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Technical Report

Literature Review – National and International Standards and Guidelines for Asbestos Threshold Levels in Waste

Prepared for:
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Scientist & Engineer (OCSE)

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Literature Review – National and International Standards and Guidelines for Asbestos Threshold Levels in Waste

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- Common Forum on Contaminated Land in Europe
- Maine Department of Environmental Protection (DEP), OHMS III Bureau of Remediation and Waste Management

Abbreviations & Glossary

ACM	Asbestos-containing material (ACM) means any material or thing that, as part of its design, contains asbestos.
Asbestos	The asbestiform variety of mineral silicates belonging to the serpentine or amphibole groups of rock-forming minerals includes actinolite, amosite, anthophyllite, chrysolite, crocidolite, tremolite and any mixture containing 2 or more of those (WA DEC, 2012).
Bonded (non-friable) asbestos-containing material (bonded ACM)	Bonded (non-friable) ACM is where the asbestos fibre is bound by another material or is part of a matrix, for instance, asbestos cement sheeting or vinyl tile. Bonded ACM can include broken, weathered or fragmented material that retains its basic integrity. Bonded ACM corresponds to material that is larger than 7mm x 7mm (WA DWER, 2021).
Fibrous asbestos (FA)	Include friable asbestos material, such as severely weathered ACM and asbestos in the form of loose fibrous material such as insulation products. Friable asbestos is material that is in a degraded condition such that it can be broken or crumbled to a powder form by hand pressure (WA DWER, 2021).
Asbestos fines or fibres (AF)	Includes small asbestos fibre bundles, free asbestos fibres and also ACM fragments that can pass through a 7mm x 7mm sieve
Construction and demolition waste (C&D waste)	Materials in the waste stream that arise from construction, refurbishment, or demolition activities.
Recovered material / Recycled waste	Materials extracted from the waste stream, particularly from construction, refurbishment, or demolition activities, that can be reused or repurposed.
Recovered fines	The residues remaining after all recyclable construction and demolition waste material have been removed from skip bins.

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1. Introduction

crcCARE was engaged by the NSW Office of the NSW Chief Scientist & Engineer (OCSE) on 10 April 2024 to conduct this review of the standards and guidelines of waste and recovered materials where threshold levels for asbestos in recycled waste have been established, particularly within the framework of resource recovery. The review aims to provide sufficient information to understand and communicate the prevailing national and international standards and guidelines to form a cohesive understanding of the accepted thresholds for asbestos in waste materials.

The findings from this comprehensive literature review will inform OCSE review of the management of asbestos in recovered fines and recovered waste material for beneficial reuse/recycling and resource recovery to support the circular economy in NSW.

Implementing pragmatic guidelines is important to enhancing resource recovery for the beneficial reuse of materials and to ensure the risk of exposure to asbestos to employees at construction and demolition (C&D) recycling facilities, customers using recycled C&D materials, and the general public is acceptable and minimised.

This literature review into threshold levels for asbestos in waste is prepared for the OCSE to support their review on the management of C&D recovered materials intended for beneficial reuse. The review report provided findings of the threshold levels of asbestos in recycled waste material for beneficial reuse from national and international jurisdictions.

1.1 Terms of Reference

The project's research was to have regard to:

- Identification and overview of national and international jurisdictions' standards and guidelines where asbestos thresholds in waste and recovered materials have been applied.
- Background to the thresholds including evidence for setting the threshold, in particular any environment and/or human health factors considered when establishing the threshold.
- Management and/or compliance of asbestos waste and recovered materials likely to contain asbestos, where thresholds have been established.
- Identification of end-use or reuse of asbestos waste where thresholds have been established.
- Other information of relevance to Terms of Reference (TOR) - 1 is presented in Appendix A.

The project requirements specifically excluded assessment of the following matters:

- Asbestos content in products, materials and components to determine compliance with the standards of asbestos content in products.
- Asbestos content in soil to determine compliance with contaminated land assessments.

2. Review Processes

The Review team undertook its research using a range of processes. The key activities of the project are described below:

- Communicating with national and international staff of the Environmental Protection Authority (EPA), government regulators, departments, and organisations to source relevant information.
- Undertaking a literature search of threshold levels for asbestos in recycled waste materials.
- Attending project team meetings with the OCSE to discuss updates and content review of the report.
- The final document was subject to an internal review process completed by crcCARE's Senior Scientist Dr Girish Choppala who has expertise in the subject matter of this report.

2.1 Report structure

Based on the terms of reference and the requirements of the OCSE, this report provides a review of threshold levels for asbestos in waste within each Australian State and Territory, and international jurisdiction regulatory guidelines, a discussion on the distinction between asbestos in soil and in recycled waste materials in relation to a potential health risk, an outline of standard analytical methods and detection limits of asbestos in the laboratory, and the key findings and conclusion.

The report structure is set out as below:

Section 1 – Introduction
Section 2 – Review processes
Section 3 – Background
Section 4 – Asbestos in new building material
Section 5 – Asbestos in soil and recycled waste materials
Section 6 – Threshold level for asbestos in recycled waste
Section 7 – Standard analytical methods and laboratory detection limits
Section 8 – National and international standards and guidelines for asbestos in waste and recovered materials
Section 9 – Reuse of recycled waste where threshold level for asbestos has been established – Case Studies
Section 10 – Conclusion

3. Background

Asbestos refers to a set of minerals known for their fibrous, crystalline structure, capable of being woven into thin yet robust material. These minerals are primarily categorised into two groups: serpentine asbestos, with chrysotile as its sole member, known for its spiral fibres, and amphibole asbestos, which includes crocidolite, amosite, tremolite, actinolite, and anthophyllite, recognised by their slender, rod-like fibres. A range of asbestos materials can be found in different materials such as construction materials or other products (SafeWork NSW, 2023).

Waste containing asbestos from renovation, deconstruction and demolition activities makes up the largest proportion of asbestos-containing materials (ACM) and falls into two broad categories: fibrous asbestos (FA) and non-friable (also known as bonded ACM) (WA DWER, 2021; Frangioudakis, 2023). Non-friable asbestos material has a propensity to become friable with use and is characterised by its capacity to be reduced to a powder form or crumbled by hand when dry, e.g. low-density asbestos fibre board and textile materials or fibres contained within a less durable bond, e.g. used gaskets and textile products. The removal of friable asbestos is strictly regulated, requiring a licensed professional with a specific friable asbestos license. 'Non-friable' or bonded ACM, also known as ‘Fibro’, is used to refer to ACM in which the asbestos is firmly bound in the matrix of the material including broken, weathered or fragmented material that retains its basic integrity. Bonded ACM are mainly made up of asbestos fibres together with a bonding compound (such as cement or resin) and typically contain up to 15% of asbestos. These materials are unlikely to release measurable levels of asbestos fibre into the airborne environment if they are left undisturbed. Therefore, they generally pose a lower risk to health.

Around 70-90% of raw asbestos was used in asbestos cement products (WHO, 2014). In existing buildings, asbestos is mainly found in cement roofs (10-20% asbestos) and other products like wall sheets, sewage pipes, and ventilation ducts (around 15% asbestos) (Khamhing, 2023). Sprayed asbestos materials for sound and fireproofing can contain 5-95% asbestos. Vinyl asbestos flooring and fireproof asbestos fabrics are also common (Maduta, 2022).

Asbestos poses a risk to human health if the asbestos fibres become airborne and are inhaled. Inhalation is the primary route of entry to the body (ATSDR, 2001). The likelihood of exposure occurring depends upon the potential for the asbestos material to release fibres, whether the asbestos material is contained or covered, and any operational control measures or personal protective equipment that have been applied to limit the generation and/or inhalation of airborne fibres. Fragments of fibres can enter the air and water from the weathering of natural deposits and the wearing down of manufactured asbestos products. Small-diameter fibres and fibre-containing particles may remain suspended in the air for a long time and be carried long distances by wind or water currents before settling. Larger diameter fibres and particles tend to settle more quickly. Asbestos fibres are not able to move through soil. Asbestos fibres are relatively chemically inert—they do not evaporate, dissolve, or undergo significant reactions with most chemicals. They do not undergo significant degradation in the environment (ATSDR, 2001).

The human health effects from asbestos exposure are well documented as hazardous and a carcinogen by health and environmental authorities (enHealth, 2005; WHO, 2000; ATSDR, 2001). Health effects commonly associated with inhalation exposure to asbestos are asbestosis, lung cancer, and a rare cancer called mesothelioma that affects the pleural and peritoneal membranes lining the chest and abdominal cavity. Benign pleural abnormalities, also known as pleural plaques, can also result from asbestos exposure. The latency period between exposure and asbestos-caused disease manifestation can span years which often makes it difficult to relate historical exposure to current symptoms. For example, signs of mesothelioma may not appear until 30 to 40 years after asbestos exposure. Asbestos has far-reaching and long-lasting impacts on human health, both through occupational and environmental exposure (Luus, 2007).

Asbestos exposure is not limited to occupational environments; it can also occur in various non-occupational environments, through proximity to industrial sites or through contact with workers who handle asbestos, mines, industry, sites contaminated with asbestos and other sources. Such non-occupational exposure has been linked to asbestos-induced illnesses, including cancer. Although the risk of cancer is generally associated with the level and duration of asbestos exposure, the medical literature has documented cases of mesothelioma, a specific type of cancer, arising from shorter exposure durations, sometimes just a few months (enHealth, 2005; ATSDR, 2001).

Australia phased out the use of asbestos and ACMs in the 1980s and banned its use, sale or import since 2003 nationwide. Of the 13 million tonnes of asbestos products installed in earlier decades, an estimated 50% remain in situ today (Frangioudakis, 2023). The NSW EPA articulated prohibition of asbestos waste in any form to be reused or recycled in section 144AAB of the Protection of the Environment Operations (POEO) Act 1997 which makes it an offence to cause or permit asbestos waste in any form to be reused or recycled. This ban encompasses all waste materials that contain asbestos, irrespective of the concentration level. Consequently, it is not permissible to process, sift, or separate asbestos waste. For example, materials such as asbestos cement cannot be extracted from waste, necessitating that all waste containing asbestos be relegated to a landfill authorised for such disposal.

