazards to human health when inhaled. The selection of the quantification method is important as each will report different aspects in relation to asbestos exposure and risk. Hence guidelines are often tied to specific analytical methods.

Section 3. Asbestos exposure and risk

3.1 General

Breathing in asbestos fibres is the main pathway linked to risk of developing an asbestos related disease. This risk is increased with the number of fibres breathed in (i.e. the dose) and the length of time of exposure. This is illustrated in **Figure 3.1**, that illustrates the risk factors relevant to asbestos (enHealth 2013). Touching the fibres or eating them has not been linked to disease.

Every Australian is exposed to very low levels of asbestos in the air we breathe every day. There are usually between 10 and 200 asbestos fibres in every 1000 litres of air. This means we breathe in up to 3000 asbestos fibres a day (also refer to **Section 3.4** for additional discussion in background exposures). Despite this very few people experience ill effects from such exposure (HACA 2016).

Most people who have developed asbestos related diseases in Australia have had exposure to much higher levels of asbestos fibres through working directly with asbestos or asbestos products. Family members of these workers have also been known to develop asbestos-related diseases because the workers carried asbestos fibres home on their clothing, skin and hair (HACA 2016).

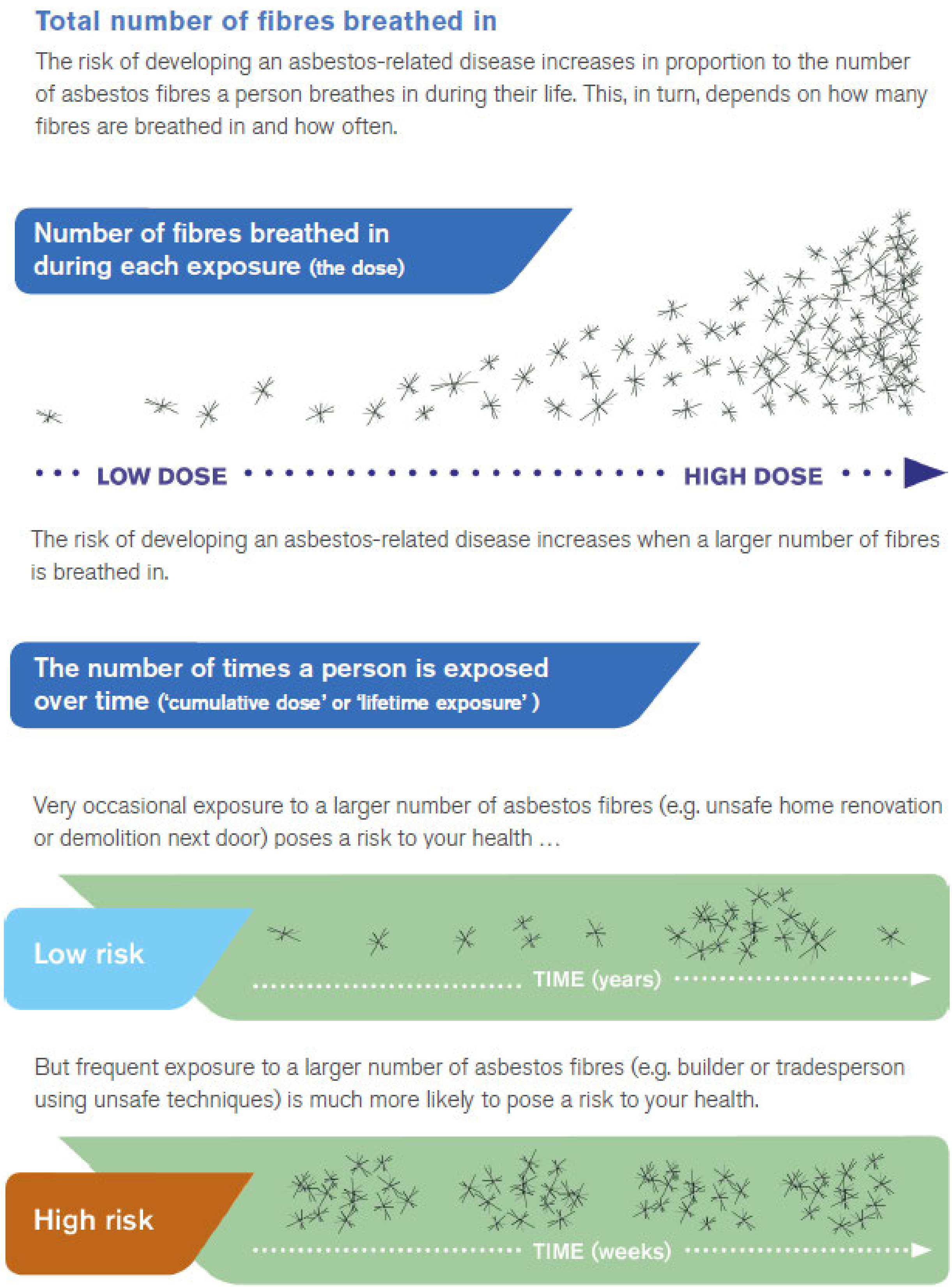


Figure 3.1: Risk factors in developing asbestos-related disease (enHealth 2013)

3.2 Risks posed by asbestos

The hazards associated with exposure to asbestos relate to the inhalation of small fibres (refer to **Section 2**) (enHealth 2013). Hence risks posed by the presence of asbestos materials depends on the nature and condition of the material and the potential for asbestos fibres to be released to air.

The common forms of asbestos include (enHealth 2005, 2013):

- Bonded products, where asbestos is bound into solid products with asbestos comprising around 10% to 15%. The materials are solid, rigid and non-friable and the fibres are not often released to air. These materials are commonly referred to as 'fibro', 'asbestos cement' and 'AC sheeting'. Bonded ACM is visible. **Where intact, these materials are considered very low risk. Where damaged or badly weathered, the materials may become friable and the risk is increased in such situations**. Further discussion on the potential for asbestos fibres to be released to air from weathering and mechanical damage is provided in **Section 3.3**.

- Friable products are generally soft and loose and crumble into fine material or dust with light pressure. Such products contain a high levels of asbestos (up to 100%) and the fibres can easily be released to air. **These materials pose the highest risk**. Unless present in complete products, once disturbed or crushed the fibres are not visible.

  In the demolition of structures in NSW (and Australia), all friable asbestos (including any building that has fire damaged asbestos materials) is required to be properly removed by a suitably licenced person. Where this process is properly undertaken, there should be no friable asbestos present in demolition materials removed from the site (post asbestos removal).

Figure 3.2 produced by enHealth graphically displays this risk information (enHealth 2013). The risk terms outlined by enHealth, as presented in this figure, have been used in this assessment with the following contextualisation relevant to this assessment:

- A '**very low risk**' is considered to relate to concentrations of asbestos fibres indistinguishable from background ranges and estimated not to exceed 0.01 f/mL in concentration.
- A '**low risk**' is considered to relate to concentrations of asbestos fibres slightly above background for a short period of time. These slightly increased concentrations are very unlikely to exceed 0.01 f/mL and are estimated to not exceed the occupational guideline of 0.1 f/mL.

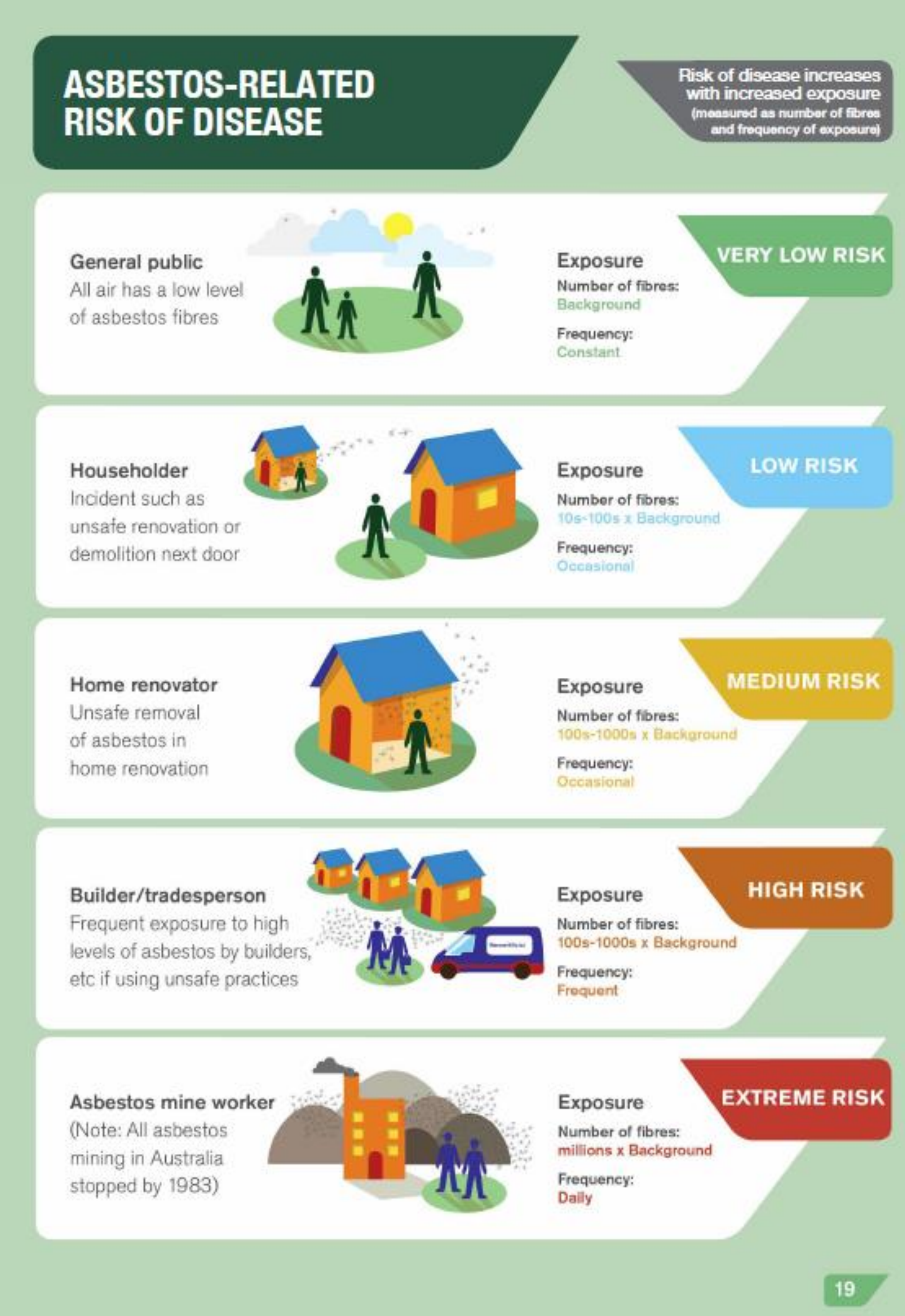


Figure 3.2: Asbestos related risk guide developed by enHealth (2013)

3.3 Effects of weathering and damage of asbestos in cement materials

The performance of asbestos cement (AC) materials requires that the cement matrix adheres to the outside of the asbestos fibres and fibre bundles so that the high tensile strength of the fibres is used to create a stronger product, than if just cement alone was used. The asbestos is added to the cement and wet mixed before being formed, compressed and cured to produce the end product.

In the asbestos cement, which contains approximately 10% – 15% of asbestos by weight, the larger asbestos bundles may be visible by eye especially at newly fractured edges. Any physical breaking and cracking of AC material exerts high mechanical forces to the fracture surface and tends to pull out asbestos fibres and bundles, thus making them more able to become airborne. Fires and very high temperatures cause the hydrated cement to release water vapour and the cement sheet to expand internally, leading to explosive failure where the sheet will crack and spall extensively, leaving areas of pulled-out fibres. A proportion of the fibres disturbed during mechanical breakage will be made airborne at the time. Mechanical attrition of the cement will also lead to release of airborne asbestos fibres and cutting of the cement sheets with saws and angle grinders are particularly able to release fibres from inside the AC. Similarly, mechanical cleaning of dry surfaces of AC sheets are also known to release substantial numbers of airborne asbestos fibres (Burdett 2007).

A typical example of a chrysotile bundle present in a sample of AC material following breakage is shown in **Figure 3.3**. Although the matrix material will 'cement' particles together, and some of the exposed fibres will have cement particles adhered to the fibres, the bundles of chrysotile fibre contain many fibres and fibrils, which are not in direct contact with the cement matrix and may not have cement fragments adhered to the surface (Burdett 2007).

Primarily, the weathering of an AC sheet is based on its major component (90% cement). As it weathers the more resistant asbestos is left increasingly free of the cement matrix. Therefore, weathered asbestos cement often has the potential to release more fibres from the surface than unweathered asbestos cement due to the much greater numbers of loosely bound fibres exposed on the surface. In more extreme cases, weathering may cause the surface to flake or crack, giving an even greater area from which asbestos may be released into the air (Burdett 2007).

Asbestos fibres are typically resistant to weathering, however, the AC product is expected to be affected by weathering. The nature of the weathering may affect the potential for loose asbestos fibres to be present that may move into the air. Where materials have undergone significant weathering from water or acidic materials (or leaching) there is the potential for asbestos fibres to be exposed and remain on the surface of the AC material (refer to **Figure 3.4**) (Campopiano et al. 2009). Other forms of weathering may result in asbestos fibres and bundles being exposed (refer to **Figures 3.5 and 3.6**), some of which may include particles of concrete adhered to the fibres, but there may be some fibres where no concrete is adhered (Burdett 2007; Campopiano et al. 2009).

More detailed review of the asbestos fibres from these weathered AC materials indicates some have a coating (mainly calcium) and many of the individual fibres have attached cement particles, while others do not (Burdett 2007). These are further illustrated in **Figure 3.7**.

