28 February 2023

To: The Department of Climate Change, Energy, the Environment and Water

Re: Australian Organics Recycling Association (AORA) - PFAS NEMP 3.0 Consultation Draft Response

The Australian Organics Recycling Association (AORA) is the peak industry body and national voice for businesses across the organics recycling supply chain. AORA envisions a future where recycling and reuse of organic materials within a circular economy is widely understood and supported by all Australians. AORA works to facilitate an operating environment which maximises the recycling and reuse of organic materials, and promotes the benefits of compost, soil conditioners and mulches across the Australian community and business.

AORA requested and received a proposal from ADE Consulting Group (Dr Matthew Askeland) to develop a response on behalf of the Australian organics recycling industry to the PFAS NEMP 3.0 Consultation Draft. Our response represents the collective view of many of our organics processing members nationally. The level of interest and concern related to PFAS, and it's proposed regulation has been indicated by the high levels of interest and collaboration we have received in developing this response. PFAS is a significant issue of concern for the Australian organics recycling industry, with uncertainty surrounding how the PFAS NEMP 3.0 will be adopted by state and territory jurisdictions generating significant anxiety and stifling growth in the industry now.

The Executive Summary in our attached response clearly articulates the AORA and the wider Australian organics recycling industry's concerns. The risk of not managing the regulatory approach to PFAS sensibly, proportionally, and appropriately is significant to the Australian organics recycling industry, nationally. This issue constitutes a significant risk to our industry's long-term sustainability and viability and as such, poses a real threat to the achievement of circular economy objectives and to the many commercial organics recycling enterprises leading the way to ensure a better future for all of us.

It cannot be reiterated enough in the context of this PFAS NEMP 3.0 Consultation Draft response that the Australian organics recycling industry does not use or create PFAS but is rather an inheritor of the contamination. To unduly focus on the end point of the problem and not the source will inevitably lead to the problem continuing for some (extended) period of time to come and achieves nothing meaningful in terms of timely and effective management and control.

On behalf of the Australian organics recycling industry, we thank you for your consideration of our response to the PFAS NEMP 3.0 Consultation Draft.

John McKew
National Executive Officer
Australian Organics Recycling Association

22.1147.00 AORA - PFAS NEMP 3.0 Response Consultation Draft Response

Prepared for: **Australian Organics Recycling Association (AORA)**

A602022.1147.00 | v0 Final | 27.02.2023

T. 1300 796 922| E. info@ade.group

John McKew
National Executive Officer
Australian Organics Recycling Association
PO Box 585, Hove SA 5048.
ABN: 17 158 519736
Phone: 0434 711 077
Email: john@aora.org.au

ADE Consulting Group
14 617 358 808 (NSW)
93 617 743 012 (VIC)
45 629 475 743 (QLD)
52 093 452 950 (A.D. Envirotech)

Head Office
6/7 Millennium Court
Silverwater NSW 2128

Melbourne Office
4/95 Salmon Street
Port Melbourne VIC 3207

Email: info@ade.group
Website: www.ade.group
Telephone: 1300 796 922

PFAS NEMP 3.0 CONSULTATION DRAFT RESPONSE

Dear John,

ADE Consulting Group (VIC) Pty Ltd (ADE) is proud to support the Australian Organics Recycling Association (AORA) in the coordination and collation of its review and response to the Heads of EPAs of Australia and New Zealand (HEPA) draft per- and poly-fluoroalkyl substances (PFAS) National Environmental Management Plan (PFAS NEMP) version 3.0 for public consultation (Hereafter "Draft PFAS NEMP 3.0"). ADE is pleased to provide AORA (the client) with the below outcome of the review and engagement with AORA members regarding the content of the Draft PFAS NEMP 3.0. The final version of this document will be provided in response to the Draft PFAS NEMP 3.0, on AORA's behalf, once approved by AORA.

ADE and AORA recognise and celebrate the efforts of the National Chemicals Working Group of the Heads of EPAs in keeping the NEMP up to date, and would like to thank all involved for the opportunity to provide a response. We look forward to further engaging with relevant parties toward supporting the update of the document in a manner that is meaningful, and supportive of the best interests of the Australian environment, people, and economy.

If you would like to engage in further discussion with ADE or AORA please do not hesitate to contact ADE ECTRR Business Unit Manager, Matthew Askeland via email matthew.askeland@ade.group.