4. Asbestos in New Building Material

In many countries, low levels of certain types of asbestos are still allowed in manufacturing. This occurs either due to contamination or residual presence in raw materials resulting in the continued presence of trace levels of asbestos in new building materials. It is important to understand and mitigate the risks associated with asbestos in new materials, even if they are ostensibly labelled as asbestos-free.

In many countries, despite the known threat to human health, local standards allow low levels of certain types of asbestos to be used for manufacturing (ABF, 2024). Asbestos can still be found in some products, including building materials, often because of contamination or residual presence in raw materials. For instance, certain types of talc, vermiculite, and other minerals can be naturally contaminated with asbestos fibres. Building materials that incorporate recycled content might inadvertently include asbestos from older, asbestos-containing products. This can happen if the recycling process does not adequately screen out or remove asbestos fibres. The continued presence of asbestos in trace levels in new building material products is a significant concern.

Goods manufactured outside Australia might be labelled "asbestos free" and still contain low levels of asbestos. For instance, in China, materials containing less than 5% asbestos content can be labelled as asbestos-free. In the United States, the US EPA regulates asbestos under the Toxic Substances Control Act (TSCA) which states for labelling purposes, materials generally must contain no more than 1% asbestos to meet safety standards, though stricter requirements apply to certain products and contexts (TSCA, 1999). These materials are not allowed to be imported into Australia.

The import and export prohibitions for asbestos in Australia also capture goods manufactured with mineral raw materials contaminated with naturally occurring asbestos (NOA), regardless of the quantity. An example of this is trace amounts in found in stone products (ABF, 2024).

All use of asbestos has been banned in the European Union (EU) since 2005, and several Member States had adopted asbestos bans well before then (EEA, 2022). In New Zealand, the import and use of asbestos and ACMs is prohibited unless the importation is authorised by a permit (Ministry for the Environment, 2016). Materials must be certified as completely asbestos-free, meaning no detectable asbestos content is allowed.

5. Asbestos in Soil and Recycled Waste Materials

5.1 Asbestos in Contaminated Soil

Contamination of soil with asbestos typically occurs through several pathways, including industrial processes, such as mining, manufacturing, and construction, which have historically involved the use of ACMs. Improper disposal practices or accidental releases during these activities could also result in the contamination of soil in surrounding areas.

Demolition or renovation of building structures containing ACMs can result in the release of asbestos fibres into the soil and into the air, where it can be transported beyond the source. Improper handling or disposal of construction debris may further exacerbate soil contamination. Some regions have naturally occurring asbestos deposits in the soil, posing a risk of exposure during excavation or other land-disturbing activities.

In Australia, there is a national guideline framework, and state/territory jurisdictions have established screening levels for asbestos contamination in soil (NEPC, 2013). These levels dictate the concentration of asbestos fibres in soil, beyond which further action such as investigation or risk management will be required. For example, NSW, VIC and WA jurisdictions have a typical threshold for asbestos contamination in soil of 0.001% (10 mg/kg) for friable asbestos and 0.01% (100 mg/kg) for bonded ACM (non-friable) asbestos, depending on the intended land use (residential, industrial, commercial) and risk assessment outcomes (WA DOH, 2021; SafeWork NSW, 2023; NEPC, 2013). This will require the implementation of an asbestos management plan or environmental management plan to aid in the management of the risks associated with any asbestos that remains on a site.

Management of asbestos-contaminated soil falls under the jurisdiction of contaminated land and planning legislation. Regulatory requirements and guidance for conducting thorough site investigations and threshold criteria of asbestos contamination in soil are established in work health and safety, land-use planning and environmental legislation, and the NEPC (2013). The guideline for the assessment, remediation and management of asbestos-contaminated sites prepared by WA DoH (2021) is referenced in most of the guidelines in Australia. This guide provides general guidance on the assessment and management of asbestos in soil addressing implications for the current and future occupants of the land and/or any workers employed on the site.

Examples of threshold levels for asbestos in soil are provided below:

Netherlands, (Swartjes, 2008)[1]

- intervention value of 0.01% w/w (asbestos equivalents[2]) in soil for friable and non-friable asbestos.
- limit of 0.1% w/w in soil for non-friable ACM if this is the only form present.

[1] The Ministry of VROM documents presented in Dutch, Swartjes presented the citations of the guideline in English.
[2] The sum of the concentration of chrysotile asbestos and ten times the concentration of amphibole asbestos

NEPC (2013)

- screening level of 0.001% for asbestos for FA and AF assessment in soil (A 10-fold extra “safety” factor is applied to the Netherlands criteria for drier Australian soils and no allowance for differences in asbestos type).

NEPC guidance provides screening criteria for the assessment of asbestos contamination in soil via quantification as % w/w by gravimetric methods.

- 0.01 % w/w asbestos in ACM – standard residential use (Residential A)
- 0.04 % w/w asbestos in ACM - residential, minimal soil access (Residential B)
- 0.02 % w/w asbestos in ACM – parks etc. (Recreational C)
- 0.05 % w/w asbestos in ACM - commercial/industrial (Commercial/Industrial D)

This literature review does not encompass an examination and evaluation of threshold levels of asbestos contamination in soil, and this aspect is explicitly excluded from the scope of the review. Relevant legislation and guideline documents for asbestos in soil are available nationally and in each jurisdiction. A brief discussion on methodologies for derivation of thresholds concentration for asbestos in soil is presented in Appendix C.

5.2 Asbestos in Recovered Material

Management of land contaminated with asbestos follows a unified national framework, yet there is a lack of uniformity in the approaches adopted by different jurisdictions for handling asbestos-contaminated waste. There is a need for a consistent approach in relation to threshold criteria for asbestos content by resource recovery facilities and regulators for handling recycled products and beneficial reuse.

Historically asbestos was utilised in a multitude of domestic and architectural products, automotive parts, such as brake pads and clutches, textiles and paper products, in the shipbuilding industry for insulation, fireproofing and soundproofing. Asbestos waste encompasses any refuse containing asbestos and disposal of asbestos waste poses intricate challenges. Asbestos waste from building maintenance, renovation and demolition activities makes up the largest proportion of ACM waste (European Union, 2024). Nearly 97% of ACM waste comes from construction materials, with insulation materials making up the remaining 2%, totalling 99% of such waste generated in member states over the past decade (European Commission, 2018).

Recycling C&D waste is important for reducing the demand for virgin materials, diverting waste from landfills and salvaging valuable resources. While regulations and procedures are in place to identify and remove ACM from buildings before demolition, there is still a risk that some asbestos or ACM will be contained in C&D waste that is directed to recycling facilities. Typically, C&D waste received at recycling facilities is mechanically processed through crushing and screening equipment. If asbestos is present in the C&D waste, these processes can result in the release of asbestos fibres into the air and can also result in recycled products containing small quantities of asbestos. These, in turn, can present a potential threat to the health of those who may be exposed to airborne asbestos fibres both on and off the premises, and also to those who may come into contact with the recycled product (WA DWER, 2021; WA DEC, 2012).

Principal considerations in determining how to manage asbestos in soil or waste include:

- the form of the ACM, and how readily it generates airborne fibres.
- the extent or scale of asbestos contamination in soil or waste.
- whether the asbestos in soil is predominantly on the surface or is buried at depth.
- where the recycled waste containing asbestos is used.
- the current and possible future uses of the affected land and whether these uses may materially affect the risk posed by the ACM.

Critically, the most effective control point for the separation and safe removal and management of asbestos is during the demolition of a structure. The recovery rate of useful material is hampered by cross-contamination with other materials, particularly in the mixed construction and demolition waste stream. Asbestos contamination is a well-documented problem and still presents a significant issue in waste derived from demolition and renovation works, not new construction. High recovery rates for materials are achieved when materials are captured closer to the source before there is an opportunity for mixing with other wastes. This is demonstrated in the case studies (Section 9), where the greatest recycling rates are achieved when the waste materials are captured early and segregated.

Contamination of material with asbestos is an ongoing challenge for the recycling industry. Currently, portable screening tools such as microPHAZIR™ asbestos analyser or similar technologies have been tested for use concurrently with visual inspection at the weighbridge.

Compliance testing by the NSW EPA in 2019 found that around half of all recovered fines produced are high-quality clean soils which is of benefit for reuse. Recovered fines are the residues remaining after all recyclable construction and demolition waste material has been removed from skip bins. They are reused as a sand/soil substitute in landscaping materials such as turf underlays or construction fill. However, the other half of the inspected recovered fines contained contaminants including asbestos, that may have human health or environmental risks. Other key contaminants were synthetic mineral fibres, plastics and micro-plastics.

Currently, there is no national guideline for acceptable tolerable threshold levels set for asbestos in recycled waste including recovered fines intended for beneficial reuse. In Australia, states and territories have inconsistent approaches to managing this issue and there is no harmonised approach.

Typically, most of the countries presented in this review have guidance and policies on the licencing requirements for the removal, separation, collection, storage and transport of ACMs from building demolition. Construction demolitions generally require asbestos removal before demolition starts or mandate separation during demolition. Licensing or permit systems for asbestos removal operations and operators are also commonly in place.

In addition, most national legislation and guidance documents maintain public registers of authorised asbestos removal operators, ensuring transparency and compliance with legal requirements. These registers help building owners find suitable companies and

assist authorities in enforcing regulations. Detailed requirements for the collection and transport of ACMs in sealed plastic bag containers or packaging are also typical (European Union, 2024; DCCEEW, 2011).

6. Threshold Level for Asbestos in Recycled Waste

Threshold levels related to disease risk are established based on epidemiological studies, toxicological data, and health assessments aimed at protecting individuals from asbestos exposure and its associated health effects (ATSDR, 2001). For asbestos, these are set based on the potential health risks posed by inhaling asbestos fibres, which can lead to diseases such as asbestosis, lung cancer, and mesothelioma (National Research Council, 1984). The primary goal is to minimise the incidence of asbestos-related diseases by limiting exposure levels that are known to increase the risk of developing such diseases.

The dose-response characteristics of the various fibre types have been extensively studied, but there are limitations to many of these studies due to inadequate testing regimes. The evidence for a threshold is strongest for asbestosis and lung cancer. The data from published occupational studies generally show there is a direct relationship between exposure and risk for all industries and fibre types, although the estimates of risk vary between studies. The incidence of mesothelioma was found to be exposure-dependent (enHealth, 2005). There is still a lot of uncertainty related to the risk of asbestos in the non-occupational environment.