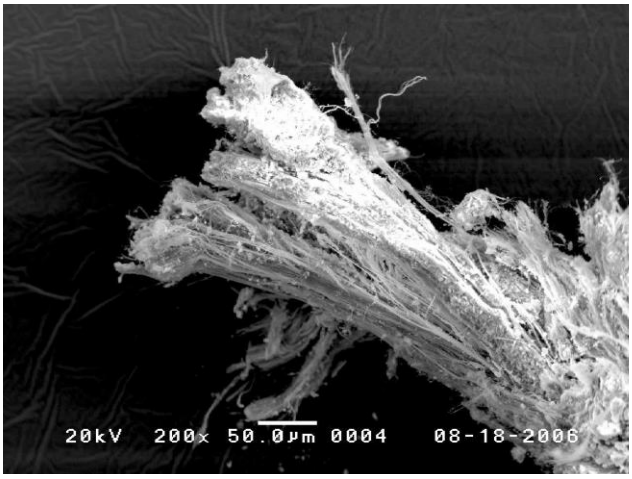


Figure 3.3: Chrysotile fibre bundle projecting from broken section of AC material (scanning electron microscopy [SEM] image at approx. x 200) (Burdett 2007)

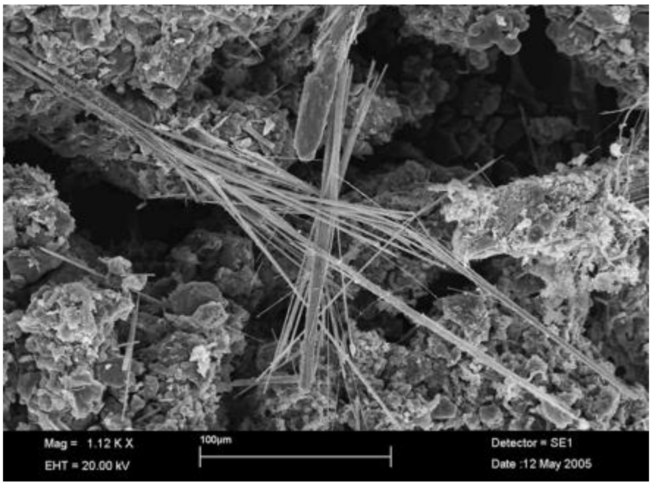


Figure 3.4: Amosite fibres exposed or detached from cement sheeting following weathering (SEM image) (Campopiano et al. 2009)

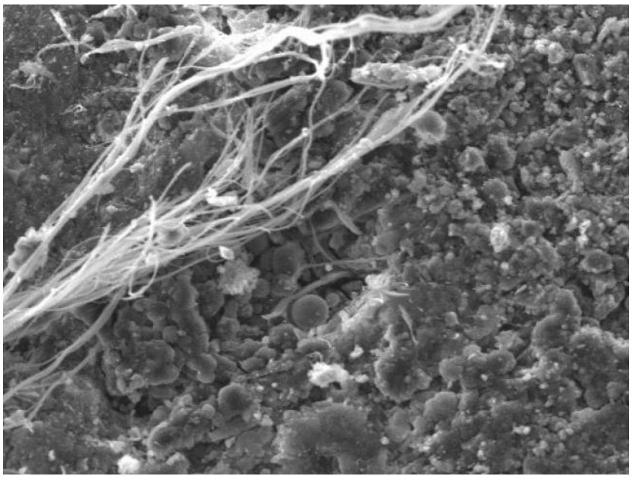


Figure 3.5: Chrysotile fibres exposed on the surface of weathered AC material (SEM image at approx. x 600) (Burdett 2007)

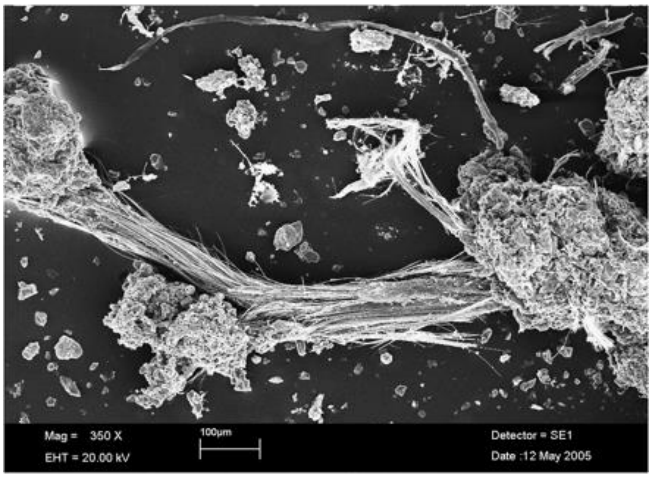
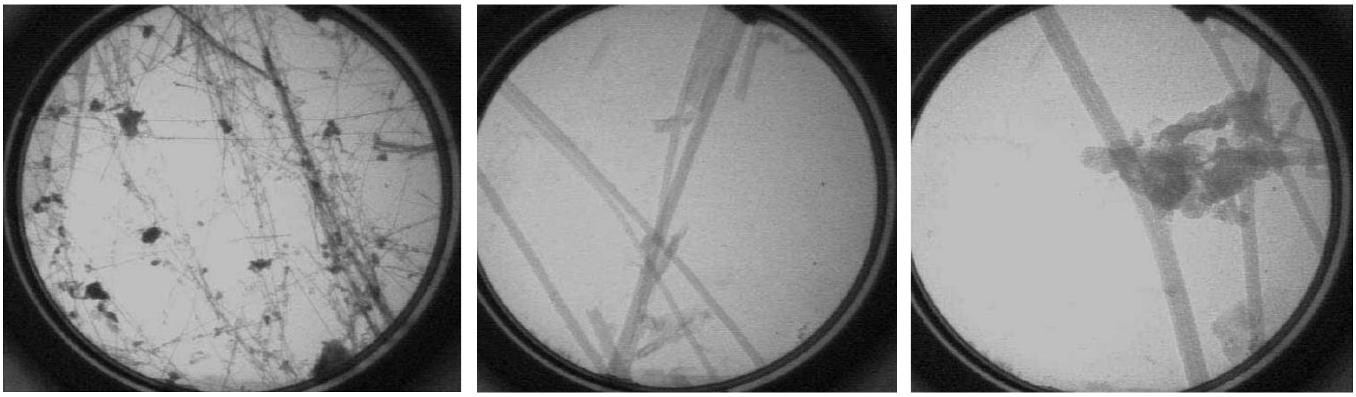


Figure 3.6: Chrysotile fibres detached from weathered AC material (SEM image)



A B C

Figure 3.7: Chrysotile fibres from weathered AC material, A: showing small cement particles attached to the fibres, B: Fibres at high magnification showing no evidence of coating or many attached particles, C: High magnification example of particle attached to fibre (Burdett 2007)

Overall, it appears that the vast majority of fibres are uncoated and there is no evidence to support the claim that all the chrysotile has been chemically or structurally altered (Burdett 2007).

Further review of asbestos fibres in air (derived from these weathered materials) identified that the fibres had only a few small particles of cement attached or were free of any coating or particles, as illustrated in **Figure 3.8**. This may suggest that the presence of cement particles on asbestos in weathered material may reduce the potential for asbestos fibres to be present in air, with only fibres with small amounts of cement particles or no cement particles moving into the air phase.

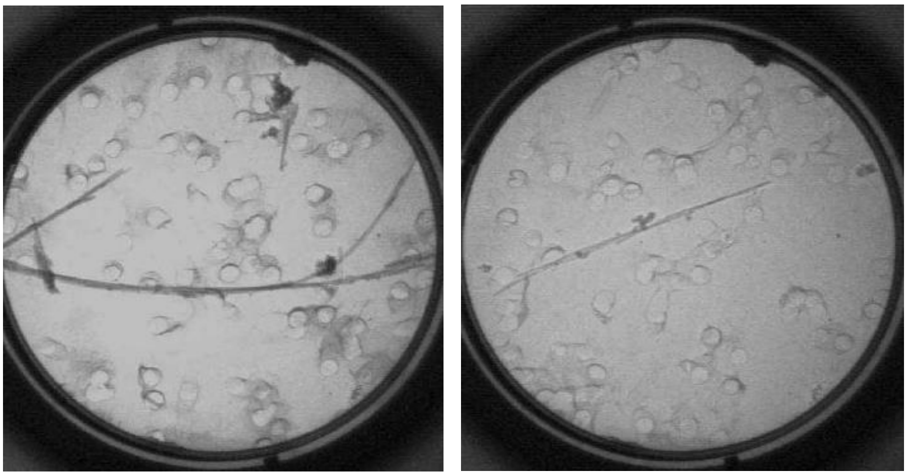


Figure 3.8: Examples of magnified airborne chrysotile fibres from weathered AC material, showing a few small particles attached to fibres and fibres free of particles (Burdett 2007)

The fibres found in the air samples essentially showed no significant alteration and would be able to be distinguished as asbestos fibres using standard methods (Burdett 2007).

In relation to the inhalation of asbestos fibres derived from the weathering or damage to AC materials, there are no differences in the carcinogenic potencies between 20 year old weathered chrysotile asbestos fibres from the surface of AC sheets and friable chrysotile asbestos fibres (Spurny 1989; Tilkes & Beck 1989).

Human epidemiology has shown that chrysotile asbestos cement manufacture is low risk compared to other asbestos products. The low risk is largely due to the lower levels of fibre emissions in the manufacturing industry, as much of the asbestos production is carried out using wet processes and when dry the asbestos is locked into a resilient cement matrix. There was also increasing use of dust controls in western production plants (Burdett 2007).

Teichert (Teichert 1986b, 1986a) concluded that despite evidence of “considerable erosion”, only “very low” (i.e. in most cases undetectable) asbestos fibre emissions were observed from AC roofing. A strength of this work was that fibre concentrations were related to the prevailing weather conditions at the time of measurement. The proportion of released fibres in the external air that were asbestos in nature were reported to be very low at 1.1 % for shorter fibres of 2.5 µm to 5.0 µm in length and less than 0.2% for fibres greater than or equal to 5.0 µm in length (Teichert 1986b).

In a review of their previous work Spurny (Spurny 1989) concludes that AC corrodes in response to “aggressive” atmospheric pollution (e.g. to acids arising for sulfur dioxide and other industrial gases). The extent of corrosion is dependent on several factors including the concentrations of these pollutant gases, the relative time of exposure and the prevailing weather conditions. Spurny (1989) indicates, however, that only about 20% of free asbestos is released into the air. The remaining 80% is hypothesised to be removed by rain. It is not known if these northern European findings can be directly related to the drier conditions found in Australia (ASCC 2008).

Overall, the broad consensus from the available information is that the release of asbestos fibres is exceedingly small from non-friable asbestos materials (AC) as a result of aging, weathering and/or corrosion (ASCC 2008; Burdett 2007). This is partly due to:

- The relatively lower amount of asbestos used in this product compared to others; and
- The hard resistant nature of the cement matrix which makes it more difficult to release airborne fibres (as noted above);

AC is considered non-friable and has a low hazard except when physically damaged or handled (e.g. by using power tools and other machinery). Where released to air, fibres from these materials are no less hazardous than those released from friable asbestos.

3.4 Background exposure

Natural sources are important, because asbestos minerals are widely spread throughout the earth's crust and are not restricted to the few mineable deposits. In particular, chrysotile is present in most serpentine rock formations. Emissions from these sources are due to natural weathering and can be enhanced by man's activities, such as quarrying or street building. Very little, however, is known about the amounts emitted from natural sources (WHO 2000). Man-made emissions originate from activities in the following categories:

a) mining and milling
b) manufacture of products
c) construction activities
d) transport and use of asbestos-containing products
e) disposal.

Indoor asbestos fibre concentrations can be considerably higher than outdoor concentrations.

Asbestos fibres normally constitute only a relatively small fraction of the total number of fibres in ambient air. The biologically more important so-called "critical" fibres are those equal to or longer than 5 μm and having diameters up to 3 μm with an aspect ratio equal to or greater than 3:1 (WHO 2000) as already discussed.

Table 3.1 presents a summary of the available data on background levels of asbestos in air in urban, rural and industrial areas. In addition, the table includes calculated lifetime burdens, i.e. the number of asbestos fibres inhaled over a lifetime in urban and rural areas compared with workplace exposures. This shows that all members of the population are always exposed to asbestos in air, with significant (a million to many millions) numbers of fibres inhaled over a lifetime, even where no exposure occurs in a workplace. In spite of this, the general population (non-occupationally exposed population) does not contract asbestos related disease in any significant numbers. The background rate of mesothelioma is noted to be less than 1.5 per million per year.

Table 3.1 Summary of background levels of asbestos reported in the environment

Exposure	Concentrations reported (f/cm^3 = f/mL)	Reference
Urban air (typically 10 times higher than rural)	0.000003 to 0.0198 for multiple countries 0.00004 to 0.05 (0.0011 mean) in US 0.0016 to 0.0037 (0.0016 mean) for 1990's US 0.0001 to 0.001 lowest background	(Krakowiak et al. 2009) (Abelmann et al. 2015) (ASCC 2008) (WHO 2000) (IARC 2012)
Rural air	0.0003 to 0.0218 for multiple countries 0.0000048 to 0.013 (0.00039 mean) in US 0.000014 to 0.000092 (0.000018 mean) in 2000's in US 0.00001 to <0.0001 lowest background	(Krakowiak et al. 2009) (Abelmann et al. 2015) (ASCC 2008) (WHO 2000) (IARC 2012)
Industrial air	<0.0006 to 91.4	(Krakowiak et al. 2009)
Heavy traffic road crossing or freeway	0.0009 to 0.0033	(WHO 2000)
Indoors	<0.001 buildings with no ACM <0.001 to 0.01 buildings with friable asbestos 0.00003 to 0.006 in homes, schools etc 0.00012 (mean) in US	(WHO 2000) (IARC 2012) (ATSDR 2001) (Lee & Van Orden 2008)
Outdoor ambient levels or background	0.00003 to 0.0047 in the US	(Glynn et al. 2018)

Exposure	Concentrations reported (f/cm^3 = f/mL)	Reference
Lifetime burdens	**Urban population** exposed to 0.00003 to 0.0002 f/cm^3, exposure for 70 years = ~1.5 x 10^7 to 10^8 accumulated fibres	(WHO 2000)
	Rural population exposed to 0.00001 f/cm^3, exposure for 70 years = 10^5 to 10^6 accumulated fibres	(WHO 2000)
	Asbestos workers exposed to 0.1 to 1 f/cm^3 Exposure for 50 years = 10^{10} to 10^{11} fibres Exposure for 0.7 year (incidental exposure) = 5x10^7 fibres	(WHO 2000)

Comments on exposure and risk

Different types of asbestos pose different levels of risk to workers and the community. The level of risk posed by asbestos will depend on the nature of the materials in which asbestos is present, and the nature and duration of exposure.

High Risks – This relates to asbestos that may be present as friable asbestos, that can easily move into air where exposure may occur. The greater the duration of exposure to scenarios where these fibres are present in air in elevated numbers, the greater the risk. The presence of friable asbestos in building and demolition waste is expected to be negligible where these materials are properly removed in accordance with existing regulatory requirements and guidelines that require these materials to be removed by a licenced contractor prior to any demolition.

Low Risk – This relates to asbestos that remains bound or bonded in products, where there is a very low potential for asbestos fibres to be released to air, even where weathering may have occurred.

Risks may be increased where these materials are heavily weathered or mechanically damaged, and asbestos fibres may be available to move into the air. The movement of asbestos to air may be more limited from these materials. However, once in air, the hazards posed by airborne asbestos fibres remain unchanged.

The background presence of asbestos, relevant to all members of the community in urban and rural areas means that the concept of zero asbestos or zero asbestos exposure and risk is meaningless.

While it is accepted that zero tolerance is part of NSW asbestos waste regulations and community expectations, the concept is meaningless in technical terms. Everyone is exposed to fibres from natural sources. Such sources are not targeted for management by regulation or policy.

These background exposures have been further considered in relation to the concept of trivial in **Section 6**.

Section 4. Asbestos guidelines – Australia

4.1 General

There is scientific uncertainty regarding the dose–response relationships for asbestos – i.e. how many fibres are needed to cause the various effects. There is also considerable public concern about unwilling exposure to asbestos fibres. As a consequence, regulators typically adopt a conservative approach to policy and guidelines in relation to asbestos.

4.2 Regulation of asbestos in Australia

Exposures to asbestos in the past were very high in some Australian industries and occupations. For example, there has been as much as 25 million particles per cubic foot (150 fibres/mL) in asbestos pulverisers and disintegrators in the asbestos cement industry (Roberts and Whaite, 1952 quoted in Leigh et. al. (Leigh et al. 2002)), and up to 600 fibres/mL in baggers at Wittenoom (Major, 1968 in Leigh et.al. 2002). However, the recognition of the associated health risks led to a series of regulations being adopted nationally in the late 1970s. Exposure limits of 0.1 fibres/mL for crocidolite and amosite; and 1.0 fibres/mL for chrysotile were imposed. In July 2003, a revised national exposure standard for chrysotile asbestos of 0.1 fibres/mL was declared by the National Occupational Health and Safety Commission (NOHSC).

The asbestos air-quality limit for protecting the public around contaminated sites is 0.01 fibres per millilitre (f/mL) (using the membrane filter method) as endorsed by the enHealth Council (enHealth 2005; NOHSC 2005).