Kind Regards

Dr. Matthew Askeland
PhD(EnvEng), BAppSc(EnvSc)(Hons)
Business Unit Manager - ECTRR
Emerging **C**ontaminants**, T**reatment**, R**emediation & **R**esearch

27-02-2023

EXECUTIVE SUMMARY

ADE has, on behalf of AORA, reviewed the Draft PFAS NEMP 3.0 and the Supporting Document (biosolids) to enable the preparation of this response to be provided to the Department of Climate Change, Energy, the Environment and Water for consideration in the final draft of the PFAS NEMP 3.0 by the National Chemicals Working Group of the Heads of EPAs. The response aims to provide the position of AORA members on the content of the Draft PFAS NEMP 3.0 as well as to provide the context surrounding the impacts of the current version of the document alongside some recommendations for the Draft PFAS NEMP 3.0 in addition to the PFAS NEMP more generally.

Contextually, this response document outlines that the recycled organics industry:

- Includes processors and supporting businesses that collect and/or process organic waste streams using composting techniques to produce value added recycled organics products, and provides an important amenity in the waste removal sector as well as producing a product with significant benefit to the agricultural, horticultural and soil remediation sectors.

- Is a lead industry in achieving resource circularity through its role in diverting organic waste away from landfill and has been demonstrated to play a pivotal role in reducing national carbon emissions.

- Contributes significantly to the Australian economy, with substantial capacity for growth, potentially compounding the current benefits provided by the industry.

Further, the document contextualises the current state of knowledge regarding PFAS in the recycled organics industry, noting that:

- PFAS are not used in the organics recycling industry, but are inputs from other industries or practices, including diffuse consumer inputs. However, PFAS concentrations in recycled organics are low relative to levels in some consumer products, packaging, non-recycled waste streams (landfilled) and those found at contaminated sites. As such, management requirements for PFAS in recycled organics should consider the relative contribution of PFAS mass inputs to humans or the environment via recycled organics compared with exposure from other PFAS mass inputs.

- Presently, there are few Australia data available regarding the concentrations of PFAS in recycled organics feedstocks or recycled organics products. Globally the state of knowledge is still evolving, but literature strongly suggests that PFCAs and precursors (used here as "PFAS that transform into terminal PFAA") represent the greatest portion of PFAS mass in recycled organics products and their proportions are a factor of the type of feedstocks accepted, blending proportions, and the composting process.

- Based on a 2023 AORA survey, it is unclear to many recycled organics processors how they can achieve environmental compliance for PFAS. Each processor has differences in scale, type of feedstocks processed, and end use of recycled organics products, the diversity of which significantly varies the potential impact of PFAS management requirements on different processing businesses.

Considering the role of the recycled organics industry, its benefits nationally, and the current state of knowledge, the review of the Draft PFAS NEMP 3.0, the supporting document (biosolids), and stakeholder engagement delivered the following outcomes:

- The key objectives for AORA's review of the Draft PFAS NEMP 3.0 and provision of a response were to address or clarify issues related to the recycled organics industry and PFAS compliance, problem definition, the suitable application of existing data towards derivation of guidelines, establishing principals of net environmental benefit, and safeguarding the industries short- and long- term viability.

- Review outcomes largely covered four critical themes, for which the impacts and recommendations are provided in **Section 5**. Broadly the themes included:

  - **Source control –** source control should be the primary PFAS mitigation mechanism and will ultimately assist in reducing the burden of PFAS management at "end of pipe" operations.

  - **Consistency** – there is a need for nationally consistent guidance on analytical methods, PFAS suite and LORs, measures (i.e., oxidisable precursors), data and uncertainty representation, and quality control methodologies for PFAS in recycled organics feedstocks, products and biosolids.

  - **End use risk-based assessment framework –** there is a need for the PFAS NEMP 3.0 to provide a more detailed risk-based and end-use focused framework which can be used to derive guideline values to assess the suitability of recycled organics products for land application.

  - **Risk-proportionate guidelines and net environmental benefit** - conservative guidelines that are not proportionate to risk will render products and feedstocks non-compliant for PFAS. In turn this will threaten business models and direct large volumes of organics to landfill, passing PFAS burdens on to other "end of pipe" operators and back into the recycled organics circular economy. The diversion of recyclable organics to landfill due to PFAS will deliver a net environmental harm considering the loss of the soil amendment benefit, the increased carbon emissions and increased management requirements.