The threshold levels for asbestos in waste are primarily established to manage the environmental and occupational health risks associated with ACMs during their handling, storage, transport, and disposal or potential beneficial reuse. These levels are typically based on the potential of asbestos fibres in recycled materials to be airborne, below which it is impossible to detect an increased risk of asbestos-related diseases.

Understanding the mechanism by which asbestos fibres are released into the air from the soil and recovered material are important in evaluating the risk which may depend on the size and distribution of the fibres, the physical properties of soil / recovered material, and moisture contents. Therefore, the threshold level for soil may not be the same as for recovered material

Developing techniques for estimating levels of asbestos in air from waste containing asbestos would enable screening level estimations of asbestos exposure in advance of activities or disturbances occurring, without extensive air monitoring.

6.1 Derivation of Thresholds Concentration for Asbestos in Recycled Waste

Asbestos concentration thresholds in recycled waste are crucial for protecting public health, considering the unique handling and processing dynamics of these materials throughout their lifecycle. Unlike soil thresholds (discussed in Appendix C), recycled waste thresholds must account for potential airborne asbestos fibres generated during activities such as cutting, grinding, handling, and at any stage of the material's lifecycle.

In general, C&D waste is non-putrescible (non-rotting) waste arising from construction or demolition activity. Studies by the Department of Environment and Climate Change (DECC) in 2007 identified that asbestos and asbestos-contaminated materials comprised 24.7% of C&D waste disposed of in the Sydney metropolitan area, followed by contaminated soil (21.1%) and concrete (16.6%) (DECC, 2007). This study

indicated that over 50% of the C&D waste is currently disposed of because of contamination with asbestos and chemical contaminants. Timber was the most common material from the mixed waste disposed to landfill from the Materials Reprocessing Facilities (MRFs). Concrete, for instance, shows potential for increased recovery rates if sorting techniques improve and C&D activities remain robust (DECC, 2007).

Emission factors for asbestos in recycled waste differ significantly from those in soil due to factors including variations in particle size distribution, moisture content and the heterogeneous nature of recycled materials. The potential for asbestos fibres to become airborne and pose inhalation risks depends on the demolition and recycling processes involved (e.g., cutting, grinding, handling).

Safe threshold concentrations for asbestos in recycled materials are determined based on airborne exposure limits and calculated emission factors. Calculating the concentration of asbestos in recycled waste is challenging due to the heterogeneity of the material. A single value would not lead to exceedance of airborne thresholds under typical usage scenarios. The exposure scenarios and threshold level could also depend on usage scenarios identifying common uses of recycled materials, such as construction, landscaping, or manufacturing (e.g. recovered aggregate for concrete mix).

7. Standard Analytical Methods and Laboratory Detection Limits

The purpose of this section is to briefly describe the analytical methods that are available for detecting, measuring, and/or monitoring asbestos in environmental media, especially in soils and waste. The intent is not to provide an exhaustive list of analytical methods. Rather, the intention is to identify well-established methods and practical laboratory quantitation limits (PQL) for the standard method of analysis and compare it with regulatory threshold levels. Any guideline level adopted must be measurable using a validated analytical method.

For compliance with these regulations, an appropriate standard analytical method is one that is recognised internationally and is capable of detecting asbestos concentrations in soil as low as 0.1% in the sampled material. While there is currently no nationally adopted reference method to reliably quantify fibres, AS4964[3] provides a qualitative method that can identify asbestos fibres in soil, which may provide important supporting information for a site investigation. This has a practical limit of detection of 0.01 to 0.1% (WA DOH, 2021).

Commonly recognised standard analytical methods, such as polarised light microscopy (PLM), are recommended for testing bulk materials for asbestos. In Australia, AS 4964 (2004) is currently the only method in Australia that has been recognised by the National Association of Testing Authorities (NATA) for laboratory accreditation in asbestos analysis, however, the practicable level of detection for this standard 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, although reporting concentrations below 0.01% w/w is not covered by NATA certification (WA DEC, 2012). Following the AS along with NATA accreditation of the increased sample size, will ensure consistent application of methods and reporting, and will ensure standardisation, reliability, reproducibility and comparability between samples, analysts and laboratory results.

For example, to determine whether recycled products (specifically recycled drainage rock 20-27mm, recycled sand <10mm, and recycled road-base <19mm) meet the product specification for asbestos content, WA DEC (2012) recommends sample size must be a minimum of 500mL and tested using analytical approaches as follows:

1. 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. Fixed criteria for fibrous asbestos (FA) and asbestos fibres (AF) are maintained across all site uses due to considerable uncertainty in quantifying asbestos concentrations below 0.01% w/w (WA DOH, 2021). A weight-of-evidence approach may be adopted i.e. the frequency and occurrence of other positive results in the stockpile can be considered, to determine whether the stockpile being assessed is considered to meet the product specification or not; or

[3] Since commencing this review, AS4964 has been replaced with AS5370.

2. 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. Several 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 fibres by Phase Contrast Microscopy (PCM) and calculating the weight of fibres in the extracted sub-sample.

8. National and International Standard and Guidelines for Asbestos in Waste and Recovered Material

8.1 Australia

The Australian Government, through the Asbestos and Silica Safety and Eradication Agency (ASSEA), publishes asbestos waste data estimates and updates as part of national hazardous waste reporting, based on records and reports of asbestos waste disposal from states and territories. The national long-term trend shows increasing levels of asbestos waste (this includes asbestos waste in totals i.e. ACM and any soil or rubble contaminated with ACM (ASSEA, 2024)). It is understood that most asbestos waste comes from renovation and urban development and goes to landfill.

ASSEA also oversees the implementation of the asbestos national strategic plan coordinating national actions to improve asbestos awareness and the effective and safe management, removal and disposal of asbestos (ASSEA, 2024).

Construction and Demolition Waste Status Report (2011) prepared by Hyder for DCCEEW indicated that performance in terms of resource recovery from the C&D stream is highly variable across the different Australian jurisdictions (DCCEEW, 2011).

The Australian Government does not have direct authority over the regulation of C&D waste, unless it involves the implementation of international treaties such as the Basel Convention[4] or the project has significant national environmental impact. In Australia, the states and territories are mainly in charge of handling environmental issues, and waste management and resource recovery policy is undertaken at the state and territory level. The regulatory framework and threshold for asbestos in recovered waste material and provisions of management in each state are summarised for each jurisdiction in the section below.

In executing the review, information in this report is based on data available from websites and public sources published online. The review reflects the research and understanding of the authors. The project team did not seek confirmation or engage with EPA representatives and it is recommended to refer to the regulatory authorities for any updates or changes that may not be included.

8.1.1 NSW EPA

Regulatory Framework: The regulatory framework for asbestos in environmental media in NSW is governed by various legislative instruments, including the Protection of the Environment Operations Act (POEO Act) (2018).

The Protection of the Environment Operations (Waste) Regulation 2014 (NSW).

NSW EPA (2019). Standards for Managing Construction Waste in NSW.

[4] Basel Convention is an international treaty that was designed to reduce the movements of hazardous waste between nations. The Basel Convention classifies asbestos waste as hazardous and requires that its transboundary movement be controlled and monitored. Specifically, asbestos is listed under Annex I (Categories of Wastes to be Controlled) and Annex III (List of Hazardous Characteristics) of the convention.

SafeWork NSW (2010). Management of asbestos in recycled construction and demolition waste Guide.

Prohibition on reuse of recycled waste containing asbestos: Section 144AAB of the POEO Act (1997) prohibits the reuse and recycling of asbestos waste.

Asbestos threshold for recycled waste: Any waste found to include ACM is classified as 'Special Waste (asbestos waste)' and must be disposed of at a facility licensed to accept such waste. ‘Asbestos waste’ is any waste that contains asbestos, including asbestos contaminated soil. 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.

Contaminated soil or materials that are managed onsite and are not intended for disposal may not meet the POEO Act definition of 'waste' under certain circumstances and thus may be eligible to be reused.

8.1.2 WA DWER

Regulatory Framework: In Western Australia Department of Water and Environment Regulation (DWER) manages and regulates the state’s asbestos waste through the Environmental Protection Act 1986 and Environmental Protection (Controlled Waste) Regulations 2004.

WA DWER (2021). Managing asbestos at construction and demolition waste recycling facilities.

WA DOH (2021). Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia.

Prohibition on reuse of recycled waste containing asbestos: At C&D recycling facilities, waste-derived products containing <0.001% w/w[5] asbestos could potentially be reused.

WA DWER (2021) presents a risk classification matrix to assess the risks associated with asbestos in the load based on the build date, to direct it to the appropriate area for unloading and further inspection.

For example, where the source of the load can be determined to be a building or structure constructed after 1990 then the load can be considered to represent a ‘low risk’ of asbestos contamination. On the other hand, where the waste originates from a building constructed before 1990 or there is uncertainty over suspect ACM is identified, the load must be reclassified as ‘high risk’. The high-risk wastes are spread over a sufficiently large area (to a depth of less than 30 cm and to turn over) to enable a comprehensive visual inspection of all sides of the material. Where suspect ACM is identified and is not capable of being easily removed by hand, the load must be rejected and disposed to a licenced landfill. If ACM fragments are capable of being easily removed by hand, once all suspected or assumed ACM has been removed from a load by handpicking, the residual waste can be processed (WA DEC, 2012).

[5] To determine whether recycled products meet the product specification for 0.001% w/w asbestos content at the laboratory, samples must be a minimum of 500 mL in size.

The Department of Health (WA DOH) is currently developing a more robust framework moving away from focusing on threshold levels and emphasising the use of risk assessment methods (WA DWER, 2021). Threshold levels are not the only determining factor, but it is used as an indicator of the effectiveness of the quality assurance and quality control (QA/QC) processes.

Asbestos Threshold for Recycled Waste: WA DWER (2021) stated that the asbestos content (in any form) of any recycled products must not exceed 0.001% asbestos weight for weight (w/w).

All asbestos material must be disposed of at a landfill or waste disposal site licensed by the DWER.