In 2001 NOHSC declared a prohibition on all uses of chrysotile asbestos from 31 December 2003, subject to a very limited range of exemptions, and confirmed earlier prohibitions on the use of amosite and crocidolite asbestos. The prohibition of chrysotile was adopted simultaneously under regulations in each Australian OHS jurisdiction, as well as Australian Customs, on 31 December 2003. The prohibition does not extend to ACMs that were in situ at the time prohibition took effect (i.e. part of existing buildings) and is subject to a very limited range of exemptions. Since 1988, NOHSC and then the ASCC, has provided detailed guidance material to minimise occupational exposures to asbestos. This material was revised in 2005, and most recently in 2018 and 2020 and includes national codes of practice for the safe removal of asbestos (Safe Work Australia 2018) and for the management and control of asbestos in the workplace (Safe Work Australia 2020). It also includes a Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres 2nd Edition [NOHSC:3003(2005) (NOHSC 2005)].

4.3 Australian guidelines for asbestos in contaminated sites

The ASC NEPM (NEPC 1999 amended 2013a) sets out soil levels for asbestos for different site uses below which no effects would be expected. These are derived from guidance developed by the Western Australian Department of Health (WA DOH 2009).

The asbestos in soil guideline values have been based on preventing the entrainment of asbestos fibres into the breathing zone of sensitive receptors from normal activities relevant to different long-term uses of land. In the derivation of soil guidelines, the WA Department of Health and the NEPM (Assessment of Site Contamination) use a risk-based and, where necessary, conservative approach to the uncertainties associated with protecting the public from asbestos-contaminated sites and employ the following general contamination criteria:

- The investigation criterion or clean-up goal is 0.001% asbestos in soil on a weight for weight basis (w/w) for free fibre-related materials including fibrous asbestos and free fibre itself. It should be noted that this criteria is 10 times lower than the original criteria (0.01%) derived by the Dutch (Swartjes & Tromp 2008) to account, in part, for the drier Western Australian soil;
- Depending on site use, at least a 10-fold higher criteria is applied to asbestos-containing materials (ACM) (i.e. bonded) in sound condition, such as commonly found asbestos cement fragments, since these pose much lower risks to human health; (NEPC 1999 amended 2013a; WA DOH 2009).

The derived health screening levels for asbestos in soil, as adopted in the ASC NEPM are listed in **Table 4.1** (NEPC 1999 amended 2013a).

Table 4.1: Summary of NEPM screening levels for asbestos in soil (NEPC 1999 amended 2013a)

Form of asbestos	Health Screening Levels for Relevant Land use Settings (w/w)			
	Residential A[1]	Residential B[2]	Recreational C[3]	Commercial/ Industrial D[4]
Bonded ACM	0.01%	0.04%	0.02%	0.05%
FA and AF[5] (friable asbestos)	0.001%			
All forms of asbestos	No visible asbestos for surface soil			

Notes:

1. Residential A with garden/accessible soil also includes children's day care centres, preschools and primary schools.
2. Residential B with minimal opportunities for soil access; includes dwellings with fully and permanently paved yard space such as high-rise buildings and apartments.
3. Recreational C includes public open space such as parks, playgrounds, playing fields (e.g. ovals), secondary schools and unpaved footpaths.
4. Commercial/industrial D includes premises such as shops, offices, factories and industrial sites.
5. The screening level of 0.001% w/w asbestos in soil for FA and AF (i.e. non-bonded/friable asbestos) only applies where the FA and AF are able to be quantified by gravimetric procedures. This screening level is not applicable to free fibres.

The available soil criteria detailed above are based on the protection of human health (all workers and members of the public) associated with long-term (chronic[1]) exposure for commonly undertaken activities for the various land uses (NEPC 1999 amended 2013a).

It is noted that the ability of National Association of Testing Authorities (NATA) accredited laboratories, using Polarized Light Microscopy (PLM) as specified in available methods, to quantify asbestos in such low concentrations in bulk soil samples is limited to a reporting limit of 0.01% (w/w)

[1] Chronic exposure refers to exposures that may occur over at least a year. Within the NEPM chronic exposures relates to exposures over 25 years for residents and users of public open space areas and 30 years for workers

(Standards Australia 2004). Regulators may request that an attempt is made to quantify asbestos contamination at levels below 0.01% (w/w) but this is technically difficult.

4.4 Air guidelines

There are currently no ambient air quality criteria for asbestos in any state in Australia. It is noted that the WA DoH guidelines for asbestos in soil (which has been utilised in the development of the soil guideline discussed in **Section 4.3**) adopts the WHO air quality guideline value of 0.001 f/mL.

Lifetime exposure to asbestos-in-air at 0.0001 f/mL of air (>5 microns in length) has been estimated to produce about 2–4 excess cancer deaths (lung cancer plus mesothelioma) per 100,000 people.

The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA 2016b) provides methods for the assessment of air pollutants from stationary sources[2] in NSW. This applies to new as well as existing facilities where there are emissions to air. The document includes guidance on the interpretation of the modelling results and includes assessment criteria for air pollutants that should not be exceeded at or beyond the site boundary. This guidance includes assessment criteria for asbestos in air as: 0.18 mg/m^3 over a 1 hour averaging period (refer to Table 7.2a of NSW EPA 2016a). This means that asbestos can be lawfully released directly to air from new and existing stationary sources in NSW provided the concentration in air at or beyond the site boundary is below the assessment criteria.

It is noted that the NSW assessment criteria for asbestos is presented in mg/m^3, which is not comparable with other data and guidelines. Based on the most common measurement technique (phase contrast light microscope) the conversion adopted in this assessment is 30 f/ml per mg/m^3 (NRC 1984; USEPA 1986). Using this conversion, the assessment criteria is 5.4 f/ml as a 1 hour average concentration. If this criteria is converted to a long-term average (i.e. an annual average) (Ontario MfE 2004) the assessment criteria would be 0.43 f/ml. This is a long-term air criteria that is significantly elevated (by many orders of magnitude) above the WHO health based air guidelines and background levels (as detailed in **Section 3.4**).

The above essentially means that NSW guidance currently allows for significant emissions to air of asbestos from new and existing stationary sources at levels that would be considered to pose a significantly elevated (and arguably unacceptable) risk to community health.

4.5 NSW asbestos regulation

Asbestos is regulated in NSW by SafeWork NSW, the Environment Protection Authority (EPA), councils, emergency service organisations and the NSW Department of Planning and Environment (DPE).

The Heads of Asbestos Coordination Authorities (HACA) was established in 2011 to ensure that NSW government agencies and councils effectively coordinate the safe management of asbestos to help reduce the incidence of asbestos related diseases in NSW. The HACA is chaired by SafeWork NSW with senior representatives from: Department of Industry, Department of Planning and

[2] Stationary sources are defined (NSW EPA 2016a) as “any premises-based activity; does not include motor vehicles”.

Environment, Dust Diseases Authority, Environment Protection Authority, Local Government NSW, Ministry of Health, Office of Emergency Management, Office of Local Government.

HACA published an Asbestos Blueprint in 2011. The Blueprint was updated most recently in 2017 (SafeWork NSW 2017). The Asbestos Blueprint is designed to provide clarity and improved coordination of asbestos regulation in NSW, leading to better protection of the health and wellbeing of the community and workers. Improved coordination of regulatory services also leads to better services for the public. The Blueprint also provides the public with a clear description of the regulatory landscape.

Figure 4.1 provides an overview of the complex inter-governmental agency interactions and responsibilities in relation to all phases of asbestos management in NSW. **Table 4.2** provides a summary of asbestos legislation and regulations in NSW. These are taken from the Asbestos Blueprint (SafeWork NSW 2017).

In the ground	Naturally occurring asbestos	DPE/Councils
	Mineral extraction, abandoned mines	DPE
	Declared contaminated land	EPA
	Non-declared contaminated public land	EPA/Councils
	Non-declared contaminated non-workplace land	EPA/Councils
	Non-declared workplace - contaminated land	SafeWork NSW
	Asbestos remediation work	SafeWork NSW
	Illegal dumping	EPA
Supply	Illegal import/export	SafeWork NSW through DIBP
	Illegal supply	SafeWork NSW
Buildings and vehicles	Licensed asbestos assessors	SafeWork NSW
	At workplaces	SafeWork NSW
	At non-workplaces	Councils
Removal	Licensed removal work and asbestos assessors	SafeWork NSW
	At workplace not requiring a licensed removalist	SafeWork NSW
	At all locations by a PCBU or worker	SafeWork NSW
	At non-workplaces — all other cases	Councils
Emergencies	Response to emergency incidents	Fire & Rescue NSW (HAZMAT)
	Major recovery operations	Fire & Rescue NSW (HAZMAT)
	Routine recovery operations	Councils
	Waste export	EPA through DIBP
Transport and disposal	Transport by vehicle	EPA
	Landfill facilities	EPA
	Scheduled waste storage and disposal facilities	EPA
	Waste transport — interstate	EPA
	Temporary on-site waste storage — workplaces	SafeWork NSW
	Laundering facilities	SafeWork NSW

Figure 4.1: Regulatory responsibilities based on asbestos mineral life cycle (SafeWork NSW 2017)

Table 4.2: Asbestos Legislation and Regulations in NSW (SafeWork NSW 2017)

Topic	Legislation
Work health and safety	*Work Health and Safety Act 2011 (WHS Act 2011)* *Work Health and Safety Regulation 2017 (WHS Regulation 2017)* *Work Health and Safety (Mines and Petroleum Sites) Act 2013* *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014*
Environmental protection	*Protection of the Environment Operations Act 1997* *Protection of the Environment Operations (General) Regulation 2009* *Protection of the Environment Operations (Waste) Regulation 2014* *Contaminated Land Management Act 1997* *Environmental Trust Act 1998* *Dangerous Goods (Road and Rail Transport) Regulation 2009*
Planning	*Environmental Planning and Assessment Act 1979* *Environmental Planning and Assessment Regulation 2000* *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* *State Environmental Planning Policy (Infrastructure) 2007* *State Environmental Planning Policy (State and Regional Development) 2011* *State Environmental Planning Policy No 55 – Remediation of Land*
Local government	*Local Government Act 1993*
Consumer safety	*Fair Trading Act 1987* *Property, Stock and Business Agents Act 2002* *Home Building Act 1989* (For LFAI) *Conveyancing (Sale of Land) Regulation 2017* (for LFAI) *Residential Tenancies Regulation 2010* (for LFAI)
International trade	*Customs Act 1901* *Customs (Prohibited Imports) Regulations 1956* *Customs (Prohibited Exports) Regulations 1958* *Hazardous Waste (Regulation of Exports and Imports) Act 1989* *Industrial Chemicals (Notification and Assessment) Act 1989* *Industrial Chemicals (Notification and Assessment Regulations 1990*
Emergency response	*State Emergency and Rescue Management Act 1989* *Fire Brigade Act 1989*
Compensation	*Workers' Compensation (Dust Diseases) Act 1942* *Dust Diseases Tribunal Act 1989* *Dust Diseases Tribunal Regulation 2007* *Dust Diseases Regulations 2006* *Dust Diseases Tribunal (Standard Presumptions – Apportionment) Order 2007* *James Hardie (Civil Penalty Compensation Release) Act 2005* *James Hardie Former Subsidiaries (Winding up and Administration) Act 2005* *James Hardie Former Subsidiaries (Winding up and Administration) Amendment Act 2009* *James Hardie Former Subsidiaries (Winding up and Administration) Regulation 2007* *James Hardie (Civil Liability) Act 2006*

4.6 Workplaces

The control of asbestos in the workplace is regulated under the *WHS Act* and the *WHS Regulation*. SafeWork NSW administers the legislation for all workplaces with the exception of mine and petroleum sites which are administered by the Department of Industry (SafeWork NSW 2017). The asbestos requirements specified in these regulations apply to all workplaces, including workplaces at waste disposal sites or sites where temporary storage of materials is required.

Some of the key aspects of the *WHS Regulation 2017* that relate to asbestos are as follows (also refer to **Section 7.2** for further discussion):

- All asbestos or ACM at the workplace must be identified by a competent person. If the material cannot be identified, it must be assumed that the material is asbestos
- If asbestos is identified at the workplace, the person with management or control of a workplace must ensure that an asbestos register and asbestos management plan are prepared.
- A person conducting a business or undertaking (PCBU)/licensed asbestos removalist (holding a licence suitable for the removal of friable and/or non-friable asbestos) must ensure that asbestos waste is contained and labelled before the waste is removed from an asbestos work area, and disposed of as soon as practicable at a site authorised to accept asbestos waste.
- The licensed asbestos removalist must ensure that when the licensed asbestos removal work is completed, a clearance inspection of the asbestos removal area is carried out by a competent person or licensed asbestos assessor, and the person must issue a clearance certificate before the asbestos removal area at the workplace is re-occupied.
- A licence is not required for the removal of small volumes (<10 m^2) of non-friable asbestos (ACM) and there are significantly fewer controls on this work, with no requirements for reporting or the conduct of a clearance inspection and certification.

4.7 Waste

Where asbestos is transported or disposed, this is regulated by the NSW EPA.

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* No 156 (POEO Act) includes the following key aspects in relation to asbestos and waste:

Definitions:

> ***Waste*** *includes -*
>
> *(a) any substance (whether solid, liquid or gaseous) that is discharged, emitted or deposited in the environment in such volume, constituency or manner as to cause an alteration in the environment, or*
>
> *(b) any discarded, rejected, unwanted, surplus or abandoned substance, or*
>
> *(c) any otherwise discarded, rejected, unwanted, surplus or abandoned substance intended for sale or for recycling, processing, recovery or purification by a separate operation from that which produced the substance, or*
>
> *(d) any processed, recycled, re-used or recovered substance produced wholly or partly from waste that is applied to land, or used as fuel, but only in the circumstances prescribed by the regulations, or*
>
> *(e) any substance prescribed by the regulations to be waste.*
>
> *A substance is not precluded from being waste for the purposes of this Act merely because it is or may be processed, recycled, re-used or recovered.*

__waste facility__ means any premises used for the storage, treatment, processing, sorting or disposal of waste (except as provided by the regulations).

__Asbestos__ means the fibrous form of those mineral silicates that belong to the serpentine or amphibole groups of rock-forming minerals, including actinolite, amosite (brown asbestos), anthophyllite, chrysotile (white asbestos), crocidolite (blue asbestos) and tremolite.

__Asbestos waste__ means any waste that contains asbestos.

__Building and demolition waste__ means unsegregated material (other than material containing asbestos waste or liquid waste) that results from—

(a) the demolition, erection, construction, refurbishment or alteration of buildings other than -

(i) chemical works, or

(ii) mineral processing works, or

(iii) container reconditioning works, or

(iv) waste treatment facilities, or

(b) the construction, replacement, repair or alteration of infrastructure development such as roads, tunnels, sewage, water, electricity, telecommunications and airports, and includes materials such as -

(i) bricks, concrete, paper, plastics, glass and metal, and

(ii) timber, including unsegregated timber, that may contain timber treated with chemicals such as copper chrome arsenate (CCA), high temperature creosote (HTC), pigmented emulsified creosote (PEC) and light organic solvent preservative (LOSP),

but does not include excavated soil (for example, soil excavated to level off a site prior to construction or to enable foundations to be laid or infrastructure to be constructed).

Section 144AAB - Re-use and recycling of asbestos waste prohibited. A person must not cause or permit asbestos waste in any form to be re-used or recycled (with penalties outlined).

The POEO Act provide penalties for the unlawful disposal of asbestos.

Protection of the Environment Operations (Waste) Regulation 2014

The NSW *Protection of the Environment Operations (Waste) Regulation 2014* includes (by definition) any processed, recycled, re-used or recovered substance produced wholly or partly from waste that is intended to be applied to land or used as a fuel. Part 7 specifically relates to the transportation and management of asbestos waste.

POEO Amendment (Waste) Regulation 2018

The *POEO Amendment (Waste) Regulation 2018* includes the following key aspects:

Provides requirements for the transport and disposal (to landfill) of asbestos waste.