It's crucial that the PFAS NEMP 3.0 considers the inputs of this response to drive the adoption of sensible but suitably protective guidance across Australia that fosters the continued growth of the recycled organics industry. Based on the outcomes of the draft PFAS NEMP 3.0 review, literature review and AORA survey, it is clear that careful consideration is required to address issues related to PFAS in the organics recycling industry while simultaneously preserving an industry that provides significant economic benefits, carbon emission reduction, a landfill diversion pathway toward circularity, a critical waste amenity, and agronomic or environmental benefit by improving Australian soils.

Considering the frequency at which the PFAS NEMP is likely to be updated and then adopted by other jurisdictions, it is important that guidance in the PFAS NEMP 3.0 is as complete, considered, and fit for purpose as possible in the current version. Unclear guidance that is disproportionate and overly conservative will actively disrupt the organic recycling industry, prevent growth, reduce public amenity, but more so, result in the diversion of large volumes of organic waste to landfill. While managing PFAS impacts on the environment is important, the net impact on carbon emissions needs to be accounted for alongside the net environmental impact generated by PFAS.

Leading on from the above, national PFAS practices need to be considered holistically, and not be the burden of "end of pipe" resource recovery operations but instead focus strongly on significantly reducing the mass flow of PFAS into the environment to begin with through the implementation of restrictions of PFAS use in consumer products, industrial process and other applications were not necessary and critical to the function of the Australian economy. This "turning off the tap" will have meaningful and sustained downstream benefits, and reduce the intensity of ongoing PFAS management in the future.

Attention can simultaneously be paid to end of pipe solutions, noting that PFAS contamination in the recycled organics industry is based on inputs contaminated by other sources. To better manage PFAS within the recycled organics industry the final version of PFAS NEMP 3.0 should:

- Encourage research to address data gaps and both characterise and quantify risk to ensure impacts of the required mitigation measures are suitably proportionate to risks.
- Provide regulators and industry users with a clear set of objectives, including testing requirements and target PFAS species to disambiguate and reduce uncertainty around compliance.
- Support the notion that disproportional or over-conservative regulation is likely to drive significantly undesirable outcomes (with minimal risk reduction) such as increasing carbon emissions, or transferring PFAS management obligations onto other industries.

Contents

1. INTRODUCTION AND BACKGROUND

Circular economies and resource recovery operations, like that conducted by AORA members, form a critical part of achieving a sustainable future which includes the generation of key jobs and drivers for economic growth. The implementation of Per-and poly-fluoroalkyl substances (PFAS) guidance and regulations developed without adequate consultation of industry would have significant impacts on AORA members. As such AORA strongly embraces engagement with regulatory bodies to develop a beneficial relationship that can drive outcomes that are sufficiently protective of human health and the environment, but are also adequately practical and commercially feasible.

This response to the Draft PFAS NEMP 3.0 aims to position AORA to work with regulators to achieve the best results for the environment and the industry as well as provide a vehicle to drive collaborations between AORA and Government Authorities to achieve balanced, practical, and sustainable outcomes. Collectively, AORA's response to the DRAFT PFAS NEMP 3.0 and its PFAS Position Statement are intended to be powerful tools to solve PFAS problems and drive action in support of AORA's current activities and into the future as the understanding around PFAS management grows globally.

1.1 PROJECT OBJECTIVES

Aim: ADE aims to support AORA by coordinating a response to the Draft PFAS NEMP 3.0 that represents the concerns and requests for clarification of AORA members as related to PFAS management within the organics recycling industry. Further the response seeks to allow Draft PFAS NEMP 3.0 authors to better understand the complexities and challenges faced by AORA members if adequate consideration is not given to the recycled organics industry in the final version of the PFAS NEMP 3.0.

To achieve the above aim, ADE sets the following objectives:

- Review PFAS NEMP 3.0 and provide comments, generating a list of key impacts for AORA members.
- Meet with key stakeholders to quantify impacts (cost, operations, alternatives, carbon, fate).
- Update list of key impacts.
- Prepare a list of recommendations to be included in response to PFAS NEMP 3.0.
- Meet with key AORA stakeholders to review and close out the draft as a roundtable.
- Make final updates to respond to Draft PFAS NEMP 3.0 and submit via the portal.