8.1.3 QLD DESI

Regulatory framework: In Queensland, handling, transportation, and disposal of asbestos waste is regulated by the Department of Environment, Science and Innovation (DESI) through the Environmental Protection Act 1994 and the Waste Reduction and Recycling Act 2011.

QLD Government (2011), Part 8.6 of the Work Health and Safety Regulation

QLD Government (2019), Environmental Protection Regulation.

Prohibition on reuse of recycled waste containing asbestos: Under Queensland legislation, materials that have undergone recycling and meet specific criteria can be classified as “end of waste”. However, ACM is not eligible for this classification. Queensland legislation does not permit the reuse of recycled materials containing asbestos, and they must be disposed of in designated licensed landfills.

Similarly, recovered material cannot be reused under the state's 'end of waste codes'[6].

Asbestos threshold for recycled waste: there are no threshold criteria for recycled waste for ACMs.

8.1.4 VIC EPA

Regulatory Framework: The regulatory framework for asbestos in environmental media in Victoria is governed by various legislative instruments, including the Environment Protection Act 2017 and associated regulations.

VIC OH&S (2017). Part 4.4 of the Occupational Health and Safety Regulations.

WorkSafe Victoria (2017). Recycling construction and demolition material, Guidance on complying with the Occupational Health and Safety (Asbestos) Regulations.

VIC EPA (2021) Publication 1828.2 – Waste disposal categories – characteristics and thresholds.

[6] End of waste codes are codes assigned to waste materials that have undergone a process, such as recycling, to transform them into a product that can be used beneficially. These codes are typically assigned by regulatory bodies to indicate that the waste material has been sufficiently processed and no longer poses a risk to human health or the environment.

Prohibition on reuse of recycled waste containing asbestos: The VIC EPA allows the reuse of recycled C&D material.

Asbestos threshold for recycled waste: threshold criteria for recycled C&D waste for ACMs less than 0.001% set by VIC EPA.

Guidance on recycling C&D material outlines an auditable procedure to verify the removal of ACM prior to recycling. Recycled C&D material must meet test requirements to contain less than 0.001% as per the asbestos regulations before reuse.

8.1.5 SA EPA

Regulatory Framework: The regulatory framework for asbestos in recycled waste in South Australia is governed by various legislative instruments, including the Environment Protection Act 1993 and associated regulations.

SA EPA (2013). The Standard for the Production and Use of Waste-Derived Fill

Prohibition on reuse of recycled waste containing asbestos: C&D recycling operations are neither permitted nor licensed to handle asbestos-contaminated material (DSEWPC, 2012). The SA EPA has testing, submission and approval requirements for "Waste-derived fill" (WDF)[7] that apply a risk-based approach with consideration to both the chemicals present within the WDF and the source of the waste.

A recovered products plan (RPP)[8] or auditor report must be submitted to the SA EPA for proposed reuse, with sufficient details and evidence to demonstrate the suitability of the proposal for reuse of waste.

Asbestos threshold for recycled waste: Not applicable.

The SA EPA does not endorse any safe level of asbestos for use in WDF, per the Standard for WDF. Waste that potentially contains asbestos must be tested to demonstrate that the material is free of asbestos prior to use as WDF. Reuse as fill may be possible at specific sites (not general market use) if an auditor protocol is followed. This auditor protocol requires the removal of all asbestos from the fill to the maximum extent possible, a quantitative health risk assessment conducted in accordance with the Site Contamination NEPM and enHealth guidelines, and a site management plan endorsed by a site contamination auditor. Additionally, the WDF cannot be used on a site with a “sensitive use”, which includes residential, pre-school and primary school sites.

8.1.6 TAS EPA

Regulatory Framework: The regulatory framework for asbestos in Tasmania is governed by various legislative instruments, including the Environmental Management and Pollution Control Act 1994.

[7] Waste derived fill (WDF): waste soil proposed for direct reuse, processed C&D Waste, and a homogenous mineral-based industrial residue.
[8] The RPP will need to demonstrate how the wastes received and processed into WDF products meet the key considerations and wastes suitable for use as fill to ensure fit for purpose and minimisation of harm and the specific requirements.

TAS EPA (2020) Environmental Management and Pollution Control (Waste Management) Regulations 2020.

WorkSafe Tasmania (2022) Chapter 8 of the *Work Health and Safety Regulations 2022* (Tas).

Prohibition on reuse of recycled waste containing asbestos: The regulatory framework would allow the EPA to make a risk-based determination on whether a small amount of asbestos contamination in recovered products was acceptable, but it would be up to the facility to apply for that assessment. EPA Tasmania does not have a formalised position in its regulatory framework.

Asbestos threshold for recycled waste: The Tasmanian EPA does not have a formal quantitative threshold.

8.1.7 ACT EPA

Regulatory Framework: The regulatory framework for asbestos in ACT is governed by the Work Health and Safety Regulation 2011 and Dangerous Substances Act 2004.

Prohibition on reuse of recycled waste containing asbestos: Waste that may be contaminated with ACM must be disposed of at a licenced landfill authorised to accept such waste.

Asbestos threshold for recycled waste: Not applicable**.**

8.1.8 NT EPA

Regulatory Framework: The regulatory framework for asbestos transport and disposal in NT is governed by the Waste Management and Pollution Control Act 1998.

NT Government (1998) Waste Management and Pollution Control (Administration) Regulations 1998.

Prohibition on reuse of recycled waste containing asbestos: NT does not have a formalised position in their regulatory framework in relation to the reuse of the recycled waste impacted by ACMs.

Asbestos threshold for recycled waste: Not applicable.

8.2 International

crcCARE consulted with contacts from various international regulatory authorities through personal e-mail communication to gather information to assist the review, particularly with respect to the review's terms of reference, including practices and examples of relevant legislation.

The following sections provide an overview of selected policies and instruments implemented in New Zealand, European, and North American jurisdictions. While the review is not exhaustive, it offers international context and highlights example approaches. These countries were chosen based on their advanced asbestos management and regulation, as well as their similar history of asbestos use to Australia.

8.2.1 New Zealand

Regulatory Framework: The regulatory framework for asbestos in environmental media in New Zealand is governed by various legislative instruments, including the Health and Safety at Work (Asbestos) Regulations 2016, the Health and Safety at Work Act 2015 and the Resource Management Act 1991.

WorkSafe New Zealand (2016): Provides the "Approved Code of Practice for the Management and Removal of Asbestos", offering detailed guidance on safely handling and disposing of asbestos.

Ministry for the Environment (2020): Publishes guidelines on managing and disposing of hazardous waste, including asbestos.

Prohibition on Reuse of Recycled Waste Containing Asbestos: The Health and Safety at Work (Asbestos) Regulations 2016 prohibit the reuse and recycling of asbestos waste. There is also a national ban on the supply of any products containing asbestos, including recycled materials from construction and demolition activities.

Asbestos Threshold for Recycled Waste: There are no threshold criteria for recycled waste for ACMs. Any material intended for resource recovery or recycling found to include ACM is classified as 'Hazardous Waste (asbestos waste)' and must be disposed of at a facility licensed to accept such waste.

Where a load is identified as containing, or is reasonably suspected to contain, any asbestos waste, it is classified as ‘Hazardous Waste (asbestos waste)’ and must be disposed of at a licensed landfill facility. The removal of asbestos, or suspected asbestos, from stockpiles or waste-derived materials supplied to a third party by manual picking or any other processing method, is not permitted.

8.2.2 United States

In the United States (US), regulations regarding asbestos in recycled waste and reuse vary depending on the type of material and its application. Both federal (US EPA) and state EPA regulations set standards and guidelines for the safe handling and disposal of ACMs. Nationally, waste recycling operations are subjected to regulation under Subtitle C of the Resource Conservation and Recovery Act (RCRA) and Asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP). However, specific threshold concentrations for asbestos in recycled waste may be addressed by state or local regulations, as well as industry standards (USEPA, 2023).

When it comes to recycled waste, the concentration of asbestos allowed may vary based on its intended use and the risks associated with exposure. Asbestos regulations often focus on ensuring that exposure to asbestos fibres is minimised to protect public health and safety. Concentration limits may vary based on factors such as the type of material, its condition, and the likelihood of fibre release during handling or use.

Several states in the USA have regulations and guidelines allowing for the reuse of recycled materials containing asbestos, provided certain conditions are met to ensure public safety and environmental protection. Examples include:

California: California has regulations set by the California Environmental Protection Agency Department of Toxic Substances Control (DTSC) regarding the management and handling of asbestos-containing materials.

DTSC classifies asbestos-containing material as hazardous waste if it is "friable[9]" and contains 1% or more asbestos as hazardous waste. According to the California Code of Regulations, Title 22, Division 4.5, Chapter 20, Section 66261.24, the threshold level for asbestos-containing waste materials is 1% w/w. Materials containing 1% or more asbestos by weight are considered asbestos-containing waste and must be managed as hazardous waste.

DTSC considers non-friable[10] bulk asbestos-containing waste to be non-hazardous regardless of its asbestos content, so it is not subject to regulation under Title 22, Division 4.5, of the California Code of Regulations.

New York: The New York State Department of Environmental Conservation (DEC) oversees regulations concerning asbestos handling and disposal. As outlined in the New York State Industrial Code Rule 56 (12 NYCRR Part 56), the threshold level for asbestos-containing waste is 1% w/w friable asbestos-containing waste. Materials containing 1% w/w or more asbestos are subject to asbestos abatement regulations.

Wastes that contain more than 1% w/w asbestos but are not easily reduced to powder are not considered friable asbestos-containing waste but instead may be considered residential waste, construction and demolition debris, or some other waste type depending on the source. Examples of wastes that may contain asbestos include:

- Roofing shingles
- Floor and ceiling tiles
- Plaster and wallboard
- Insulation from buildings, pipes and boilers

Texas: In Texas, the Texas Commission on Environmental Quality (TCEQ) regulates ACMs under Title 30, Texas Administrative Code (TAC), Chapter 295. According to TCEQ guidelines, waste containing 1% w/w or more asbestos is considered regulated asbestos-containing material (RACM) and must be handled and disposed of in accordance with applicable regulations.