Part 8A is specific to C&D waste facilities where the following definition is provided:

> ***construction waste*** *means:*
>
> *(a) material that results from the construction of buildings or infrastructure (such as roads, tunnels, airports and infrastructure for sewage, water, electricity and telecommunications) and includes materials such as:*
>
> > *(i) bricks, concrete, paper, plastics, glass and metal, and (ii) timber, including unsegregated timber, that may contain timber treated with chemicals, and*
> >
> > *(iii) soil or other excavated material (but not virgin excavated natural material within the meaning of Schedule 1 to the Act), and*
> >
> > *Note. Construction waste includes all building and demolition waste within the meaning of Schedule 1 to the Act.*
>
> *(b) material processed from any material to which paragraph (a) applies,*
>
> *(c) waste that contains any material to which paragraph (a) or (b) applies.*

It is a condition of an environment protection licence for a scheduled waste facility that is a construction and demolition waste facility that the requirements set out in the Standards for managing construction waste in NSW are complied with at the facility.

The NSW EPA Standard on managing construction waste (EPA 2019) requires each load of construction waste that enters a C&D waste facility to undergo inspection. This requires visual inspections at 2 points:

- Inspection point 1 – top of load in truck from an elevated location or using a video camera
- Inspection point 2 – tip and spread in an inspection area, with inspection by trained personnel (visual inspection).

The Standard requires rejection of the entire load where asbestos waste is identified at either of the inspection points.

This standard does not include further risk assessment or testing for friable asbestos fibres. Such fibres are not visible so the inspection process as outlined would not detect these. The standard also does not include any additional definitions of asbestos or asbestos waste.

Dangerous Goods (Road and Rail Transport) Regulation 2014

The *Dangerous Goods (Road and Rail Transport) Regulation 2014* adopts uniform national requirements for the transport of dangerous goods including the requirements of the Australian Dangerous Goods Code ('the Code'). Asbestos is categorised by the Code as a Class 9 dangerous good; however, most asbestos waste is subject to special provision 168.

Special provision 168 – exemptions from the dangerous goods code:

> *Asbestos which is immersed or fixed in a natural or artificial binder (such as cement, plastics, asphalt, resins or mineral ore) in such a way that no escape of hazardous quantities of respirable asbestos fibres can occur during transport is not subject to this Code. Manufactured articles containing asbestos and not meeting this provision are nevertheless not subject to this Code when packed so that no escape of hazardous quantities of respirable asbestos fibres can occur during transport.*

The tracking threshold is 100 kg or 10 m^2 for “transporters of asbestos”.

Comments on the definition of asbestos

The definition of asbestos in the POEO Act, which is adopted throughout all of the NSW regulations and is consistent with the definitions adopted in other states (refer to **Section 4.11**) is very general. Similarly, the definition of asbestos waste is very general and appears to have resulted in the zero-tolerance approach adopted in NSW, where the concept of any asbestos means it is an asbestos waste.

The use of such a general definition does not enable risk to be considered, nor the characteristics of asbestos, namely fibres of a particular length and width that are of importance to the hazards that asbestos poses (refer to **Section 2**). In addition, the definition does not allow any distinction between risks posed by ACM (i.e. likely to be visible (i.e. bonded or in products)), which are low risk, and asbestos fibres that can easily move into the air, which are high risk (refer to **Section 3**).

This lack of regulatory definition, and link with the characteristics of asbestos that are hazardous, results in misunderstanding and misinformation that the hazards relate to the general term asbestos, and how these relate (or not) to the toxicological studies (Case et al. 2011).

Without clarity on the definition of asbestos waste, any facility operating in NSW would carry significant liabilities when dealing with any product, as asbestos may be present in any material from background sources, in addition to being derived from some waste materials.

Further this definition of asbestos is at odds with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (NSW EPA 2016b), that establishes guidelines that allow for new and existing stationary sources to release asbestos to air at and beyond their site boundary at levels that would pose a risk to community health.

4.8 Local Councils

Local councils are responsible for managing asbestos in the community through educating residents, regulating land use and development, and managing waste disposal.

Specifically, this relates to the following (SafeWork NSW 2017):

- Contaminated land:
    - Record known asbestos site contamination on Section 149 certificates where practicable and, for council workplaces, record on council’s asbestos register.

  - Regulate asbestos contaminated land that is not declared 'significantly contaminated' under the *CLM Act 1997* (excluding oversight of removal or remediation work which is the role of SafeWork NSW).
- Demolition:
  - Approve demolition under the *EP&A Act*.
  - Council certifiers may approve development as complying development under the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008*.
- Residential premises:
  - Respond to any public health risks (risks to council workers and wider public) relating to the removal of asbestos containing materials or asbestos work at residential properties that does not involve a business or undertaking.
  - Respond to complaints about unsafe development activities at a residential property.
  - Respond to public health risks posed by derelict properties or asbestos materials in residential settings.
  - Include properties listed on the Loose-fill Asbestos Insulation Register on section 149 (2) planning certificates.
  - In areas where loose-fill asbestos insulation has been identified, include a notation on all section 149(5) planning certificates regarding the potential for loose-fill asbestos insulation in properties that are not listed on the Register.
- Waste:
  - Manage waste facilities in accordance with environmental protection legislation.
  - Respond to illegal storage, illegal dumping and orphan waste.
  - Regulate transport and disposal of asbestos containing materials

4.9 Department of Planning and Environment

The Department of Planning and Environment's (DPE) primary role in the management of asbestos relates to administration of State Environmental Planning Policies, and the *EP&A Act* (and associated Regulation).

While the DPE does not have an operational role in the management of asbestos, it has a regulatory function and provides policy support relating to asbestos and development. In assessing proposals for development under the *EP&A Act*, consent authorities are required to consider the suitability of the subject land for the proposed development. This includes consideration of the presence of asbestos and its environmental impact (SafeWork NSW 2017).

Where asbestos represents contamination of the land (i.e. it is present in excess of naturally occurring levels), *State Environmental Planning Policy No. 55 — Remediation of Land* imposes obligations on developers and consent authorities in relation to remediation of the land and the assessment and monitoring of its effectiveness.

The *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* enables exempt and complying development across the state. While this includes demolition and the removal of asbestos, the *EP&A Regulation* specifies particular conditions that must be contained in a complying development certificate in relation to the handling and lawful disposal of both friable and non-friable asbestos material under the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008*.

4.10 NSW guidance on construction and demolition waste recycling 2010

Asbestos contamination in construction and demolition materials for recycling has been recognised as an issue for a long period of time.

In 2010, WorkCover NSW published a guide on the management of asbestos in recycled construction and demolition waste (WorkCover NSW 2010). This guidance clearly stated that products containing asbestos containing materials (ACM) are prohibited from being sold or used as recycling materials.

The guidance was intended to provide practical assistance to the construction and demolition waste recycling industry to minimise the potential risk of asbestos contamination in recycled C&D materials – e.g. concrete and brick.

It outlines the procedures to manage ACM that may enter a recycling facility. This guide covers the receipt, processing and management of construction and demolition (C&D) materials at construction and demolition (C&D) facilities.

The guidance links with regulatory obligations for the management, control and removal of asbestos.

This guidance provides for the following:

- The definition of asbestos is consistent with that provided in the POEO Act (refer to **Section 4.7** above)
- Site required to advise suppliers that asbestos and ACM will not be accepted, incorporate “no asbestos” clause in contracts, visible signs, trained staff.
- The primary control point for the removal of asbestos is prior to demolition (i.e. not at the waste facility). Buildings and structures normally undergo regulated and comprehensive asbestos removal programs and stringent clearance inspections before they are demolished. If licensed demolishers conduct the demolition, and the waste has ACM removed and separated at the source, the probability of ACM being present should be low.
- However, it is not unusual for mixed waste from unknown sources, or from small-scale demolition or refurbishment activities that place their waste into skip bins, to contain amounts of ACM waste. These sources should be considered high risk.
- An inspection process should be implemented when waste materials are received at the C&D facility. It should be a two-stage process undertaken by trained personnel.
- The first stage takes place on receipt of the load, the second when the load is tipped out (and before it is included in a mass stockpile).
- If friable asbestos is detected, the load should be immediately rejected.
- If bonded ACM is detected, it should be removed in accordance with the *Code of practice for the safe removal of asbestos* and stored appropriately for later disposal. If friable ACM is detected, the load must be isolated and kept wet during the course of further inspection.

- If ACM is detected, the load should be either:
  - assessed by an occupational hygienist
  - rejected and reloaded onto the delivery truck
  - isolated until removal is arranged.

The process is summarised in **Figure 4.2**.

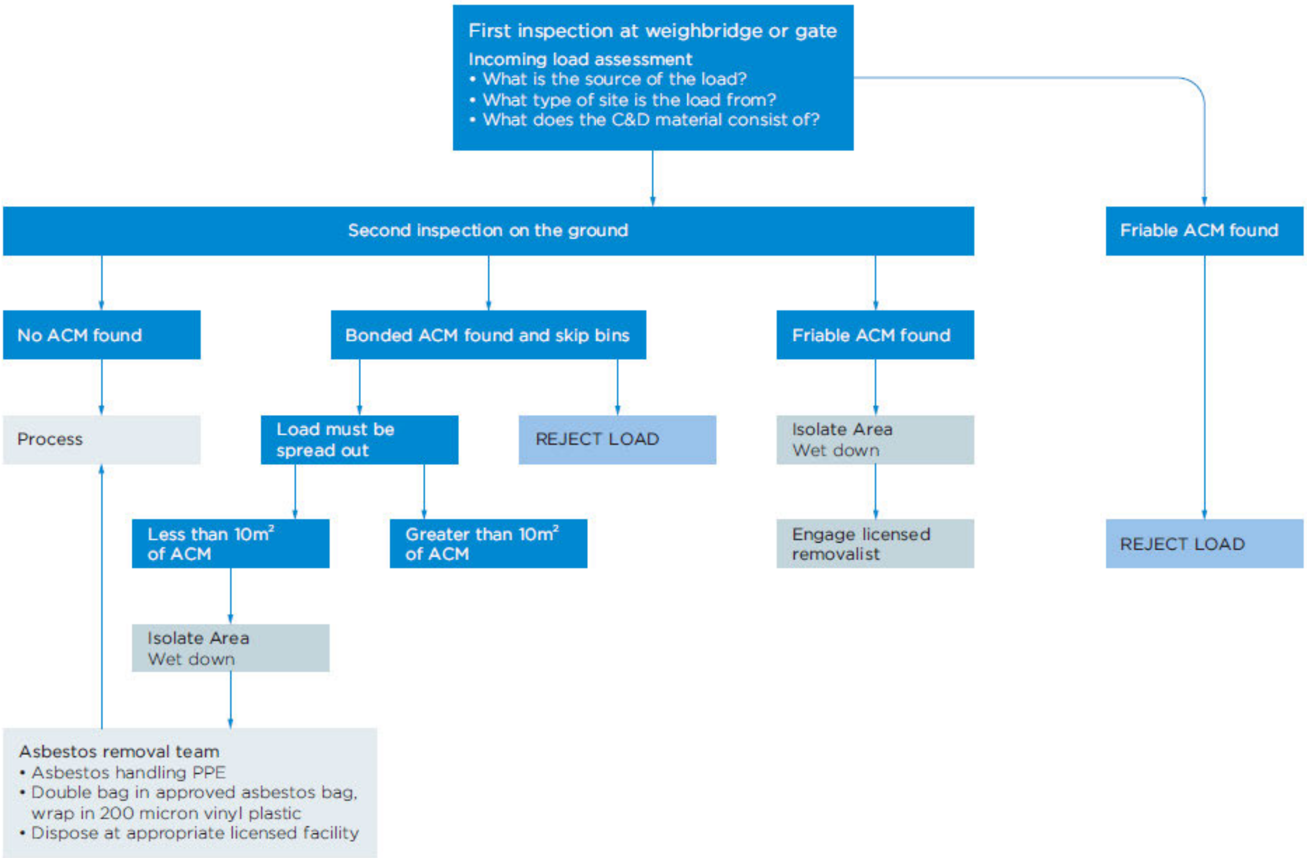


Figure 4.2: ACM inspection process from 2010 guidance (WorkCover NSW 2010)

2014

In 2014, the NSW EPA (NSW EPA 2014) provided a draft protocol on the management of asbestos during resource recovery for C&D waste.

The document states that the protocol has been developed by NSW EPA and WorkCover NSW, in consultation with industry, to:

- prevent asbestos entering a recycling facility
- improve workplace safety at recycling facilities

- outline the management requirements for asbestos where it is discovered in waste, whether unprocessed, processed or supplied to a third party.

The protocol provides practical procedures for verifying that ACM does not contaminate material intended for resource recovery and thereby meets construction industry and community expectations.

The definition of asbestos is consistent with that provided in the POEO Act (refer to **Section 4.7** above).

The protocol follows a similar process as detailed in 2010, with inspection required at the gate (preliminary inspection) and following tipping and inspection (detailed inspection)

Following completion of the detailed inspection:

- Where no asbestos, or suspected asbestos, is observed, the waste can be moved into the storage/processing area or stockpile.
- Where asbestos is sighted or suspected, the entire waste load must be rejected and details of the load entered into the Rejected Load Register.

If asbestos is observed, the load should be immediately wetted down.

The recycling facility operator must maintain an Asbestos Inspection Register where the details of each load of waste inspected in the designated inspection area are recorded.

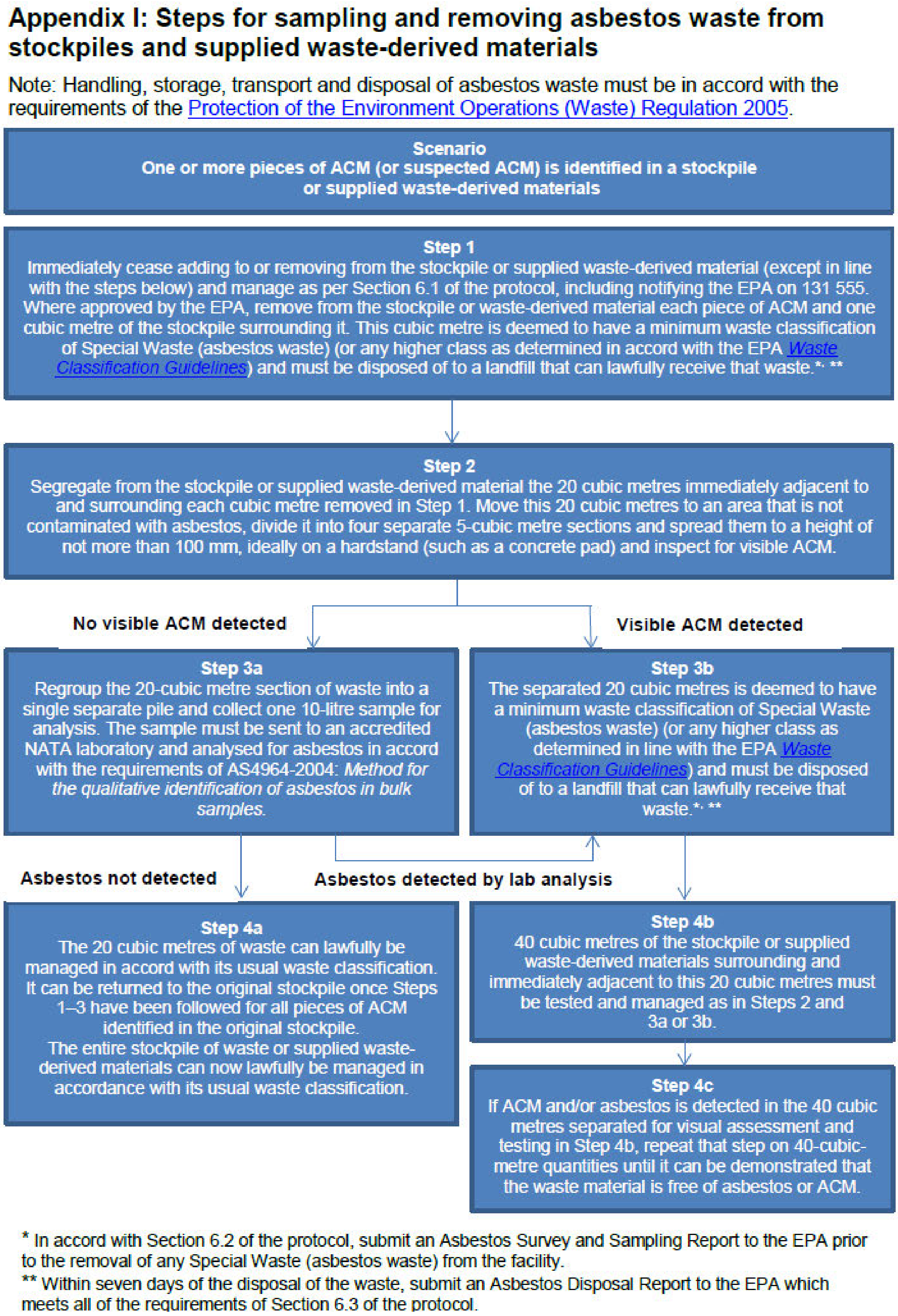
Where suspected asbestos is observed in a waste stockpile at a recycling facility or in waste-derived materials supplied to a third party or off site, and the facility can satisfy the EPA that it has complied with the requirements of the protocol, a risk-based approach to assessing the waste can be permitted. This means that the waste must be sampled, classified and managed in accordance with this protocol by an occupational hygienist or qualified professional approved by the EPA or WorkCover NSW. The final regulatory decision is a matter for the EPA.