1.2 PROJECT APPROACH

Detailed in the below sections is ADE's approach to delivering the project objectives broadly outlined in **Section 1.1**. **Table 1** provides a detailed overview of project phases and subphase activities required to achieve the objectives.

The method employed for the drafting and submission of a response to Draft PFAS NEMP 3.0 largely pertains to a detailed technical review of the document followed by further engagement with AORA members on findings to deliver a response that covers concerns most pertinent to AORA members. The response will also seek clarity on items that are unclear to AORA members and may impact on their business. Lastly the work will put forward a set of key recommendations and associated justifications for consideration in the finalised PFAS NEMP 3.0.

Table 1. Project Scope of Work

Phase	Activity	Description
1.1	**Client engagement and document review/reference**	Conduct a detailed review of original position statement and prior ADE response to assess which aspects need to be considered in the Draft PFAS NEMP 3.0 review. Use inputs from the PFAS NEMP review as well as further stakeholder engagement to derive a set of clear "target outcomes" for input into the position statement. Desired outcomes need to be outcomes that are tangible and realistic. The document will be a driver to attaining these outcomes.
1.2	**Define Potential Impacts and obtain feedback**	Collection of key statements in the NEMP 3.0 which are likely to impact AORA members, including uncertainties around adoption of the PFAS NEMP by jurisdictions.
1.3	**Refine Impact List**	Prepare a final list of key impacts as based on reviewer findings and AORA input.
1.4	**Develop case studies**	Develop 2-3 case studies to support top 3 concerns or other items which AORA wants further considered (can be anonymised). **Note – NOT ISSUED**
1.5	**Conduct AORA roundtable and prepare recommendations**	Orchestrate detailed discussion with AORA members to align impact statements and recommendations to ensure these are members' best interests. Preparation of a detailed list of recommendations including changes in wording, inclusions, exclusions, and suggested items for consideration (these will be in many cases supported by impact statements and/or case studies).
1.6	**Document final update and submission**	Undertake final update including roundtable information. Submit the document via the portal on behalf of AORA.

1.2.1 Other proposed works and integration

ADE proposed an approach which aimed to pair reviewing the Draft PFAS NEMP 3.0 with updating the AORA Position Statement on PFAS. This centres on aligning AORA members' desired outcomes, obtained through stakeholder engagement, with the outcomes of the assessment of the Draft PFAS NEMP 3.0 to prepare a detailed set of flexible position statements that reduce uncertainty as to how PFAS should be managed, both under the current state of knowledge, and as research gaps are subsequently addressed. **Figure 1** demonstrates the proposed workflow for both bodies of work, associated outputs and how the works are integrated. The current work package only applies to the review of the Draft PFAS NEMP 3.0, as detailed in project deliverables (**Section 1.2.2**). the work presented in this report focuses only on the scope detailed in Proposal 22.1147.00 PFAS NEMP 3.0 Response.