Florida: The Florida Department of Environmental Protection (DEP) oversees regulations related to asbestos management. As outlined in Chapter 62-257 of the Florida Administrative Code (F.A.C.), waste containing 1%w/w or more

[9] *when dry, can be crumbled, pulverized, or reduced to powder by hand pressure. Examples of friable materials include sheet vinyl flooring, insulation on pipes, ductwork and boilers, fireproofing, ceiling and wall texture, ceiling panels and soundproofing materials.*

[10] *Category I nonfriable asbestos materials, which are asbestos-containing resilient floor covering, asphalt roofing products, packing and gaskets rarely become friable if handled responsibly. Generally, these materials do not release significant amounts of asbestos fibers, even when damaged. However, during the demolition activity, the waste must be handled in a responsible manner which will not cause the Category I nonfriable material to become friable and become a regulated asbestos-containing material (RACM). RACM are friable asbestos material, Category I nonfriable asbestos-containing material that has become friable, Category I nonfriable asbestos-containing material that will be or has been subjected to sanding, grinding, cutting, or abrading, or Category II nonfriable asbestos-containing material that has a high probability of becoming or has become crumbled, pulverized, or reduced to powder by the forces expected to act on the material in the course of demolition or renovation operations.*

asbestos is considered ACM and must be managed and disposed of in accordance with state regulations.

Oregon: Oregon's Department of Environmental Quality (DEQ) regulates ACMs under Oregon Administrative Rules (OAR) Chapter 340, Division 248. According to DEQ guidelines, waste containing 1% or more asbestos by weight is considered ACM and must be handled and disposed of in accordance with state regulations.

These examples highlight that some states in the USA have adopted a threshold level of 1% w/w asbestos for defining ACMs. While states may not have explicit prohibitions or threshold levels of ACM waste, they may impose stringent requirements or restrictions that effectively limit or discourage their reuse. These requirements could include strict testing and documentation procedures, as well as specific handling and disposal protocols to minimise the risk of asbestos exposure. However, no specific guidance document explicitly mentioning waste containing ACM or the limit for asbestos concentration in recycled waste material from recycling facilities for beneficial reuse was found in the sources reviewed.

8.2.3 United Kingdom

In the United Kingdon (UK), requirements regarding the handling, transportation, and disposal of asbestos-containing waste materials are governed primarily by the Control of Asbestos Regulations 2012 (CAR 2012), the Environmental Permitting (England and Wales) Regulations (2016) and quality protocol for aggregates from inter waste (2013).

Under the Control of Asbestos Regulations, the UK sets out stringent requirements for the management of ACM, including waste. These regulations cover various aspects of asbestos management, including identification, assessment, removal, transportation, and disposal.

Generally, ACM wastes are categorised into different codes based on the concentration of asbestos fibres present (Environmental Agency, 2021). The classification system typically includes codes such as:

1. **Lower-Risk Waste (LRW)**: This category includes materials with a lower concentration of asbestos fibres, typically below a 0.1% w/w threshold. LRW may include materials such as asbestos cement products with a low asbestos content (e.g., roofing sheets, pipes), floor tiles, and textured coatings. Generally requires less stringent controls.
2. **Higher-Risk Waste (HRW)**: This category includes materials with a higher concentration of asbestos fibres greater than 0.1%w/w. HRW may include materials such as insulation boards or sprayed coatings with a higher asbestos content and requires stringent controls and licenses for removal, handling and transporting HRW waste.

The classification of ACM into these categories is based on risk assessment and may consider factors such as the type of material, its condition, and the likelihood of asbestos fibre release during work activities. The guide provides detailed guidance on how to assess and classify ACMs into appropriate risk categories based on these factors.

The specific concentration thresholds for categorising asbestos-containing waste materials as LRW or HRW can vary depending on the regulations and guidelines set by the relevant authorities in the UK, such as the Environment Agency (EA) or the Health and Safety Executive (HSE), with criteria based on factors such as the potential risk of asbestos exposure, the type of material, and the likelihood of fibre release.

In the Guidance on the classification and assessment of waste (1st Edition v1.2.GB), Technical Guidance WM3 (2021) for England, Scotland and Wales, waste containing asbestos is classified as hazardous waste if the waste contains 0.1% or more asbestos. 0.1% is the lower threshold, considering the highest risk, therefore, 0.1% is the accepted hazardous threshold for waste materials containing asbestos. The assessment applies for waste containing fibres that are free and dispersed, and identifiable pieces of asbestos containing material.

If, at any point asbestos is identified in a recycled material (or any other waste), it would need to be recharacterised (and re-tested). If the amount of asbestos detected in the recycled material exceeds the threshold (0.1%), then the material will need to be classed as hazardous. Movement of the waste would then need to be undertaken in accordance with the Hazardous Waste Regulations (using consignment notes).

If recycled waste is intended for sell as a ‘non-waste’ product, the recycling operator would need to be able to demonstrate that the material has achieved end of waste to ensure that the waste meets an existing quality standard (e.g. WRAP Aggregate Quality Protocol).

Non-hazardous soils containing asbestos (below the 0.1% threshold) can be used for landfill restoration provided that the waste is deposited below the final restoration, or surface topsoil layer. However, this would need to be risk assessed on a case by case basis.

8.2.4 European Union and member states

Comprehensive asbestos waste statistics are not available for all European Union (EU) member states, and only about half have issued guidance documents for asbestos waste management. The primary source of asbestos waste is renovation and demolition activities, with landfilling being the predominant disposal method. However, several Member States may face landfill capacity issues in the coming years. A recent report by the European Commission (2024) indicated that several recovery technologies are in the final stages of development or ready for industrial implementation but face regulatory and economic barriers. The EU aims to reduce the landfilling of construction and demolition waste and promote its reuse, preparation for reuse, and recycling, in line with the Waste Hierarchy outlined in the Waste Framework Directive. The amount of demolition waste containing asbestos is expected to increase in the coming years due to renovations and demolitions undertaken as part of the energy transition.

The asbestos waste recovery capacity in the EU is currently close to zero. Only one industrial facility is using thermal plasma vitrification but is facing challenges due to its high operational cost (European Commission, 2018). Thermal plasma vitrification is a process that uses extremely high temperatures generated by a plasma torch in excess of 1,500°C, which is sufficient to break down asbestos fibres and other hazardous materials at the molecular level.

The report by the European Commission (2024) recommends that, to advance asbestos waste recycling and beneficial reuse across the EU and member states, several measures should be adopted. These include fiscal incentives, certification of end products, standardisation of operations, and dissemination of best practices. Currently, there are no environmental criteria for asbestos in recycled wastes, and in general, most EU countries do not have a threshold level for asbestos in recycled wastes.

The regulations surrounding the reuse of ACM vary significantly across different European countries.

Netherlands:

Quantitative Threshold Criteria: The Netherlands sets specific thresholds for the permissible concentration of asbestos in waste materials. For example, certain types of ACM may be allowed for reuse if they contain less than 0.01% w/w (below laboratory detection limits) and meet other criteria specified by Dutch regulations.

The Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) of the Netherlands incorporated the value of 0.01%w/w dry weight (asbestos equivalents) in the interim policy on asbestos in soils, sediments, dredge materials and demolition waste (granules) (Swartjes, 2008).

In the case of bound asbestos, the concentration in the air will hardly ever exceed acceptable risk level. However, because it is difficult to determine when bound asbestos turns into friable asbestos due to aging (weathering and erosion), it was proposed to include this nuance in the site-specific risk assessment only. Therefore, the above-mentioned value of 0.01%w/w dry weight (asbestos equivalents) is valid for bound as well as for friable asbestos. The value also applies to the residual concentration for the recycling of soil material, dredging and demolition waste (granules) and as a criterion for remediation of roads and private property. The Intervention Value of 0.01%w/w dry weight (asbestos equivalents) was incorporated in the new Dutch soil policy on soil contamination (Ministry of VROM, 2006).

Reuse Allowed: According to a national regulation for end-of-waste most recycled aggregates / recycled materials are a product and not considered a waste anymore. Recycled and/or treated waste containing asbestos may be allowed for reuse in the Netherlands if it meets the established criteria for asbestos content and handling with a focus on road building construction products such as blocks, bricks, pavers, cement treated base, water buffering and drainage, aggregates for asphalt, concrete, concrete products and mortar (Frangioudakis Khatib, 2023; FIR, 2024).

Germany:

The permissible concentration of asbestos in waste materials is governed by the Technical Instructions on Hazardous Substances 519 (TRGS 519) and the new LAGA M23 (BAuA, 2007; LAGA, 2023).

Quantitative Threshold Criteria: Materials with an asbestos content of less than 0.1% w/w (laboratory detection limit) may be eligible for certain reuse applications. Material containing naturally occurring asbestos with up to

0.1% w/w asbestos can be recycled. Material with added asbestos cannot be recycled, unless the asbestos content is less than 0.010%.

Reuse Allowed: Recycling hazardous asbestos-containing waste is not allowed in Germany, and the same holds for preparation for reuse. Landfilling of asbestos-containing waste must occur at approved facilities. However, the new LAGA M 23 includes an assessment value of 0.010 % which links recyclability to a concrete value with the help of a clear definition of "asbestos-free".

Italy:

National legislation and guidance on asbestos waste management is governed by guidance INAIL DIT (Department of Technological Innovation) (INAIL DIT, 2021)

Quantitative Threshold Criteria: asbestos is a category 1 substance, all wastes that contain ACM concentrations exceeding 0.1% w/w are classified as hazardous.

Reuse Allowed: Under certain conditions and if the asbestos content is below the specified threshold, recycled waste containing asbestos may be allowed for reuse in various applications like in road construction and manufacturing as a composite with a ceramic matrix (INAIL DIT, 2021; Sergio Arfò, 2019).

Finland:

There is no specific guidance document for asbestos waste or the limit for asbestos concentration in waste from recycled facilities is not explicitly mentioned in the sources reviewed.

Austria:

In Austria, the management of asbestos-containing waste is strictly regulated. The building owner and the contractor are responsible for the correct conduct and documentation of the dismantling of the building. The documentation of the dismantling must be according to ÖNORM B 3151 when more than 100 tonnes of construction and demolition waste arise from a demolition (excluding excavated materials).

However, the specific limit for asbestos concentration in waste from recycled facilities is not explicitly mentioned in the sources reviewed.