Removal of asbestos, or suspected asbestos, from stockpiles or waste-derived materials supplied to a third party by ‘emu-picking’ or processing of any other kind is not permitted.

Where asbestos is observed in a waste stockpile at a recycling facility or in waste-derived materials supplied to a third party, and the facility cannot demonstrate compliance with the requirements of the protocol to the satisfaction of the EPA, all of the waste material involved is required to be classified and removed to a facility that can lawfully receive it.

Figure 4.3 provides a summary of the steps required in the draft Protocol.

The 2014 draft protocol has never been finalised, and it is understood that the draft document was withdrawn by the EPA in 2019.



Appendix I: Steps for sampling and removing asbestos waste from stockpiles and supplied waste-derived materials

Note: Handling, storage, transport and disposal of asbestos waste must be in accord with the requirements of the Protection of the Environment Operations (Waste) Regulation 2005.

Scenario
One or more pieces of ACM (or suspected ACM) is identified in a stockpile or supplied waste-derived materials

Step 1
Immediately cease adding to or removing from the stockpile or supplied waste-derived material (except in line with the steps below) and manage as per Section 6.1 of the protocol, including notifying the EPA on 131 555. Where approved by the EPA, remove from the stockpile or waste-derived material each piece of ACM and one cubic metre of the stockpile surrounding it. This cubic metre is deemed to have a minimum waste classification of Special Waste (asbestos waste) (or any higher class as determined in accord with the EPA *Waste Classification Guidelines*) and must be disposed of to a landfill that can lawfully receive that waste.*, **

Step 2
Segregate from the stockpile or supplied waste-derived material the 20 cubic metres immediately adjacent to and surrounding each cubic metre removed in Step 1. Move this 20 cubic metres to an area that is not contaminated with asbestos, divide it into four separate 5-cubic metre sections and spread them to a height of not more than 100 mm, ideally on a hardstand (such as a concrete pad) and inspect for visible ACM.

No visible ACM detected

Step 3a
Regroup the 20-cubic metre section of waste into a single separate pile and collect one 10-litre sample for analysis. The sample must be sent to an accredited NATA laboratory and analysed for asbestos in accord with the requirements of AS4964-2004: *Method for the qualitative identification of asbestos in bulk samples.*

Visible ACM detected

Step 3b
The separated 20 cubic metres is deemed to have a minimum waste classification of Special Waste (asbestos waste) (or any higher class as determined in line with the EPA *Waste Classification Guidelines*) and must be disposed of to a landfill that can lawfully receive that waste.*, **

Asbestos not detected

Step 4a
The 20 cubic metres of waste can lawfully be managed in accord with its usual waste classification. It can be returned to the original stockpile once Steps 1–3 have been followed for all pieces of ACM identified in the original stockpile.
The entire stockpile of waste or supplied waste-derived materials can now lawfully be managed in accordance with its usual waste classification.

Asbestos detected by lab analysis

Step 4b
40 cubic metres of the stockpile or supplied waste-derived materials surrounding and immediately adjacent to this 20 cubic metres must be tested and managed as in Steps 2 and 3a or 3b.

Step 4c
If ACM and/or asbestos is detected in the 40 cubic metres separated for visual assessment and testing in Step 4b, repeat that step on 40-cubic-metre quantities until it can be demonstrated that the waste material is free of asbestos or ACM.

* In accord with Section 6.2 of the protocol, submit an Asbestos Survey and Sampling Report to the EPA prior to the removal of any Special Waste (asbestos waste) from the facility.
** Within seven days of the disposal of the waste, submit an Asbestos Disposal Report to the EPA which meets all of the requirements of Section 6.3 of the protocol.

Figure 4.3: Procedures for managing asbestos in C&D materials as per Draft Protocol (NSW EPA 2014)

2020

It is understood that the NSW EPA is developing a new or updated Asbestos Unexpected Find Procedure which aims to provide an approach to managing what is termed “unexpected finds” at resource recovery facilities. This procedure is being developed in consultation with industry and it is understood that the basis of the procedure remains the concept of zero tolerance.

4.11 Guidance in other Australian states and territories

Victoria

Key legislation in relation to C&D waste includes:

- *Environment Protection Act 1970* (The Act)
- *Environment Protection (Industrial Waste Resource) Regulations 2009* (IWR Regs)
- *Environment Protection (Scheduled Premises and Exemption) Regulations 2007* (Sched. Prem. Regs)
- State Environment Protection Policy (Prevention and Management of Contamination of Land) (PMCD SEPP)
- National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM).

The definition of asbestos adopted in Victoria is consistent with that used in NSW.

Guidance on recycling C&D material in Victoria is provided in a WorkSafe Victoria document (WorkSafe Victoria 2007).

This guidance material provides information to assist industry to meet its obligations under the *Occupational Health and Safety (Asbestos) Regulations 2003* (the Asbestos Regulations). The guidance material describes an auditable procedure to verify that asbestos-containing material has been removed from C&D materials prior to recycling.

The Asbestos Regulations require that a licensed asbestos removalist be engaged to remove asbestos from workplaces, other than in a few very limited circumstances. Following removal of the asbestos, the person who commissioned the removal work must obtain a Clearance Certificate from an independent person prior to the site being re-occupied. This is not required where the asbestos-containing material removed was non-friable and less than 10 square metres.

The guidance uses a risk based approach to classifying C&D waste. The guidance requires inspection at the gate, with a Material Risk Classification Matrix used to classify the materials. Where asbestos is sighted the load should be rejected. Inspection is also required when unloading with the type of inspection dependent on the risk level relevant to the load. This may include sampling of the waste.

This remains consistent with the approach outlined in the EPA Victoria toolkit for C&D waste (EPA Victoria 2017).

The *Occupational Health and Safety Regulations 2007* note that regulations around asbestos handling “do not apply to construction and demolition material -

a) produced in accordance with an auditable process, determined by the Authority, to verify that asbestos-containing material has been removed from that material; and
b) of which less than 0·001% is asbestos-containing material measured using a method determined by the Authority."

This allows for the use of a definition of asbestos in C&D waste.

Queensland

Queensland has no specific guidance on the potential presence of asbestos in the C&D waste recycling industry.

Sections 452 and 453 of the *Work Health and Safety Regulation 2011* require asbestos to be removed before demolition commences so far as reasonably practicable.

The tracking threshold for asbestos is 175 kg non-friable for transport in Queensland.

Queensland does not track asbestos-contaminated soils (or other contaminated soils). However, it does define where waste is asbestos waste to be regulated (>0.01% w/w) based on the contaminated land criteria.

South Australia

South Australia has no specific guidance on the potential presence of asbestos in the C&D waste recycling industry. However, it did conduct a review of the re-use and recycling of clean fill and building and demolition waste (SA EPA 2001). Guidance is available on wastes containing asbestos (SA EPA 2017). A Standard for the production and use of waste derived fill (WDF) includes requirements in relation to asbestos (SA EPA 2013) and includes C&D waste. The following relates to asbestos in these materials:

- The EPA supports the removal of asbestos from the environment and expects that, to the maximum extent possible, persons involved in construction, demolition and recycling take specific measures to ensure that no asbestos is incorporated into WDF. This position is based on the precautionary principle for best practice waste management. This approach aims to continue to reduce the overall risk of exposure to asbestos by preventing pollution and continually removing it from the environment and ensuring its secure and safe disposal at authorised facilities. The EPA does not endorse any safe level of asbestos for use in WDF.
- Any waste proposed for use as WDF that is derived from materials potentially containing asbestos, must be subject to representative analysis in order to demonstrate the material is free of asbestos if it is to be considered as meeting the waste fill criteria.
- If the proponent believes there is a suitable beneficial use that will not pose any risks to human health or the environment, use as fill may be possible at specific sites and under specific conditions. These include:
    - remove all asbestos from the fill to the maximum extent possible and achievable
    - conduct a thorough, scientifically sound and robust quantitative human health risk assessment (refer to information below)

- submit a site management plan endorsed by a site contamination auditor, engaged for that purpose in accordance with EPA requirements, in which the auditor provides the opinion that, based on the knowledge available at the time including appropriate assessment of the site, the WDF is suitable for use, will not pose an unacceptable risk of causing harm and the land will be suitable for its proposed use at the completion of the project. An audit report for the destination of the WDF containing asbestos (ACM) in this regard must be produced at the completion of the project and must be attached to the title of the land in accordance with questions under Form 1 as required by section 7 of the LBSC Regulations
- adhere to all conditions of the site management plan and audit report
- not use the WDF at a destination with a sensitive use.

Any risk assessment would need to comply with the ASC NEPM.

South Australia acknowledges that asbestos waste can be a concern in C&D Wastes, and refers to the above as well as the NSW Draft guidance (NSW EPA 2014) for additional information.

Western Australia

Western Australia have guidelines on the recycling of C&D waste (DEC 2012). These guidelines note the following:

- Recycling C&D waste is important for reducing the demand for virgin materials, diverting waste from landfill and salvaging valuable resources.
- Asbestos is a hazardous material.
- While regulations and procedures are in place to identify and remove asbestos and asbestos-containing materials (ACM) from buildings prior to demolition, there is still a small risk that some asbestos or ACM will be contained in C&D waste that is directed to recycling facilities.
- The operation of C&D waste recycling facilities and landfills accepting asbestos waste are regulated under Part V of the Environmental Protection Act 1986 (the Act).
- The objectives of these guidelines are to document the procedures DEC expects C&D waste recyclers to implement to:
  1. Minimise the risk of asbestos being received and processed at the premises;
  2. Minimise the potential risk of asbestos in emissions within and from their recycling premises; and
  3. Minimise the potential risk of asbestos contamination in recycled construction and demolition (C&D) materials and products.

The procedures outlined in the guidance are summarised as follows:

- If suspect FA or AF are detected, the load must be isolated, kept wet and once appropriately contained and redirected to an appropriately authorised disposal facility.
- Where suspect ACM is identified within a load and is not capable of being easily removed by hand, the load must be rejected and should be isolated, kept wet and once appropriately contained, and redirected to an appropriately authorised disposal facility.

- Where suspected ACM fragments capable of being easily removed by hand are identified in a load, the suspect ACM must be removed from the load and either:
  1. Appropriately isolated and covered for asbestos testing. If testing of representative samples confirms the material is ACM, it must be redirected to an appropriately authorised disposal facility. If testing confirms the material is not ACM, the waste can be added to the stockpile awaiting further processing; or
  2. Assumed to be ACM and redirected to an appropriately authorised disposal facility.
- ACM and FA are subject to visual inspection and sampling procedures since they are larger in size (>7 mm). AF (<7 mm) is assessed by submitting samples for laboratory analysis.
- Each sample collected must be at least 10 litres in volume and then be divided into 2 size fractions (>7 mm and <7 mm) in the field by sieving though a 7 mm screen or spread out for inspection on a contrasting colour fabric. The >7 mm fraction should be examined for any suspect asbestos material and this should be retained to calculate the level of contamination. The <7 mm fraction will need to be a minimum 500 mL, be wetted, and submitted for laboratory analysis. This sample size is considered necessary to improve the limit of detection for asbestos in the analysis procedure.

Sample Analysis Method >7 mm sample fractions as follows:

- Asbestos concentrations (for ACM and FA) should be calculated in accordance with the methods detailed in section 4.1.7 of Department of Health (DoH), 2009, Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia.
- As detailed in the DoH Guidelines, averaging asbestos levels across the stockpile is not appropriate and asbestos levels within each sample should be reported.
- Each <7 mm sample fraction must be analysed for FA and AF. Asbestos analysis must be undertaken by an independent NATA certified laboratory and comply with Australian Standard Method for the Qualitative Identification of asbestos in bulk samples (AS4964–2004) or be demonstrated to be able to achieve the equivalent level of results to this Australian Standard. AS4964-2004 is currently the only method in Australia that has NATA certification and the practicable level of detection for this standard polarized light microscopy method (PLM) and dispersion staining (DS) is 0.01% w/w. It is possible, however, to measure asbestos contamination at or lower than 0.001% w/w where an increased sample size is used, however, DEC recognises that any reporting of concentrations below 0.01% w/w will be outside the conditions set by NATA.
- Therefore, to determine whether recycled products meet the product specification for asbestos content, samples must be a minimum of 500 mL in size. Proponents must adopt one of the following analytical approaches:
  - Detected/non-detected – where any quantity of asbestos is detected by the PLM method it must be assumed, without further analysis, to be in concentrations above the product specification limit of 0.001%w/w. A weight of evidence approach may be adopted i.e. the frequency and occurrence of other positive results in the stockpile can be taken into account, to determine whether the stockpile being assessed is considered to meet the product specification or not; or

    - Where any quantity of asbestos is detected by the PLM method, the sample is subject to further testing in the form of a semi-quantitative method with a lower level of detection for asbestos.
- A number of laboratories have developed such semi-quantitative methods for the analysis of low levels of asbestos. Techniques include:
    - The extraction and weighing of fibre bundles or fibre cement material from the total sample; and
    - Measuring the width and length (i.e. volume) of individual fibre by Phase Contrast Microscopy (PCM) and calculating the weight of fibres in the extracted sub-sample.

If the visual inspection, sieve sample or analytical results identify asbestos above or possibly above the 0.001% w/w criteria then that stockpile or product process should be deemed potentially contaminated and considered for off-site disposal as asbestos waste, or subject to further actions to remediate it or to demonstrate its acceptability by further assessment. A record should be made of the decision making and action taken e.g. off-site disposal, further assessment undertaken etc, in relation to that stockpile.

The WA guidelines allow for the hand-picking or emu-picking of ACM materials from the waste (with details provided on how this can be done effectively).