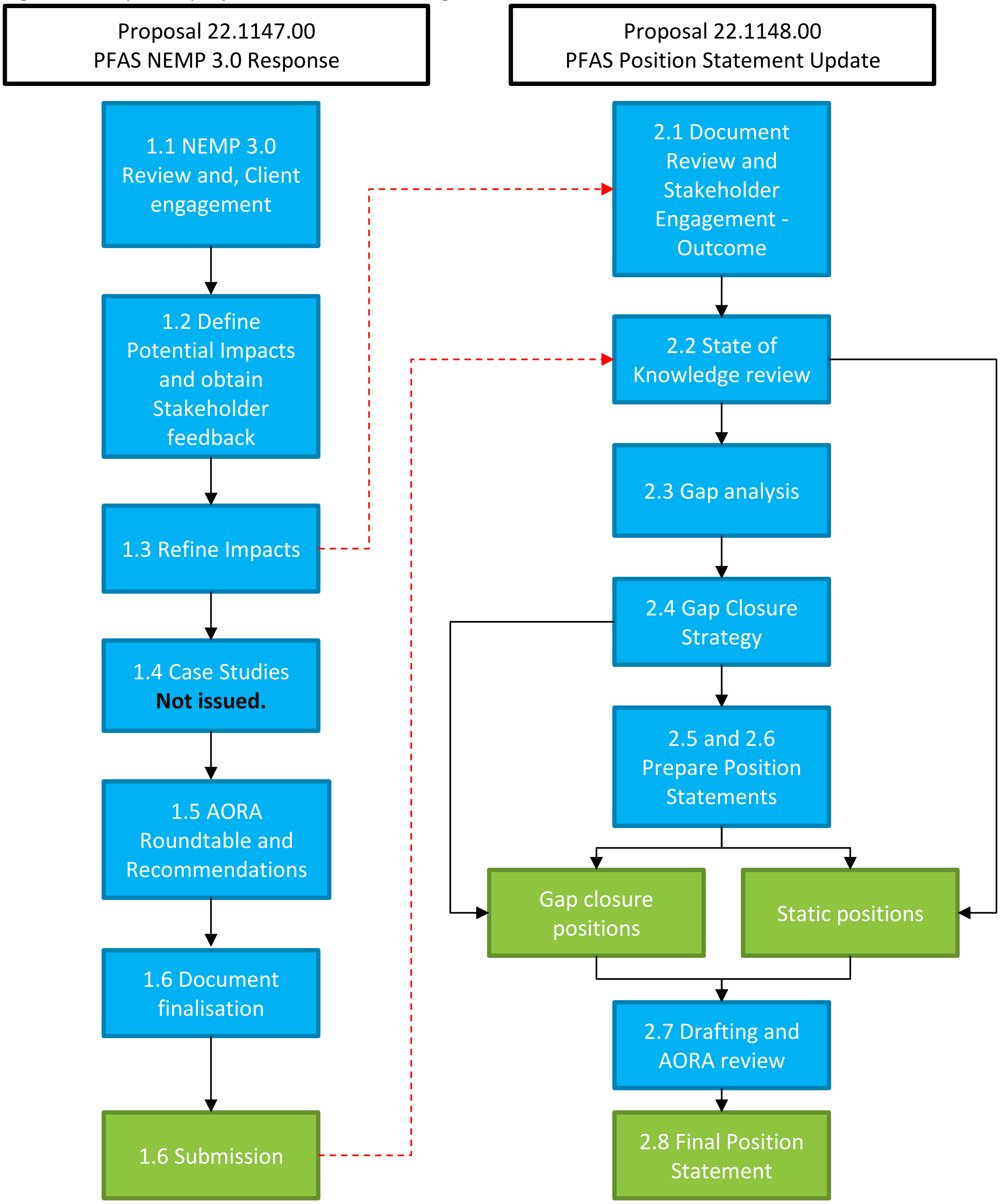
1.2.2 Project Deliverables

Delivery of the project will be staged based on the phases **listed** in **Table 2.** below:

Table 2. Scheduled Deliverables

Phase	Works	Deliverables
Aim 1 (A1)	Preparation of Response to Draft PFAS NEMP 3.0	▪ Draft response for AORA review ▪ AORA roundtable outcomes ▪ Final response and submission

Figure 1. Proposed project workflow and integration.



2. THE PFAS NEMP 3.0

2.1 FUNCTION OF THE PFAS NEMP

This section on the PFAS NEMP has been included for context. The PFAS NEMP represents Australia's acknowledgment at the Federal and State/Territory Government level that the environmental management of the PFAS contaminant group is a priority. This has come about due to the widespread presence and persistence of PFAS in the environment and its chemical properties which result in its mobility and uptake into the food web. Considering this, and the uncertainties associated with the risk presented by many PFAS, species the application of the precautionary approach to protect the environment and human health is applied throughout the PFAS NEMP. The following principles of sound environmental regulation guide the current and future development and implementation of the PFAS NEMP:

- A focus on protection of the environment, including flora and fauna, ecological communities, ecosystems and, as a precaution, protection of human health.
- Consideration of the principles established by the Intergovernmental Agreement on the Environment, which is a Schedule to the National Environment Protection Council Act 1994, in all decision-making.

The PFAS NEMP is designed to provide nationally agreed guidance on the management of PFAS contamination in the environment. This includes key information and guidance surrounding the likely sources, transport pathways and mechanisms to prevent the spread of PFAS contamination. The PFAS NEMP provides central point to support collaboration on PFAS management across Australia between the Commonwealth, state and territory and local governments. In addition, the PFAS NEMP is an Appendix to the Intergovernmental Agreement on a National Framework Responding to PFAS Contamination.