8.2.5 Canada

In Canada, regulations regarding the handling, transportation, and disposal of ACM waste materials vary by province and territory. However, there are overarching federal regulations that apply across the country, as well as provincial and territorial regulations that may impose additional requirements or standards.

Regarding the disposal of ACM waste, federal regulations may also apply, particularly if the waste is being transported across provincial or territorial boundaries. The Canadian Environmental Protection Act of 1999 and its regulations may govern the disposal of hazardous waste, including asbestos, to ensure compliance with environmental protection standards.

At present, test results identifying asbestos at 0.1% or more, with fibres that demonstrate both of the following characteristics (fibres having an aspect ratio of at least 3:1, meaning the fibres are at least three times longer than they are wide and fibres longer than 5 micrometres), will be considered by ECCC and Health Canada as evidence of the presence of asbestos in more than a trace amount. The specific limit for asbestos concentration in waste from recycled facilities is not explicitly mentioned in the sources reviewed.

9. Reuse of Recycled Waste Where Threshold Levels for Asbestos have been Establish – Case Studies

Waste legislation generally sets strict requirements mandating the disposal of asbestos in landfills. However, since the waste hierarchy prioritises recovery over disposal, exploring alternative, environmentally sound treatment methods is a priority. This approach mitigates health risks associated with asbestos exposure by transforming hazardous waste into useful products and promoting sustainable industrial practices (Gualtieri, 2012). Industrial applications for these secondary materials include concrete, geopolymers, clay bricks, ceramic pigments, glass ceramics, rockwool glasses, and magnesium phosphate cement (Shiv Bolan, 2023).

Recycling ACMs into secondary raw materials offers multiple advantages:

- Recycling reduces the volume of waste requiring disposal in landfills, thereby conserving valuable landfill space that could otherwise be used for other non-recyclable waste streams.
- The creation of new products from recycled ACMs opens opportunities for innovation in material science and industrial applications.
- Proper treatment and recycling of ACMs lower the health risks associated with asbestos exposure, as the fibres are often immobilised or transformed during the recycling process.

There are several technologies to treat ACMs, transforming it into safe, reusable secondary raw materials, however, most of them are at a pilot or demonstrator plant level and they are yet to be realised at an industrial scale. Thermal treatment is the most established process and is currently the only commercially available technology. The process involves transforming ACMs into harmless silicate glass by heating above 1000°C. Despite its effectiveness, the technology is energy intensive. Given the lack of calorific value of asbestos and its incombustibility, the process requires significant electricity or fuel. This poses a barrier due to high operational costs and the need for specialised facilities.

Instead, most countries opt for sorting and removing ACMs from waste streams. Some utilise advanced technologies like microPHAZIR™ asbestos analysers to detect asbestos fibres. This method is cost-effective, environmentally friendly, and more accessible. Safe removal of ACMs and recycling of non-hazardous materials balance environmental, economic, and health considerations. Advances in sorting technologies and regulatory frameworks will enhance this approach.

The recovery rate is hampered by cross-contamination with other materials, particularly in mixed construction and demolition waste streams. High recovery rates are achieved when materials are captured close to the source, minimising the opportunity for mixing with other wastes. Case studies demonstrate that the greatest recycling rates occur when waste materials are segregated early in the process (DSEWPC, 2012).

The process typically involves the inspection and identification of waste to identify and separate ACMs from non-asbestos materials using manual labour and mechanical sorting equipment. The remaining non-asbestos containing materials are processed for reuse in various industrial applications, such as concrete, road base, and landscaping

products. However, challenges include the high labour intensity and difficulties around ensuring the accurate detection and removal of all ACMs.

9.1 Reuse of Recycled Waste - Australian Case Study

Western Australia has introduced the Roads to Reuse (RtR) incentives program, which rewards local governments for procuring recycled C&D products for civil applications (WA DWER, 2020). The RtR product specifications prohibit the use of recycled concrete (CRC) within 100 meters of wetlands or watercourses, on or above land subject to flooding, or within P1 Public Drinking Water Source areas. RtR products can be utilised in State Government, Local Government, or commercial construction projects. For example, by June 2020, Main Roads Western Australia (MRWA) had used over 31,000 tonnes of RtR material in the Kwinana Freeway Northbound Widening project, where RtR material was used as a subbase under full-depth asphalt. The RtR product specifications and supplier approvals ensure robust processes and criteria for managing asbestos and other potentially hazardous contaminants. These specifications include strict inspection and testing regime requirements within the supplier's quality system and Mandatory Asbestos Sampling Procedures (MASPs) to ensure asbestos levels do not exceed the Department of Health's maximum acceptance limits (Reporting presence/absence – quantification to 0.001% w/w where asbestos is detected) (WA DWER, 2020).

9.2 Reuse of Recycled Waste - International Case Study

In Europe, countries like Germany and the UK implement comprehensive recycling programs for ACMs, emphasising early segregation of waste to achieve high recovery rates. These programs incorporate advanced mechanical sorting, thermal treatments, and strict regulatory oversight to ensure safe and effective recycling practices.

In Germany, the new communication from the Federal/State Working Group on Waste (LAGA M 23) aims to maximise the recycling of C&D waste into reinforced concrete (RC) building material. To achieve this, LAGA M 23 introduces an assessment value of 0.010%, like standards in the Netherlands. This value provides a concrete definition of "asbestos-free," facilitating the recyclability of C&D waste (European Union, 2024).

At the time of this review, limited project information was available pertinent to the reuse of processed and treated recycled C&D waste with traces of asbestos. Review in consultation with the local EPA is recommended to source project-specific information.

10. Conclusions

In Australia, asbestos was progressively banned between the 1980s and 2003, with a complete ban on the use, import, and sale of asbestos and asbestos-containing materials coming into effect on December 31, 2003. Asbestos is banned in new applications, including building products, but structures built before 2003 may still contain asbestos materials. Therefore, the primary risk of asbestos contamination arises from the handling of demolition and renovation projects, waste disposal and recycling of C&D waste. The risks associated with asbestos contamination are significant, given its well-documented health hazards, including asbestosis, lung cancer, and mesothelioma. In response to these risks, various jurisdictions have implemented stringent regulations and guidelines to mitigate the potential for asbestos exposure.

To protect human health and the environment from potential risks and hazards from reused asbestos-contaminated recycled C&D waste, it is important for regulatory criteria for tolerable threshold levels to be set based on scientific evidence and controls that could be applied to mitigate environmental and human health risks (including education, regulation, monitoring, reporting etc).

Unlike the national approach for managing asbestos contaminated land, inconsistent approaches exist across jurisdictions in managing asbestos contaminated waste. For instance, in Western Australia to keep asbestos-contaminated materials out of C&D waste recycling facilities, it is acceptable to screen and remove asbestos cement material at recycling facilities.

The Western Australia guidance on managing asbestos in C&D waste recycling facilities states that to ensure the health of those using or encountering recycled C&D products is protected, the asbestos content (in any form) in any recycled products must not exceed 0.001% w/w. Further, Western Australia offers additional guidance that sets an asbestos limit of <0.001% for reuse in civil applications such as crushed recycled concrete and recycled C&D for road base material (e.g. Roads to Reuse (RtR) incentives program). In Victoria, the management of asbestos in the C&D waste guidance outlines procedures to ensure ACMs are removed from C&D loads before recycling.

By contrast, NSW enforces zero tolerance for asbestos in recovered materials and it is an offence to cause or permit asbestos waste in any form to be reused or recycled. The prohibition applies to all wastes containing any form of asbestos at any concentration. Also, it means asbestos waste cannot be processed, screened or segregated. Therefore, ACM, for instance, cannot be removed from the waste and all waste loads with identified ACM must be disposed of to a landfill licensed to receive the waste. However, the NSW EPA 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 review of international regulatory guidelines demonstrates that many states in the USA have adopted a threshold level of 1% w/w asbestos for defining ACM. In Canada, asbestos waste is classified as hazardous waste, and there is generally no specific threshold level for asbestos in waste. Any material containing asbestos is subject to hazardous waste regulations and must be managed and disposed of accordingly.

While in the UK the HSE guidance may not specify a specific threshold, it provides criteria for assessing the risk associated with ACM and determining appropriate control measures and work practices based on the level of risk. Overall, in the UK, there are no specific threshold criteria for asbestos in waste separate from other regulations governing the management of ACM.

Across European countries, the threshold criteria for asbestos in waste vary significantly. In the Netherlands, recycled waste can be reused if the asbestos concentration is below 0.01% w/w, meeting Dutch regulatory criteria. Germany allows recycling materials with <0.010% asbestos which are considered as asbestos-free. Italy allows the reuse of recycled waste under certain conditions if the asbestos content is below 0.1% w/w. In Finland and Austria, the specific limits for asbestos concentration in recycled waste are not explicitly mentioned.

Table 1. Summary of threshold levels for asbestos in recycled wastes in national and international jurisdictions.

Jurisdiction	Threshold level (W/W)	Date of enactment of threshold	Re-use permitted	Examples of reuse
National Jurisdictions				
WA	0.001%	WA DOH (2021).	Yes	Road to Reuse (RtR) project
NSW,	No ACM (i.e., No set threshold and no method specified)	Section 144AAB of the POEO Act (1997) as amended in 2008	No	-
SA	Risk-Based Approach	SA EPA (2013).	Yes, based on risk assessment	No information available
TAS, NT, ACT	NA	NA	No	-
International Jurisdictions				
USA#	1%	state EPA's regulations	Yes	No information available
Canada*	0.1%	The Canadian Environmental Protection Act, 1999	No	-
New Zealand	No ACM (i.e., no visual identification of ACM and below laboratory PQL)	Health and Safety at Work (Asbestos) Regulations 2016	No	-
European Union @	No ACM (i.e., no visual identification of ACM and below laboratory PQL)	(European Commission, 2018).	No	-
Netherlands	0.01%	(Ministry of VROM, 2006).	Yes,	No information available
Italy	0.1%		Yes	No information available
Germany	0.010%	LAGA -23	Yes	No information available

Jurisdiction	Threshold level (W/W)	Date of enactment of threshold	Re-use permitted	Examples of reuse
UK	Risk-Based Approach	(CAR 2012).	Yes, based on risk assessment	No information available
Finland	NA	NA	No	-
Austria	NA	NA	No	-

*Note: * - In Canada, there is generally no specific threshold level for asbestos in waste, however, the detection of trace amounts of asbestos are to be below 0.1%.*

 # - Many states in the USA have adopted a threshold level of 1% w/w asbestos for defining asbestos-containing waste materials, while some states may not have explicit prohibitions or threshold levels of waste asbestos-containing materials.