4.12 Australian review

A report was completed in 2011 which included a review of issues relating to C&D waste across Australia (Hyder 2011). The following is a summary of the key findings from that review:

> *Asbestos contamination is a critical issue in C&D recycling, and Federal intervention may be required to produce a workable solution for all stakeholders. Best Practice Guidelines for screening incoming loads to minimise contamination risk, coupled with adoption of a small allowable limit of <0.001% contamination in end products, may provide a solution.*

> *Due to the widespread use of asbestos material over many years, resource recovery operators who adopt the most stringent acceptance and testing regimes cannot fully guarantee there are no asbestos fibres in materials coming into their sites and in their final products. In some jurisdictions there is a zero tolerance approach to asbestos, while others have allowable limits of < 0.001% of asbestos in products.*

> *In NSW, consultation for this review has highlighted that the presence of asbestos contamination presents one of the most problematic issues for the C&D waste recovery market. Due to widespread use of asbestos material in the NSW construction market over many years, even resource recovery operators who adopt the most stringent testing regimes and make all possible effort to avoid any asbestos coming onto their sites cannot fully guarantee there is no asbestos fibres in their final products. However, the NSW regulator currently has zero tolerance of asbestos in recovered materials.*

> *The current situation is extremely problematic, with the potential to completely destroy the C&D resource recovery sector. So long as there is zero allowable limit of asbestos in end products, and no way for even the most diligent operators to guarantee this outcome, all*

operators carry continual risk of being in breach of legal requirements. All stakeholders expressed a view that the current situation is unsustainable.

One example provided in the review concerned a recent project where 600 tonnes of recycled material was supplied to a client at around $20/tonne (total value approximately $12,000), and a small amount of asbestos material was found in the material (less than 1 kg). The cost for the company to remove all material and clean up the site was estimated at more than $150,000.

Industry participants point to the adoption of allowable levels of asbestos in Victoria and WA as a workable solution to this potentially debilitating issue. The allowable limit adopted in Victoria and WA is <0.001% (as discussed in ***Section 4.11****). While this is a very small percentage, it should be noted that, due to the high volumes of end products coming out of the C&D recycling sector, this could equate to a considerable amount of asbestos being legally allowed into the marketplace. In the example above involving 600 tonnes of products, an allowable limit of 0.001% could equate to 6 kg of asbestos at the project site.*

An alternative solution that has been discussed by some industry operators is to close their operations altogether and cease attempting to recover resources from C&D waste streams. While wholesale abandonment of existing operations by established and profitable organisations is certainly an extremely unlikely outcome, it should be noted that the issue of asbestos does have the potential to completely close down the C&D resource recovery market in NSW.

WorkCover NSW produced a guide for the Management of asbestos in recycled construction and demolition waste (SafeWork NSW 2010). The document was produced in consultation with industry, and is considered a best practice guide to minimising the risk of asbestos contamination in recovered C&D material. The use of this guide, combined with the adoption of some very small allowable limit of asbestos in C&D products, as implemented in Victoria and WA, is worthy of serious consideration. However, the human health, environmental, legislative and political complexities surrounding asbestos in NSW mean that and any change to the government's approach on this issue would require careful management.

The management of asbestos in C&D waste recovery and recycling will require the engagement of the State's WorkCover Authority or health department. In Victoria, this approach was taken in collaboration with environmental agencies and the unions representing employee interests, to achieve an outcome that was satisfactory to all parties.

Asbestos contamination is one of the most critical issues in the NSW market. Victoria and WA have adopted small allowable limits of asbestos to solve this issue. NSW is unlikely to independently progress toward a similar solution.

The recycling of wastes, in particular C&D waste, is acknowledged by the Australian Government to be hampered by cross-contamination, with asbestos identified as a well documented problem (NSW EPA 2014).

A national Asbestos Safety and Eradication Agency (ASEA) was established under the Asbestos Safety and Eradication Agency Act 2013 to administer the National Strategic Plan (ASEA 2019) which aims to prevent exposure to asbestos fibres in order to eliminate asbestos-related disease in Australia. Website: https://www.asbestossafety.gov.au/

A review commissioned by the Asbestos Safety and Eradication Agency (ASEA) (ASEA 2016; Blue Environment 2017) identified that the management of asbestos varies across the states of Australia. This includes differences in the definitions of asbestos waste.

There is no threshold for asbestos in waste (i.e. any concentration of asbestos is classified as asbestos waste) in NSW, ACT, NT, QLD, SA.

The *Occupational Health and Safety Regulations 2007* note that regulations around asbestos handling "do not apply to construction and demolition material – (b) of which less than 0.001% is asbestos containing material measured using a method determined by the Authority".

The WA *Environmental Protection (Controlled Waste) Regulations 2004* define material containing asbestos as "material which contains 0.001% or more of asbestos fibres weight/weight". This is likely to dictate thresholds in asbestos waste.

Different states also have different threshold requirements for tracking asbestos waste.

- NSW, Vic, Qld and SA track ACM through waste generator, transporter and receiver to ensure it is disposed of in a facility that will appropriately manage the risks posed by asbestos waste to human health
- SA and Vic both require the tracking of asbestos waste by commercial asbestos waste companies for any amount of asbestos, but do not require tracking of domestic self-haul regardless of the tonnage. SA does not record the fate of the waste asbestos – only the name of the receiving facility.
- The ACT, NT, Tas, and WA do not track asbestos transport for either commercial asbestos companies or domestic self-haul asbestos transport.

For asbestos contaminated wastes (asbestos contaminated soils, C&D wastes):

- Vic, SA, track asbestos contaminated wastes.
- ACT, NSW, NT, Tas, WA do not track asbestos contaminated wastes.
- Qld does not track asbestos contaminated soils under their hazardous waste tracking system, but does have another permitting system for contaminated soils movements.

Comments on approaches adopted in other states

Victoria and Western Australia provide a definition of an acceptable level of asbestos, as measurable fibres, in waste that is consistent with risk-based guidance in the ASC NEPM. The criteria of 0.001% is also consistent with the detection limits that may be achievable for the analysis. Including the requirement to analyse for fibres addressed the key risk related to asbestos – the inhalation of fibres that are not visible so cannot be addressed by current control measures. The WA guidance also allows for the removal of visible ACM by emu-picking, which provides a workable approach to dealing with low risk asbestos in these materials.

South Australia and Queensland are largely silent on an acceptable level of asbestos in C&D waste.

Section 5. International approaches to asbestos in C&D recycling

5.1 General

This section provides an overview of guidelines available in other countries that specifically relate to the C&D industry.

5.2 UK

Asbestos waste is "Hazardous Waste" when it contains more than 0.1% asbestos – definition adopted in England and Wales, with the same criteria for "Special Waste" as adopted in Scotland. It is not permitted to mix asbestos waste with other waste to get below 0.1%.

CL:AIRE CAR-SOIL^{TM} , Control of Asbestos Regulations 2012, Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials: Industry guidance (CL:AIRE 2016), where the following is noted:

> *The aim of the guidance is to set out what is good practice for assessing and managing risks from asbestos in soil and C&D materials.*
>
> *'Asbestos' is the general term used for the fibrous silicates listed in regulation 2(1) of CAR 2012. Guidance provided in ACoP L143 states, in respect of the determination of asbestos in bulk materials, that any mixture containing one or more of these fibrous silicates at more than "**trace**" amounts, as defined in Appendix 2 of the first edition of HSG248, Asbestos: The analysts' guide for sampling, analysis and clearance procedures ('The Analysts' Guide'), is within the definition.*
>
> *HSG248 provides a definition for 'trace' amounts of asbestos in bulk samples, below which the Regulations do not apply. It is important for the purpose of this guidance to define what an 'asbestos-containing material' is in the context of soil and/or C&D materials that may have been contaminated by asbestos and, therefore, the point at which the Regulations will apply*
>
> *For representative bulk samples of fragments of suspect materials thought to contain asbestos and submitted for asbestos identification analysis, HSG248 recommends that 'asbestos not detected' is reported when no asbestos fibres are found after careful searching of the sample under the stereo microscope for 10 minutes and searching a minimum of two preparations mounted in suitable Refractive Index (RI) liquid at high magnification by Phase Light Microscopy (PLM)/Phase Contract Microscopy (PCM) for a further 5 minutes.*
>
> *HSG248 goes on to say that if during the search only one or two fibres are seen and identified as asbestos, the term "**asbestos [fibres] identified at the limit of detection**" may be used. This is taken to be the equivalent of 'trace' asbestos, for bulk materials.*
>
> *A 'Blue Book' method describes the quantification of the mass of asbestos in soil, construction materials and products, or associated materials, using a gravimetric method for ACM and fibre bundles, plus dispersion and fibre counting for free fibres using Phase*

Contrast Microscopy (PCM), including calculations for the concentration of Total Fibres and Regulatory Fibres as counted using Annex 1 of HSG248, as appropriate.

Analysis of soil and/or C&D materials in accordance with the 'Blue Book' method requires prior identification analysis by the asbestos identification method described in HSG248. The Limit of Quantification of the 'Blue Book' method is given as 0.001% w/w, based on a practical Limit of Detection of 0.0001%.

*For samples of soil and C&D materials where no fragments of ACMs are isolated and fewer than three asbestos fibres are identified during detailed and extended identification and gravimetric analysis procedures combined, the mass concentration of asbestos fibre is likely to be many orders of magnitude below the 0.0001% w/w Limit of Detection; this generally will be taken to mean '**trace**' asbestos fibre contamination.*

In such circumstances, therefore, on the basis that the potential risk from exposure to such trivial concentrations of asbestos in the external environment is likely to be very low to negligible, it is practical to conclude that such material, whilst containing very few isolated asbestos fibres, is not strictly an ACM that falls under the definition of asbestos in the Regulations.

Prohibitions on the manufacture, supply and use of asbestos and asbestos-containing articles and materials are not contained in CAR 2012. They can be found in direct-acting EU legislation, the Registration, Evaluation, Authorisation & Restriction of Chemicals Regulations (REACH), which applies in the UK and other EU Member States. For the convenience of the reader some information on REACH and its application to asbestos-containing aggregate materials is presented below.

*REACH prohibits the manufacture, placing on the market and use of any article or product to which asbestos has been **intentionally added.***

Recycled aggregates, which fall under the definition of 'articles' under REACH, where asbestos is found to be present are deemed to have had asbestos intentionally added, "subject to evidence to the contrary being adduced in any proceedings.

Caution must be exercised, therefore, to ensure that the mixing of asbestos and inert demolition wastes does not occur if asbestos and/or ACMs have not first been removed from a building prior to its demolition.

5.3 EU

The EU recognises that contamination with asbestos of C&D materials to be recycled is an issue due to the nature of the materials being managed. This is noted to be a key risk to the C&D waste recycling industry (EC 2018).

Asbestos cannot be readily isolated from other components in the mineral fraction of demolition waste. For this reason, the only practical means of guaranteeing the absence of asbestos is to ensure thorough removal prior to demolition, and this, in turn, requires a comprehensive survey of the fabric of the structure to identify occurrences of this material.

The EU has a C&D waste management protocol. This outlines the need for proper removal of asbestos so that it does not contaminate materials for reuse and recycling. Hazardous C&D waste is defined as containing asbestos-based materials in the form of breathable fibres (EC 2016). Hazardous C&D waste is required to be separated from other waste and disposed to an appropriate facility. No more specific detail is provided on the management of asbestos within the protocol.

The EU Council Decision of 19 December 2002 established criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (2003/33/EC). This states that construction materials containing asbestos and other suitable asbestos waste may be landfilled at landfills for non-hazardous waste without testing.

The EU Commission Decision of 16 January 2001 amending Decision 2000/532/EC as regards the list of wastes (2001/118/EC) defines that construction materials containing asbestos were classified as hazardous waste. **Asbestos waste is any waste which contains more than 0.1% w/w asbestos**.

The Nordic Council of Ministers have end-of-waste guidance for C&D waste (Norden 2016) which provides criteria under which specified waste fractions are no longer considered to be waste. The criteria include values for a range of metals and other chemicals but do not include a value for asbestos. The Nordic countries (Denmark, Finland, Norway and Sweden) already have procedures for selective demolition, depollution of buildings and on-site sorting of C&D waste/concrete that, if they are followed and properly inspected, probably will be sufficient to ensure a good quality input material. This includes procedures to effectively reduce contamination from asbestos. Most Nordic countries state that there is a total ban on asbestos in C&D materials.

5.4 United States

Asbestos and ACM is required to be removed during demolition and renovations by an approved contractor and must be properly disposed as asbestos waste.

In the US, most C&D waste is regulated at the state level, with around half the states applying specific C&D regulations. However, when C&D waste contains hazardous materials such as lead-based paint, asbestos, or elements such as lead, mercury, cadmium, PCBs and arsenic, disposal is regulated under the Federal Resource Conservation and Recovery Act (RCRA).

Some states and cities have implemented policies to encourage C&D recycling, including the following:

- Demolition contractors are required to pay a deposit in order to receive a building permit – the deposit is refunded if the contractor can demonstrate that the C&D waste was taken to a certified recovery facility.
- Contractors are required to produce a complete site plan prior to receiving a building permit – the site plan must detail recycling of rubble (concrete/asphalt), land-clearing debris, corrugated cardboard, metals and wood.
- State solid waste legislation specifies recycling goals for counties, and a certain amount of C&D waste is allowed to count toward those goals.

The USEPA provides a document on the characterisation of building-related C&D debris in the US (USEPA 1998). This provides a summary of various state waste requirements. Most do not accept any asbestos materials in C&D debris or waste.

5.5 Canada

Canada provides the following definitions of asbestos[3]:

Airborne asbestos fibre: Asbestos fibres that are longer than 5 µm (micrometres) with an aspect ratio equal to or greater than 3:1 and that are carried by the air.

Asbestos: actinolite, amosite, anthophyllite, chrysotile, crocidolite and tremolite in their fibrous form.

Asbestos-containing material (ACM): means

- Any article that is manufactured and contains 1% or more asbestos by weight at the time of manufacture or that contains a concentration of 1% or more asbestos as determined in accordance with Method 9002 set out in the document entitled NIOSH Manual of Analytical Methods published by the National Institute for Occupational Safety and Health, as amended from time to time, or in accordance with a scientifically proven method used to collect and analyse a representative sample of the material; and
- Any material that contains a concentration of 1% or more asbestos as determined in accordance with Method 9002 set out in the document entitled NIOSH Manual of Analytical Methods published by the National Institute for Occupational Safety and Health, as amended from time to time, or in accordance with a scientifically proven method used to collect and analyse a representative sample of the material.

Zero airborne asbestos concentration: The concentration of "zero" airborne asbestos fibres in COHSR 10.19 (1.1, 3) corresponds to a recognized asbestos analytical method, such as NIOSH Method 7400 or NIOSH Method 7402, used to analyse an asbestos sample that returns a result that is below the limit of detection (LOD) of the analytical method. The LOD of NIOSH Method 7400 and of NIOSH Method 7402 is less than 0.01 f/mL (cm^3). After a qualified person conducts asbestos air sampling, when a result is below the limit of detection for that method, the asbestos sample can be effectively considered to be "none detected" or "zero". The specific value of the LOD is set by the technological limits of the analytical equipment required in the analytical method, rather than being chosen by a person.

In relation to consumer products (which would be expected to include recycled products), Canada has regulations that prohibit the import, sale and use of processed asbestos fibres. Asbestos is a commercial term applied to six different varieties of minerals: chrysotile, amosite, crocidolite, anthophyllite, tremolite and actinolite. Based on current scientific data, human health risks associated with exposure to trace amounts of naturally occurring asbestos are expected to be low.