@ - In general, most European Union Countries don't have a threshold level for asbestos in recycled wastes.

NA - The specific limit for asbestos concentration in waste from recycled facilities is not explicitly mentioned in the sources reviewed.

PQL – practical quantitation limit of laboratory (0.001% w/w)

There is limited information that explicitly discusses the threshold level for asbestos concentration in waste from recycled facilities. Asbestos contamination remains a critical issue in C&D recycling worldwide. Developing comprehensive guidelines for asbestos management in C&D recycling is a complex task that necessitates collaboration among various stakeholders, including health authorities, environmental agencies, and legislative bodies. Jurisdictional safe work authorities, EPAs and health departments should lead these efforts, working closely with the resource recovery industry and relevant environmental agencies.

Guidance on managing asbestos in the C&D waste recycling sector is essential for promoting recycling and the use of recycled C&D materials. Understanding the associated risks and developing practical regulatory guidelines are key to increasing the recovery of C&D waste and reducing its landfilling. Additionally, government procurement policies that favour the use of reprocessed C&D materials can significantly boost the adoption of recycled products. This is particularly impactful in civil works projects, where social acceptance and environmental benefits are important considerations.

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APPENDIX A.

Summary of Standards and Guidelines for Asbestos in Recycled Waste, Australian States and Territories

Appendix A summarises the standards and guidelines for managing asbestos in recycled waste across Australian states and territories, detailing regulatory frameworks, permissible asbestos levels, and management requirements. Each state has its own approach to handling asbestos in construction and demolition waste, ensuring safe practices for handling, transport, and disposal, and promoting public health and environmental safety.

Table A.1 Summary of Standards and Guidelines for Asbestos in Recycled Waste, Australian States and Territories

States and Territories	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
NSW EPA	S144AAB of the POEO Act	Section 144AAB of the POEO Act (1997) as amended in 2018 No. 80 prohibits the reuse and recycling of asbestos waste.	• Bonded asbestos waste must be securely packaged during transport. • Transport of >100kg of all asbestos (including bonded), or >10 square metres of waste asbestos sheeting must be tracked using WasteLocate (which will be soon replaced by the Integrated Waste Tracking System). • All asbestos (including bonded) is subject to cover requirements with VENM on disposal at a landfill. • Each load that enters the C&D waste facility requires visual inspections at 2 points – reject the entire load when asbestos waste is identified. Wet down the load containing ACM. • In regard to the onsite reuse of soils contaminated with bonded asbestos, the recently published position statement on the WA Asbestos Guidelines states that "Removal of asbestos fragments is not a remedial approach to 'clean' asbestos contaminated soils or stockpiles for reuse".	The levy rate for asbestos waste is the same as for other wastes
WA DWER	WA DOH (2012), and WA DWER (2019a)	*At C&D recycling facilities, waste-derived products containing <0.001%*	• Reject, isolate and wet loads containing FA or AF, and ACM. • Asbestos must be separated from other waste for disposal where practicable.	Licensees of landfills can claim a levy exemption for bonded asbestos waste and friable asbestos products.

States and Territories	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
		w/w asbestos can be re-used. *Department of Health (WA DOH) currently working on setting a more robust framework that goes beyond just a number.*	• Asbestos is to be wrapped or otherwise contained and labelled "CAUTION ASBESTOS" in letters >50mm. • Material containing asbestos defined as material containing >0.001% asbestos fibres weight/weight. • The person disposing of the asbestos must inform the landfill operator the material is or contains asbestos. • There is no requirement for tracking or licensing of asbestos transportation (Regulation 3(5) of Environmental Protection (Controlled Waste) Regulations 2004) • Specific levy exemption for asbestos waste disposal (material that has been designed with asbestos in it, not asbestos-containing material) • The 'Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia' (WA Asbestos Guidelines), permit the onsite reuse of soils contaminated with low levels of bonded asbestos, after mechanical screening to remove the asbestos and subsequent validation. • The WA guidelines allow for the hand-picking or emu-picking of ACM materials from the waste.	Contaminated soils and other wastes contaminated with asbestos are not eligible for the levy exemption.

States and Territories	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
SA EPA	SA EPA (2013), Environment Protection Act 1993	C&D recycling operations are neither permitted nor licensed to handle asbestos-contaminated material. A risk-based approach is recommended and approved by the accredited contaminated land auditor	• Wet the asbestos cement with water before removal (if safe to do so) and keep it wet until packaged for transport. • Bonded asbestos must be taken to the landfill in manageable-sized packages in thick (200-micron) plastic. • All asbestos disposed at a landfill is covered with a minimum of 150mm waste fill at the close of operations. • Commercial loads of all asbestos (including bonded) need to be tracked to the landfill by a licensed transporter. • The domestic transport of asbestos does not require a licence. Contractors removing more than 10 m2 of non-friable asbestos require a relevant licence.	A $0 levy applies for the disposal of packaged asbestos waste only. Asbestos soils must pay the solid waste levy ($143 per tonne).
NT EPA	*Waste Management and Pollution Control Act 1998*	NT does not have a formalised position in their regulatory framework of a threshold level for asbestos in recycled wastes, therefore it is considered here that the threshold is zero (i.e., no visual identification of	• No requirement for asbestos transport tracking within the state • All asbestos waste must be bagged or wrapped to prevent the release of airborne fibres using heavy-duty 200 µm (0.2 mm minimum thickness) polythene bags or sheets. • Bagged or wrapped asbestos waste must be secured with adhesive cloth tape and labelled 'Asbestos Waste, do not open or damage bags, do not inhale dust.'	The NT Government does not currently have a waste levy.

States and Territories	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
		ACM and below laboratory PQL).	• Transporters of asbestos that is removed on a commercial basis (i.e. service fee) must hold an EPL. • Interstate asbestos waste must be tracked through the NT Online Waste Tracking Portal. • Asbestos should be disposed of promptly to a landfill licensed to receive it, however, given the remoteness of communities in NT other options such as temporary storage (less than 12 months) and on-site containment cells may also be permitted. • Landfills and temporary storage facilities designed to accept asbestos must hold an EPL. • Landfills licensed to accept asbestos must have a designated area for the acceptance of only asbestos contaminated material. • Landfills must cover each load of bonded asbestos immediately with at least one metre of a suitable inert material and orange marker mesh to indicate that asbestos is buried below. • Temporary storage facilities must have a designated secure container for the acceptance of only asbestos-contaminated material. • There is a general environmental duty that all persons must take reasonable and practicable measures to reduce pollution.	

States and Territories	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste

QLD DESI	Environmental Protection Act 1994 and Waste Reduction and Recycling Act 2011, QLD Government (2019), Section 57	QLD has not published their position on recovered fines and there are no explicit provisions in their regulatory framework that allow or prevent the reuse of asbestos waste.	• Require asbestos to be removed before demolition commences so far as reasonably practicable.
			• An environmental authority is required for transporting 175kg or more of asbestos waste.
			• Waste tracking documentation is required by all commercial operators transporting any quantity of asbestos waste, and by individuals if the waste exceeds 250kg.
			• Asbestos waste must be appropriately packaged:
			  ○ Double-wrapped in 0.2mm thick plastic, sealed with tape and labelled.
			  ○ Placed into a plastic-lined industrial skip provided by a waste contractor with an environmental authority to transport regulated waste.
			• Asbestos waste must be disposed of at a local government-approved site.
				Most lawfully managed and transported asbestos wastes are exempt from the QLD landfill levy, as is illegally dumped waste collected by public land managers.

VIC EPA	Regulation 206(b) and 217 of VIC OH&S (2017)	The VIC EPA allows the reuse of recycled C&D material. The threshold criteria for	• Requires waste inspection at the gate, with a Material Risk Classification Matrix used to classify the materials.	The levy rate that applies to asbestos soils and separated and wrapped asbestos wastes is lower than the rate for other

States and Territories	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
	WorkSafe Victoria (2023). WorkSafe Victoria (2007) Publication 1828.2 – Waste disposal categories – characteristics and thresholds	recycled waste for ACMs is less than 0.001%. Guidance on recycling C&D material outlines an auditable procedure to verify the removal of ACM prior to recycling. Recycled C&D material must meet test requirements to contain less than 0.001% as per the Asbestos Regulations before reuse.	• 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. • Regulations around asbestos handling do not apply to C&D waste if it is verified that ACM has been removed and is less than 0.001%. • Transportation of asbestos from industrial activities requires transport certificates and tracking. • Transportation of domestic-sourced asbestos, unless it is removed by a licensed asbestos removalist, does not require certificates and tracking. • Packaged asbestos waste is classified as a reportable priority waste (the most hazardous subset of industrial waste), meaning that the following 'general duties' apply to people with management or control of the waste: ○ Report to the EPA each time the waste is exchanged via the EPA's electronic waste tracker tool. ○ Transport only in a permitted vehicle. ○ Take reasonable steps to contain the waste to prevent escape or contamination. ○ Isolate the waste to enable resource recovery to occur.	manufacturing, industrial and contaminated wastes. The levy rate for these other wastes ranges from $106 per tonne to $258 per tonne, while the levy rate for packaged asbestos and asbestos soils is $31 per tonne.

States and Territories	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
			○ Provide information regarding the waste to the next person in the supply chain so that they can meet their duties. ○ Make sure that the place receiving the waste is a lawful place. ○ No disposal of the waste at a lawful place without consent from the manager of the premises. ○ Minimise the risk of harm to human health or the environment as far as reasonably practical.	
ACT EPA	Section 472 and Section 484 of the Work Health and Safety Regulation 2011.	ACT EPA does not have a formalised position in their regulatory framework of a threshold level for asbestos in recycled wastes, therefore it is considered here that the threshold is zero (i.e., no visual identification of ACM and below laboratory PQL).	• No tracking requirement for asbestos transport. • Scheme allowing for free disposal of bonded asbestos waste. • Driver of vehicles transporting asbestos waste is not required to hold a dangerous goods license, but they must: ○ be trained in the risks associated with asbestos exposure. ○ have been instructed in a safe work method to carry out the work. ○ inspect the vehicle after transport and report the presence of any suspect material or potential release of respirable asbestos fibres to Access Canberra.	The ACT Government does not currently have a waste levy.