[3] https://www.canada.ca/en/employment-social-development/services/health-safety/reports/asbestos-exposure-management-programs.html

Hence Environment and Climate Change Canada and Health Canada have defined what are considered to be **trace amounts of asbestos**, as follows[4]:

- Trace amounts of asbestos are those below 0.1% when measured using a suitable standard analytical method with polarized light microscopy (PLM).
- At present, test results identifying asbestos at 0.1% or more, with fibres that demonstrate both of the following characteristics, will be considered by Environment and Climate Change Canada and Health Canada as evidence of the presence of asbestos in more than a trace amount:
  - Fibres longer than 5 µm, with a mean aspect ratio greater than 3:1. Aspect ratios should be determined for fibres, not bundles.
  - Very thin fibrils, less than 3 µm in width.

Ontario laws in relation to C&D waste (R.R.O. 1990, Regulation 347[5]), define asbestos waste as follows:

"**asbestos waste**" means the following solid or liquid waste that contains asbestos in more than a **trivial** amount:

1. Waste that results from the removal of asbestos-containing construction or insulation materials.
2. Waste that results from the manufacture of asbestos-containing products.
3. Waste that results from the removal of asbestos-containing components from a motor vehicle.
4. Waste that results from the removal or handling of waste or materials described in paragraphs 1, 2 and 3, including personal protective equipment, tools that cannot be decontaminated and cleaning materials.

The law does not define "trivial", but Section 17 includes details on the management of asbestos waste.

[4] https://www.canada.ca/en/environment-climate-change/services/management-toxic-substances/list-canadian-environmental-protection-act/asbestos/trace-asbestos-consumer-products-guidance.html

[5] https://www.ontario.ca/laws/regulation/900347

Comments on international approaches

Most international jurisdictions are clear that the effective and complete removal of asbestos at a site, prior to demolition is key to managing asbestos in C&D waste. Some jurisdictions adopt the concept of zero asbestos in waste.

The UK and Canada go further and allow for trace amounts of asbestos to remain. The UK adopts the reporting limit for the detection of fibres (using a specified method). Canada provides a definition of trace levels that is higher than in the UK. Ontario references the term trivial but does not define trivial. Further discussion on trivial is provided in **Section 6**.

Canada also provides a definition of zero asbestos in air, which is essentially the reporting limit of the method (with the analysis method stated).

The concept of zero asbestos is meaningless (refer to **Section 3**), as we are all exposed to background levels of asbestos all of the time, and with anything that requires measurement, a non-detection never means zero.

Being able to define what is meant by “zero” or allowing consideration of trivial levels of asbestos and defining what is trivial enables these concepts to be better understood by industry and the community.

Section 6. Contamination: Trivial or not

In Australia (referent to **Section 4**), the definitions of asbestos are very general. In addition, with the exception of Victoria and Western Australia, there are not quantitative amounts of asbestos that may be present in waste for recycling in C&D waste. Where states such as NSW have a "zero tolerance" approach, there is no definition of what "zero" means. Internationally, there are a number of jurisdictions where the concept of trivial or trace levels are permitted and defined, with Canada also providing a definition of what is meant by "zero". Most of these levels or definitions relate to the detection limit for a particular method (with the method specified).

Whenever something is measured, the concept of zero is meaningless as it depends on the measurement method used, which has a unique detection limit or practical quantitation limit. There is no way to measure zero for any chemical. The ASC NEPM (NEPC 1999 amended 2013e) indicates that the term non-detect should be used rather than zero or not present when reporting results in relation to contamination.

The concept of trivial levels of contamination or pollution is used in NSW legislation.

The NSW EPA does not use licensing to regulate every potential pollutant that could be contained in a discharge or activity. This is because some pollutants are present at such low levels in a discharge that they are highly unlikely to pose a reasonable risk of harm to human health or the environment. Also, some activities are conducted in such a way that discharges to the environment are avoided – such as where an intensive agricultural activity uses an engineered runoff retention basin.

The POEO Act 1997 (Part 5.7, Section 147) in relation to duty to notify pollution incidents defines that "*harm to the environment is material if – (i) it involves actual or potential harm to the health or safety of human beings or to ecosystems that is **not trivial***,".

In addition, "***land pollution** or **pollution of land** means placing in or on, or otherwise introducing into or onto, the land (whether through an act or omission) any matter, whether solid, liquid or gaseous - (a) that causes or is likely to cause degradation of the land, resulting in actual or potential harm to the health or safety of human beings, animals or other terrestrial life or ecosystems, or actual or potential loss or property damage, that is **not trivial**,"*

In relation to pollution of water, the NSW EPA licencing fact sheet[6] states that:

- It is the responsibility of licence holders to:
    - be aware of the pollutants that are discharged to waters from their premises
    - be aware of the environmental impacts that pollutants discharged from their premises have on the environment
    - ensure that their licence specifically regulates the discharge from their premises of all those pollutants that pose a risk of **non-trivial** harm to human health or the

[6] https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/epa/130119eplswater.ashx

environment – where the premises discharges a pollutant that is not regulated by the licence, the licence holder does not have a defence against the pollution of waters offence for the discharge of that pollutant.

- Licence holders are unlikely to be complying with their licence or the POEO Act if a discharge from their premises:
  - does not comply with the concentration limits for each pollutant specified in condition L3.3 of the licence, or
  - contains pollutants other than those specified in condition L3.3 of the licence and those pollutants are at levels that are **not trivial** – '**trivial**' here relates to both the concentration of the pollutant as well as its risk to the environment.
- The EPA Prosecution Guidelines set out how the EPA decides what regulatory action to take, ensuring that all relevant matters are considered, and the action is proportional to the offence (the **EPA does not act on trivial matters**).

The concept of trivial is also adopted by SA EPA (SA EPA 2008, 2019) in the *Environment Protection Act 1993* (*EP Act*) in relation to site contamination – Section 5B:

> *(1) For the purposes of this Act, site contamination exists at a site if— (a) chemical substances are present on or below the surface of the site in concentrations above the background concentrations (if any); and (b) the chemical substances have, at least in part, come to be present there as a result of an activity at the site or elsewhere; and (c) the presence of the chemical substances in those concentrations has resulted in— (i) actual or potential harm to the health or safety of human beings that is **not trivial**, taking into account current or proposed land uses; or (ii) actual or potential harm to water that is **not trivial**; or (iii) other actual or potential environmental harm that is **not trivial**, taking into account current or proposed land uses.*

To assist in determining 'actual or potential harm' and 'not trivial', as stated in each point of section 5B(1)(c) of the EP Act, the application and use of published investigation criteria or trigger levels is considered appropriate. In assisting consultants and auditors to make consistent determinations of the existence of site contamination, the SA EPA has reviewed available national and international guidance and adopted published criteria. Those that are recognised as appropriate criteria by the EPA are specified in Appendix 2 of the site contamination guideline (SA EPA 2019). Appendix 2 includes the ASC NEPM health screening levels for asbestos contamination in soil.

The description of trivial also includes the concept of background (SA EPA 2008) – **concentrations consistent with background are considered trivial**.

Comments on trivial

The concept of defining pollution based on its potential to cause harm and whether or not it is non-trivial is already within NSW legislation and guidance. The concept of non-trivial, however, is not defined, particularly in terms of asbestos, where it gets caught up in the definitions of asbestos in the POEO Regulation which effectively mean zero-tolerance.

The SA EPA also adopts the concept of trivial and has included consideration of background, which is important for asbestos (refer to **Section 3**) and references the health based guidelines on asbestos in the ASC NEPM to assist in understanding what is considered trivial.

Given the concept of trivial is already relevant in NSW, it would be appropriate to provide a definition of what is non-trivial in terms of asbestos in C&D recycling industry. Defining such levels could be undertaken such that it reflects the reporting limits for asbestos (refer to **Section 4.10**) and the level of risk posed by the materials likely to be present in C&D waste (refer to **Section 3**) and require management.

To further evaluate the concept of trivial, the background concentrations of asbestos in air presented in **Section 3.2** have been further considered.

Based on a background outdoor dust concentration of 0.039 mg/m^3 (NEPC 1999 amended 2013b), and an assumption of 0.0001 f/mL background level of asbestos in air (low value for urban air and reasonable for rural air as per **Table 3.1**), this relates to a soil concentration of 0.0077% w/w, calculated using the following equation.

$$\text{Soil criterion} = \frac{\text{Asbestos in air x mass}}{\text{Dust concentration}} \qquad \text{(mg asbestos/mg soil)}$$

where:
Air concentration = 0.0001 f//mL
Mass of an asbestos fibre = 3 x 10^{-8} mg/f (USEPA 1986)[1]
Dust concentration = Concentration of soil (dust) in the air (mg/mL = mg/m^{3}x10^{-6})

This is higher than the asbestos guideline for friable asbestos in soil adopted in the NEPM (**Section 4.3**) and, also, higher than the guideline adopted for asbestos in C&D recycling in Victoria and Western Australia (**Section 4.11**). The soil concentration that relates to an air concentration is dependent in the level of dust generated, however, the above is presented to illustrate that achieving a 0.001% w/w criteria in soil or waste results in air or exposure concentrations of asbestos below background.

Where background exposures are considered, the value of 0.001% could be considered trivial (refer to **Section 6**).

Section 7. Current C&D recycling processes in NSW

7.1 General

This section provides a description of the current C&D recycling processes, including the procedures adopted to identify and manage asbestos. This section also provides a list of the current issues with the existing regulatory system for the management of asbestos. Some of the information presented in this section has been provided by the C&D industry.

7.2 General description of the C&D recycling process

C&D recycling can be broken down into three distinct waste streams:

1. Mixed waste such as demolition materials, building site clean-up waste and skip bin collected waste;
2. Source separated concrete, brick, and asphalt; and
3. Unprocessed soils.

There are other C&D waste streams such as source separated timber and plasterboard but these are not included in this report.

It must be emphasised that the first and key phase of managing asbestos materials in C&D waste occurs “upstream” well before materials leave a site and may be transported as C&D waste. NSW, along with all other states and territories, require the removal of asbestos waste at the source – i.e. at the building, prior to demolition or other works. In NSW, these requirements are detailed in Chapter 8 of the *Work Health and Safety Regulation 2017 (WHS Regulation 2017)*.

Friable asbestos, and any fire damaged asbestos material, is required to be removed by a licenced[7] asbestos removalist, prior to demolition or any other works. The requirement to use a licenced asbestos contractor for these materials reflects the level of risk these materials pose to workers and the public, should they not be removed and disposed properly. Where this process is undertaken properly, then no friable asbestos or fire damaged asbestos, would be present in C&D waste.

Small quantities (up to 10 m^2) of non-friable asbestos are permitted to be disposed by householders and contractors with no asbestos licence. This is the source of waste that poses the greatest risk for C&D waste in terms of the potential presence of asbestos.

The removal of more than 10 m^2 of non-friable asbestos[7] is required to be undertaken by a licenced asbestos removalist.

There are a range of requirements detailed in the *WHS Regulation 2017* that must be followed for the removal of asbestos by a licenced removalist, including completion of a clearance inspection and issuing a clearance certificate. The clearance requires no visible asbestos residue from

[7] The contractor must hold a Class A licence that permits the removal of any amount of friable asbestos. A Class B licence does not permit removal of friable asbestos but allows for the removal of any quantity of non-friable asbestos. Refer to NSW *WHS Regulation 2017* and SafeWork Australia guidance for further detail.

asbestos removal work in the area, or in the vicinity of the area and airborne fibre levels less than 0.01 f/ml.

It is noted that the *WHS Regulation 2017* requirements in relation to asbestos do not apply to soil where (Clause 419 (5)):

i. there is no visible ACM or friable asbestos, or
ii. if friable asbestos is visible – does not contain more than trace levels of asbestos determined in accordance with AS 4964:2004.

AS4964:2004 details the method for qualitative identification of asbestos in bulk samples and includes a method for determining trace levels, which uses polarised light microscopy. This method has a detection limit of 1 in 10000 parts by weight or 0.1 g/kg or 0.01% w/w. This means it is permitted for waste to contain trace amounts of asbestos when it leaves a demolition/construction site.

Processes and procedures at C&D waste recycling facilities

The procedures at the facilities include:

1. The mixed waste streams use specialised purpose-built sorting plants that separate the different waste materials generally by shredding, screening and density separation. The aim is to separate the waste into the following:
   - Clean masonry fraction to meet the requirements of the Recovered Aggregates Resource Recovery Order
   - Clean soil to meet the Recovered Fines Resource Recovery Order
   - Steel for recycling by others
   - Non-ferrous for recycling by others
   - Wood suitable for reuse complying with the Compost or Mulch Resource Recovery Orders or as alternate fuels in approved facilities
   - Other materials such as plasterboard, green waste, and cardboard for recycling by others
   - Residual waste either for further processing at other facilities or for landfill.
   - A typical percentage split of materials produced from the mixed C&D waste recycling process is:
     - Soil = 35-45%
     - Masonry =20-30%
     - Wood =10-15%
     - Ferrous & Non-Ferrous metal = 3-5%
     - Other = 1-2%
     - Residual waste = 15-25%
2. Source separated concrete, brick and asphalt material is recycled using crushing and screening equipment and the products produced are manufactured to the relevant Resource Recovery Orders. Ferrous and non-ferrous metal is produced for recycling by others during this process. Only a very small percentage of residual waste is produced when processing source separated concrete and brick (<0.1%).

The products produced are used in drainage works, behind retaining walls, electrical trenches, temporary ground cover on building sites, under concrete slabs, pipe backfill and in various landscaping applications. Many products are additionally manufactured to comply with specifications from the Transport for NSW, Sydney Water Corporation, electricity supply utilities and local councils and as such are extensively used in road construction.

3. Soils are typically processed at C&D recycling facilities via screening to produce recovered fines, masonry for subsequent crushing and screening to make recovered aggregates, and residual waste.

7.3 Current processes/procedures used to identify and manage asbestos

Under current EPA legislation, a C&D recycling facility must comply with the requirements set out in the EPA's document "*Standards for managing construction waste in NSW".*

This Standard imposes minimum procedures including various stages of inspection during the receival and processing stages.

The requirement of the Standard is to undertake **visual** inspections at the weighbridge, upon discharge of the load and upon spreading of the load prior to it being incorporated into a stockpile for processing. Visual inspections are also required of product stockpiles after processing and prior to despatch from the premises.

The important fact here is that the inspections required are visual only and consequently only pieces of asbestos containing material (ACM) will be observed as asbestos fibres are not visible to the naked eye.

Many facility operators have equipped their facilities with a "Micro Phazir" (or similar) portable asbestos analysis device to assist in the identification of material as ACM. It is noted that these devices are not NATA certifiable or 100% accurate in the detection of ACM. In addition, these devices cannot identify if any fibres may be present in waste.

Under the current Standard, any load of waste that has even a single piece of ACM (regardless of size) MUST be rejected by the facility and the details recorded in a register as per the Standard.

7.4 Current issues with the existing system for the management of asbestos in this industry

By way of background, the long-term recycling facilities in the Sydney waste industry have been managing asbestos through inspection of incoming loads since the early 2000's. These facilities have their own written procedures that they follow. In 2010 Workcover produced a Guide titled *'Management of asbestos in recycled construction and demolition waste'.* The industry groups WMRR (formerly WMAA) and WCRA contributed to this document by aggregating their members inspection procedures. This document was extensively adopted by Workcover in their Guide.

In 2019 the EPA released their document "*Standards for managing construction waste in NSW"*. The fundamentals are the same as the Workcover Guide, however, its more prescriptive regarding how to manage stockpiles.

These new Standards mandate the inspection and rejection protocols, however, make it extremely onerous when a piece of asbestos is found in a stockpile of material that has previously been inspected and cleared.

The EPA (some staff, as noted by industry) appear to be of the view that the Standards will totally prevent ACM being found at a recycling facility but this is not achievable due to the nature of the waste received and the range of possible sizes of ACM.