States and Territories	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
Tasmania EPA	TAS EPA (2020), WorkSafe Tasmania (2018). Section 274	TAS EPA does not have a formalised position in their regulatory framework of a threshold level for asbestos in recycled wastes, therefore it is considered here that the threshold is zero (i.e., no visual identification of ACM and below laboratory PQL).	• No tracking requirement for asbestos transport. • Asbestos must be double-wrapped. • Asbestos is classified as a "controlled waste" which means: ○ It can only be transported by a person who is a Registered Controlled Waste Transporter. • The permits for Registered Controlled Waste Transporters have conditions for asbestos management on them.	A state-wide landfill levy is due to start on 1 July 2022. Asbestos will be exempt from the landfill levy.

APPENDIX B.

Summary of International Standards and Guidelines for Asbestos in Recycled Waste

Appendix B provides a summary of international standards and guidelines for managing asbestos in recycled waste across several countries, outlining the regulatory frameworks, threshold levels, and specific management requirements for asbestos handling, transport, and disposal. This summary highlights the different approaches and standards adopted by countries reflecting the diverse strategies for safely managing asbestos waste. Each country has its own regulations, such as licensing requirements for asbestos removal workers, transportation protocols, and landfill disposal criteria.

Nation	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
New Zealand	The Health and Safety at Work (Asbestos) Regulations 2016	New Zealand does not have a formalised position in their regulatory framework of a threshold level for asbestos in recycled wastes, therefore it is considered here that the threshold is zero (i.e., no visual identification of ACM and below laboratory PQL).	**Licensing:** Workers handling asbestos must hold the appropriate class of asbestos removal license (Class A or Class B). Class A covers all types of asbestos, including friable and non-friable. Class B covers non-friable asbestos only. **Transportation:** Maintain accurate and detailed records of asbestos waste from the point of generation to final disposal. Records should include the type, quantity, and source of the asbestos waste, as well as the details of transport and disposal. These records must be retained for at least five years and should be made available for inspection by regulatory authorities, such as WorkSafe New Zealand. **Disposal Requirement:** Notify WorkSafe New Zealand before commencing certain types of asbestos removal work. Report any incidents or accidents involving asbestos to WorkSafe New Zealand. Asbestos waste must be disposed of in EPA-approved landfills that are permitted to accept asbestos-containing materials	The levy rate is subject to periodic review and may vary. The waste levy applies for construction and demolition fills, which includes asbestos waste.
United State	US EPA Asbestos Regulations	Many states in the USA have adopted a threshold level of	**Licensing:** Workers handling asbestos must be trained and certified according to OSHA standards.	The US does not have a uniform federal landfill levy for asbestos. However,

Nation	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
	Occupational Safety and Health Administration (OSHA) Asbestos Standards Department of Transportation (DOT) regulations for Hazardous Materials Regulations (HMR)	1% w/w asbestos for defining asbestos-containing materials.	**Transportation:** Asbestos-containing waste must be sealed in leak-tight containers with appropriate warning labels. Containers should be labelled with the OSHA or EPA-approved asbestos warning labels. Some companies and states may use electronic tracking systems. Traditional paper-based manifests are still widely used and accepted Keep records of asbestos waste disposal, including quantities, dates, and disposal site information. These records must be maintained for a specified period, usually a minimum of three years. **Disposal Requirement:** Asbestos waste must be disposed of in EPA-approved landfills that are permitted to accept asbestos-containing materials.	disposal fees for asbestos waste are typically set by individual landfills and may vary based on local regulations and landfill policies.
United Kingdom	Control of Asbestos Regulations 2012	Therefore, even if a waste material contains more than 0.1% w/w of asbestos, it may not be classified as hazardous waste if it does not exhibit the hazardous	**Licensing:** Contractors undertaking asbestos removal work must hold an appropriate license issued by the Health and Safety Executive (HSE). **Transportation:** Maintain detailed records of asbestos waste from the point of generation to final disposal. Use a Hazardous Waste Consignment Note to track the movement of asbestos waste. Both electronic and paper-based systems are used for waste tracking. The UK encourages electronic tracking through	Asbestos waste is typically classified as hazardous and is subject to the standard rate of landfill tax.

Nation	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
		properties of asbestos.	systems like the Environment Agency's Electronic Duty of Care (EDoC) system which must be kept for at least three years. The note includes details of the waste producer, carrier, and disposal site, along with the quantity and type of waste. **Disposal Requirement:** Asbestos waste must be disposed of in EPA-approved landfills that are permitted to accept asbestos-containing materials. Follow the landfill's specific procedures for asbestos waste disposal.	
Germany*	Federal Institute for Occupational Safety and Health (BAuA): Asbestos Information Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection	New LAGA M 23 includes an assessment value of 0.010 % which links recyclability to a concrete value with the help of a clear definition of "asbestos-free".	**Licensing:** Workers involved in asbestos removal must be trained and certified. **Transportation:** Follow the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) for the transport of hazardous materials. Maintain accurate records of asbestos waste from the point of origin to disposal. Both electronic and paper-based tracking systems are used, (Begleitscheinverfahren) to track hazardous waste, including asbestos. Records must be kept for a minimum of three years. This includes details of the type, quantity, and handling of the waste. Asbestos waste must be disposed of in authorised hazardous waste landfills. **Disposal Requirement:**	The specific rates for landfill taxes can vary for hazardous waste like asbestos.

Nation	Regulatory Framework	The threshold level of asbestos permitted in recovered waste products	Management requirements: Asbestos handling, transport and disposal requirements	Landfill levy settings for asbestos waste
	(BMUV): Hazardous Waste		The specific levy rates can vary by region in Germany. Each state (Bundesland) may have different rates and regulations governing waste disposal. Follow specific landfill procedures for asbestos waste, ensuring it is securely contained and covered to prevent fibre release.	
Canada	Environment and Climate Change Canada (ECCC): Asbestos Management Federal Environmental Protection Act, 1999, and various provincial regulations	ECCC and Health Canada consider trace amounts of asbestos to be below 0.1% when measured using a suitable standard analytical method with PLM.	**Licensing:** In Canada, the handling, transport, and disposal of asbestos are regulated at both the federal and provincial levels. Workers involved in asbestos removal must be trained and certified according to provincial regulations. **Transportation:** Follow the Transportation of Dangerous Goods (TDG) regulations for labelling and packaging. Both electronic and paper-based tracking systems are used to maintain records of the type, quantity, and handling of asbestos waste, as required by provincial regulations. Records must be retained for a specified period, often at least three years. **Disposal Requirement:** Asbestos waste must be disposed of at licensed hazardous waste disposal facilities.	In Canada, landfill levies for asbestos waste vary by province. Each province has its own regulations and fee structures for hazardous waste disposal.

Appendix C.

Derivation of Thresholds Concentration for Asbestos in Soil

Regulatory thresholds for asbestos in soil are based on extensive health risk assessments that evaluate the potential for asbestos fibres to become airborne and inhaled by humans. This involves understanding various factors such as soil characteristics (moisture content of the soil, soil texture), the type of asbestos present (fibre type), and environmental conditions. However, concentration in the soil does not consider the potential for the release of airborne fibres, and there is a poor correlation between the two (WA DOH, 2021; Addison J, 1988).

Regulatory agencies often start with established airborne exposure limits for asbestos, which are based on extensive health studies and risk assessments and consider the proportion of soil concentration to result in the airborne exposure limits to develop the guideline for soil threshold.

The key steps in the derivation of soil concentration thresholds from airborne limits include:

- Emission Factor Calculation: Calculate emission factors that relate the concentration of asbestos in the soil to the concentration of asbestos in the air. This is typically done using empirical data or models that simulate soil disturbance activities.

    - Apply human health criteria based on the estimated fibre concentrations at different risk levels for mesothelioma and lung cancer for the general population for lifelong exposure to asbestos in air. (This results in negligible risk (NR) level of 1,000 f/m3 and maximum permissible risk level of 100,000 f/m3.)
    - Determine respirable asbestos generated from a certain concentration of asbestos in soil based on simulation and laboratory experiments. (From this work it was shown that asbestos concentration around 100 - 1,000 mg/kg generates respirable asbestos fibre concentration below the NR level for both friable and non-friable.)

Once the soil concentrations corresponding to safe airborne levels are determined, regulatory agencies set these values as soil thresholds depending on the local environmental conditions. For example, WA DOH (2021) presents the development of screening criteria for all asbestos types as a concentration of 100 mg/kg or 0.01% w/w asbestos in dry soil (w/w homogeneous sample). WA DOH applied this criterion to the less hazardous bonded ACM, depending on on-site use.

A lower criterion has been applied to both FA and AF as activity and disturbance may result in the suspension of smaller particles from FA and AF in air. WA DOH adopted the 0.001% w/w soil criterion based on international research by Swartjes and Tromp in the Netherlands (Swartjes, 2008), reduced by a factor of 10 to account for greater dryness and dust-generating potential of local soils and the fact that current exposure standards treat the mineralogical forms of asbestos as equivalent.

- Health Risk Models: Apply health risk models that consider the duration and frequency of exposure to airborne asbestos originating from soil. These models estimate the cancer risk or other health impacts based on the inhalation of

asbestos fibres. In Australia, the lifetime cancer risks of 1 x 10^{-05} are acceptable for environmental contaminant hazards (enHealth, 2005).

Studies on asbestos exposure, toxicity, and epidemiology help define safe levels of asbestos in the environment. This review will not address the toxicity of asbestos but explore how the threshold levels are derived from airborne concentration and the soil concentration level.

- Reverse Calculation: Using the airborne exposure limits, calculate the corresponding soil concentrations that would not lead to exceedance of these airborne limits under typical exposure scenarios.

A tiered approach for the assessment of human health risks of soil contamination with asbestos has been developed (Swartjes, 2008). A site-specific assessment may adjust the thresholds based on local conditions, types of asbestos present, and specific land use.

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