The current situation is that, if ACM is observed at a facility, then the facility will likely be put into a lockdown situation and much investigation work required to resolve the issue prior to reopening the facility, invariably with significant time delays and costs. This will be triggered primarily due to waste materials from sites that had only small quantities of ACM which were permitted to be managed by non-licensed people. For wastes from sites that had large amounts of ACM, the strict requirements for occupational hygienists/licenced removalists should ensure that it is unlikely that such waste will contain visible pieces of ACM.

It is understood that the EPA is currently working with the industry to develop a procedure to manage an “unexpected find” of ACM so that it does not place undue/unnecessary strain on the facility both for its continued operation and financially risking its continued operation. This is a logical approach provided requirements for removing ACM at the point of demolition is undertaken to the same standard as required to be met at the waste facility, and then any ACM find should truly be an “unexpected find”.

The following provides a list of issues identified by the industry with the existing system:

- There appears to be no practical understanding of how difficult it is to inspect mixed waste to be able to guarantee there is no ACM present. If there is a large quantity of ACM in the load it will be obvious. It’s not possible, however, to see small fragments of ACM (say < 2-3 mm in size) mixed in with a variety of wastes such as plastic, plasterboard, timber, cardboard, soils etc.
- There is no understanding that ACM may be stuck to the underside of concrete or encapsulated in the concrete. This material cannot be found easily through visual inspection.
- Most large demolitions have asbestos clearances prior to the demolition of the walls and slabs. These are visual inspections and it is entirely possible for small pieces or fibres to remain mixed with the waste. This then becomes the responsibility of the recycler if these small amounts are found in products.
- Asbestos clearances are allowed to be issued even though trace amounts of asbestos material may remain in the waste which means the waste recyclers bear responsibility for material that has been passed as appropriate in another section of the industry
- Currently the EPA is proposing that when ACM is found in stockpiles or processing plants, that the facility stops operating and engages a hygienist to determine the way forward. This would include removing a quantity of stockpiled material to landfill as asbestos waste. Emu picking ACM out of stockpiles is not permitted by the EPA. This is not viable as the hygienist is not always immediately available and the facility may be closed for a number of days until the matter is finalised. Emu picking is allowed by other states in Australia once appropriately risk assessed e.g. QLD and WA.

- If ACM is found in recycled products supplied to a building site, the EPA provides no guidance other than to say any waste containing asbestos is asbestos waste and asbestos can't be recycled. This leaves the site in the difficult position as to what to do with the ACM material/recycled product. If they have one piece of ACM in 1 tonne it is easy to take it all to landfill. If there are 10 pieces found on the surface of a road where 1000 t has been supplied placed and compacted that's a more difficult problem to determine what to do.
- The regulatory framework as it relates to asbestos and the lack of a due diligence defence for facility operators. This is a critical driver as to whether businesses choose to continue operating within a 'system' that has such exposure to prosecution.

Many of these issues can be solved with a workable "Unexpected Finds' procedure that is robust and does not pose unacceptable environmental or health risks. There is a need to develop a sensible solution to ensure the viability of the C&D waste recycling industry.

Comments on the current processes

The current processes in NSW place all onus on the C&D facility to ensure there is “zero” asbestos, with these operators taking on significant legal risk in receiving waste from various sources.

The *WHS Regulation 2017* details requirements for the removal of asbestos “upstream” of the C&D recycling facility. It is entirely reasonable that an operator of a C&D recycling facility should be able to rely on works being undertaken in accordance with this regulation to ensure asbestos is removed from the waste being delivered. The key issues identified in that process are as follows:

- The removal of asbestos from buildings and structures as detailed in the *WHS Regulation 2017* does NOT require achieving and demonstrating “zero” asbestos. The *WHS Regulation 2017* has guidance on what comprises clearance (following asbestos removal) and allows for trace levels to remain in soil/waste. Neither of these requirements are consistent with “zero” asbestos. In fact, the definition of trace levels in relation to soil results in the use of detection limits that are consistent with the NEPM criteria (NEPC 1999 amended 2013a) for ACM for residential land use, but higher than the criteria for friable asbestos.
- The *WHS Regulation 2017* (and associated SafeWork Australia guidance) allows for the removal and disposal of up to 10 m^2 of non-friable ACM by individuals with no asbestos licence. The *WHS Regulation 2017* requires such materials be removed by a competent person, however, there are no requirements for clearance inspections to occur or certificates to be issued. This aspect poses the greatest risk to C&D recycling facilities as the proper removal and disposal of up to 10 m^2 does not require reporting or verification. Hence waste sent to C&D recycling facilities may include ACM from these sites.

As the processes currently applied to upstream generators of waste do not and cannot result in “zero” asbestos in the waste, the onus to achieve “zero” asbestos in waste being received at a waste facility appears to fall on the operator of the facility, at the gate. This is a significant disconnect or inconsistency.

If the C&D recycling facility can only receive waste with “zero” asbestos and the waste they receive must be cleared by people licenced by SafeWork NSW, then they should be able to rely on the procedures in the upstream waste generation stream to achieve that goal. So the on-site procedures should be sufficient to produce waste containing trivial or zero asbestos

To further compound the disconnect/inconsistency, other aspects of waste regulated in NSW, specifically contaminated soil and air emissions, certainly do not require “zero” asbestos as they allow for asbestos to be present at some level. In the case of air emissions, significant levels of asbestos in air can be lawfully discharged from a stationary source (refer to **Section 4.4**).

Many international jurisdictions make it clear that it is the responsibility of upstream waste generators to ensure that asbestos is removed from waste being delivered to C&D recycling facilities (refer to **Section 5**).

The current procedures do not appear to have any flexibility in allowing the facility to adopt appropriate practices for the identification and management of asbestos, utilising qualified asbestos experts and enabling risk-based decisions to be made in relation to the likely nature of asbestos that may be present, and how to manage those materials. This appears to result in the classification of large amounts of waste and recycled product (at times) as asbestos waste (as defined under the POEO Act). It also appears that the operator of such a facility is required to bear the cost and liability of this waste and the consequences of the waste containing “any asbestos” (or not achieving “zero asbestos”) as is currently the situation even though they have no control over the production of the material for recycling and regulations exist to ensure such producers of waste for recycling provide appropriate materials. In addition, asbestos can also be present in such waste due to it being naturally present in soils – i.e. not due to any human activities.

The likelihood of friable asbestos being present in C&D waste is low. The form of asbestos most likely to be present in C&D waste is non-friable ACM which is of low risk in relation to worker and community health (refer to **Section 3.2**). To ensure this material remains low risk, procedures to remove this material prior to any significant mechanical disturbance (the key process by which fibres may be released) should be adopted. This would be at the point of removal (i.e. upstream) and upon receipt at a facility.

Section 8. Outcomes

This review has focused on understanding the complexities of dealing with asbestos contamination in waste that is accepted, handled and managed in the C&D recycling industry in NSW. The recycling of waste, including C&D waste is a key aspect of the waste management system in NSW, to reduce the volume of waste sent to landfill.

This review has considered the current legislation and guidance in NSW as well as approaches adopted in other states of Australia and Internationally, on the identification and management of asbestos contamination in these materials. The C&D recycling industry has identified a range of issues related to the way in which asbestos is managed at recycling facilities that have posed significant difficulties.

The review has identified a number of key outcomes which are summarised below:

Hazards posed by asbestos

- It is clear that there are a range of hazards posed by the potential presence of asbestos in any environment. The key hazards relate to asbestos fibres that are of biological concern, i.e. those equal to or longer than 5 μm and having diameters up to 3 μm with an aspect ratio equal to or greater than 3:1, that can move into the air and be inhaled. When assessing asbestos, there are a range of different methods that can be used to quantify asbestos fibres, some of which enable characterisation of the fibres with characteristics that have the potential to pose hazards to human health when inhaled. The selection of the quantification method is important as each will report different aspects in relation to asbestos exposure and risk. Hence guidelines are often tied to specific analytical methods.
- Different types of asbestos pose different levels of risk to workers and the community. Asbestos that is bonded in materials (or cement sheeting) poses the lowest risk, while loose fibres, such as those present in friable asbestos, that can easily move into the air pose the highest risk.
- In relation to potential risks posed by C&D waste:
    - There is a low potential for friable asbestos to be present in C&D waste where these materials are effectively managed at the point of removal from buildings and structures (i.e. upstream)
    - The most likely form of asbestos is bonded asbestos, which is of low risk, except where the bonded material is mechanically damaged. When this occurs, there is the potential for some fibres to be released to air, where exposure may occur. This material can be more easily identified and managed in waste materials. The most effective way to manage the potential for this damage to occur is for it to be effectively removed upstream or identified at the gate.
- The background presence of asbestos fibres in air, which is relevant to all members of the community in urban and rural areas means that the concept of zero asbestos or zero asbestos exposure is meaningless.
- While it is accepted that zero tolerance is part of NSW asbestos waste regulations and community expectations, the concept is meaningless in technical terms. Everyone is exposed to fibres from natural sources. Such sources are not targeted for management by

regulation or policy. In addition, the concept of 'zero' for anything that requires any form of measurement is meaningless as its detection depends on the reporting limit of the method. It is never possible to determine "zero", only that something cannot be detected.

Definition of asbestos

- The definition of asbestos in the POEO Act, which is adopted throughout all of the NSW regulations and is consistent with the definitions adopted in other states is very general. In addition, the definition of asbestos waste is very general and appears to have resulted in the zero-tolerance approach adopted in NSW, where the concept of any asbestos means it is an asbestos waste.
- The use of such a general definition does not enable risk to be considered, nor the characteristics of asbestos, namely fibres of a particular length and width that are of importance to the hazards that asbestos poses (refer to **Section 2**). In addition the definition does not allow any distinction between risks posed by ACM likely to be visible (i.e. bonded or in products), which are low risk, and asbestos fibres that can easily move into the air, which are high risk.
- This lack of regulatory definition, and link with the characteristics of asbestos that are hazardous, results in misunderstanding and misinformation that the hazards relate to the general term asbestos, and how these relate (or not) to the toxicological studies

Current asbestos guidance

Current guidance on asbestos in NSW is mixed and is the cause of many of the issues identified by the C&D recycling industry. There is a requirement for this industry to have "zero" asbestos in waste received and managed at a facility, and "zero" tolerance on the presence of asbestos in recycled products produced.

While the concept of "zero" asbestos is meaningless, the requirement is also disconnected from other regulations and guidance in NSW:

- The key disconnect relates to the *WHS Regulation 2017*, that relates to the requirements for removing and managing asbestos from buildings and structures prior to demolition (the process that produces the waste received by a C&D facility). The *WHS Regulation 2017* does not require "zero asbestos" post asbestos removal and allows for soil to include trace levels of asbestos, which is defined as <0.01% w/w. In addition, removal of small amounts of ACM (<10 m^2) poses the greatest risk of being present in such wastes.
- NSW utilises the NEPM (NEPC 1999 amended 2013a) for the assessment and management of contaminated soil, where risk-based guidelines for the presence of asbestos that may remain in soil in different land use settings is defined.
- NSW allows for emissions to air of asbestos from stationary sources (NSW EPA 2016a), at levels that may result in significant airborne asbestos exposures within the community, well above background levels and well above WHO air guidelines.

The requirement for "zero" asbestos appears to only apply to the C&D recycling facilities. Such a requirement is not workable where the waste being delivered does not have a requirement to have "zero" asbestos when it leaves the place where such waste was produced. This places the onus and liability (of prosecution) of managing asbestos to a zero-tolerance level on the operators of the C&D facilities alone and not onto the producers of the waste being recycled.

Current NSW EPA Standard (EPA 2019)

These documents relate to visual identification of ACM.

- ACM, where bonded in materials which would be visible is considered to be low risk in terms of health and can be easily removed from soil or waste using an emu-picking approach (noted to be permitted in the 2010 Worksafe guidance, but not in 2019).
- The greatest risk, however, relates to loose asbestos fibres. As discussed in **Sections 2, 3** and **4**, the key risk for workers and the community (including consumers) relates to the inhalation of fibres. The potential for friable asbestos to be present in C&D waste is low, and the release of any fibres from bonded asbestos can be minimised by the effective removal of these materials prior to mechanical damage.

Other Australian States

- South Australia and Queensland are silent on the management of asbestos in C&D waste.
- Victoria and Western Australia provide a definition of an acceptable level of asbestos, as measurable fibres, in waste that is consistent with risk-based guidance in the ASC NEPM. The criteria of 0.001% is also consistent with the detection limits that may be achievable for the analysis. This guidance includes the requirement to analyse for fibres addressed the key risk related to asbestos – the inhalation of fibres that are not visible so cannot be addressed by current control measures. The WA guidance also allows for the removal of visible ACM by emu-picking, which provides a workable approach to dealing with low risk asbestos in these materials.

International approaches

- Most international jurisdictions are clear that the removal of asbestos at a site, prior to demolition is key to managing asbestos in C&D waste. Some jurisdictions adopt the concept of zero asbestos in waste.
- The UK and Canada go further and allow for trace amounts of asbestos to remain. The UK adopts the reporting limit for the detection of fibres (using a specified method). Canada provides a definition of trace levels that is higher than in the UK. Ontario references the term trivial but does not define trivial.
- Canada also provides a definition of zero asbestos in air, which is essentially the reporting limit of the method (with the analysis method stated).
- The concept of zero asbestos is meaningless, as we are all exposed to background levels of asbestos all of the time, and with anything that requires measurement, a non-detection never means zero.
- Being able to define what is meant by “zero” or allowing consideration of trivial levels of asbestos and defining what is trivial enables these concepts to be better understood by industry and the community.

Trivial

- The concept of defining pollution based on its potential to cause harm and whether or not it is non-trivial is already within NSW legislation and guidance. The concept of non-trivial, however, is not defined particularly in terms of asbestos, where it gets caught up in the definitions of asbestos in the POEO Regulation which effectively mean zero-tolerance.
- The SA EPA also adopts the concept of trivial and has included consideration of background, which is important for asbestos. They reference the health based guidelines on asbestos in the ASC NEPM to assist in understanding what is considered trivial.
- Where background exposures to dust and asbestos are considered, adopting a soil or waste guideline of 0.001% w/w for friable asbestos (which is consistent with NEPC guidance on contaminated land, and also consistent with the criteria for asbestos in C&D waste in Victoria and Western Australia) would result in inhalation exposures that are below background in urban and rural areas, and could be considered to be trivial.
- Given the concept of trivial is already relevant in NSW, it would be appropriate to provide a definition of what is non-trivial in terms of asbestos in C&D recycling industry.

To be able to effectively manage asbestos contamination that may be present in C&D materials taken to facilities for the purpose of recycling, there are some fundamental aspects of legislation and policy in NSW that have to be changed, including:

- Changes to the *WHS Regulation* to ensure that waste generated from the demolition of structures with asbestos (friable and non-friable) adopt the same threshold or definition of "zero" asbestos as required to be adopted by the C&D recycling industry. Only where requirements in relation to the presence (or otherwise) of asbestos is the same for the generators of the waste and the C&D recycling industry can future protocols relating to "unexpected finds" be relevant and applicable.
- Rework the definition of asbestos, so that it is better linked with the characteristics of asbestos that pose hazards to human health, and can be matched with measurement methods.
- Providing a definition of zero asbestos in the context of measurement (i.e. reporting limits for methods) and background or non-trivial exposures and risks.
- Allowing for the hand-picking or emu-picking of visible ACM prior to transport to a facility, and at receipt at a facility as this is the material most likely to be present in C&D waste and this material is of low risk. There are numerous examples of procedures that can be used to ensure this is done effectively and safely.

Without the above legislative changes, it will be very difficult to establish a workable protocol or procedure for C&D waste recycling that does not result in significant liabilities remaining with the owners of these facilities in relation to the presence of asbestos.

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