As a result of PFAS unique properties and subsequent use across a broad range of industries over the past decade, PFAS are known to be widespread throughout the Australian environment. Consequently, PFAS are found in Australia in humans, animals, and the environment. Considering the wide scope of issues associated with PFAS contamination, including the management of PFAS contaminated environments, materials, and wastes. PFAS represents a significant challenge for environmental regulators. The PFAS NEMP recognises the need for sound regulation of PFAS across jurisdictions that can adapt to local circumstances and priorities, as such the Draft PFAS NEMP 3.0 recognises:

- The generalised need for consistent national guidance about the environmental management of per- and poly-fluoroalkyl substances and preventing and/or managing PFAS contamination.
- PFAS as a contaminant group encompass complex mixtures of many different intentionally produced and unintentionally produced/generated PFAS compounds.
- Perfluorooctane sulfonate (PFOS), Perfluorooctanoic acid (PFOA), and Perfluorohexane sulfonate (PFHxS), are the most widely studied, and therefore the primary PFAS considered and discussed in the PFAS NEMP.
- PFOS, PFOA, and PFHxS are usually primary indicators of the presence of a broad range of PFAS compounds, but are likely to be present in greater proportions in situations where historic contamination has not significantly degraded and where modern replacement PFAS are predominant.
- Definitions of what constitutes PFAS, their characteristics, resulting behaviour, associated risks, and available management techniques need to reflect the evolving state of knowledge.
- The need for regular review of the guidance provided for PFAS.

- That secondary sources for PFAS contamination pose a significant challenge and may include facilities that receive waste and wastewater containing PFAS from a range of diffuse sources.
- The importance of PFAS contamination management guidance supporting the beneficial reuse of PFAS contaminated materials and wastes while maintaining environmental values and future land use options.
- The importance of ongoing research to better understand PFAS environmental and human health effects.
- That managing PFAS should be integrated into the management of contaminants of concern more broadly.

2.2 UPDATES TO THE PFAS NEMP

Commensurate with the above aims, the PFAS NEMP is an evolving document. At the request of Australian environmental ministers, the first version of the NEMP (NEMP 1.0) was published in February 2018. It was developed by the Heads of EPAs Australia and New Zealand (HEPA) and reflected the current state of knowledge at the time of writing. New scientific evidence drove the need for updated guidance, resulting in NEMP 2.0 in May of 2020, which contained updated guidance on guideline values, soil reuse, wastewater management and on-site containment.

HEPA released the draft per- and poly-fluoroalkyl substances National Environmental Management Plan version 3.0 for public consultation in late 2022. The Draft PFAS NEMP 3.0 builds on version 2.0 published in 2020, with the inclusion of new and additional guidance and standards on priority focusing on the following areas:

- The PFAS family – information surrounding international approaches to grouping of PFAS.
- Guidance on ambient monitoring data collection and land use classifications to enable comparability.
- Risk-based criteria and guidance for beneficial reuse of biosolids.
- Guidance and standards around PFAS behaviour in soil, leaching, and ecological and human health guidance.
- New guidance on the management of risks associated with PFAS in resource recovery products.
- Site-specific guidance related to:
  - The principles and approaches to remediation and management.
  - The management of construction water.
  - Guidance on estuarine, coastal, and marine sediments.

2.3 ADOPTION OF THE PFAS NEMP

The NEMP recognises the need for sound regulation of PFAS by each jurisdiction in a way that can adapt to local circumstances, but also aligns with Australia's future participation in the Stockholm Convention, which would mean Australia implements international standards for the management for PFOS, PFOA and PFHxS. It also means that Australia accepts and implements measures that are appropriate for these contaminants which meet the screening criteria for persistence, bioaccumulation, potential for long range environmental transport, and evidence for adverse impact as concluded by the Persistent Organic Pollutants Review Committee, noting that additional PFAS may be nominated in the future.

Environmental legislation in many jurisdictions includes obligations and duties to understand and prevent or minimise risks of, and report occurrences of, environmental harm, nuisances, waste mismanagement and contamination. The Draft PFAS NEMP 3.0 does not detail the application of this type of guidance, which should therefore be undertaken by each jurisdiction's relevant regulatory authority. This means the adoption and implementation of the Draft PFAS NEMP 3.0 will be undertaken individually by each jurisdiction within its own environmental framework.

Based on this jurisdictional approach the environmental regulator should be involved from the outset in planning and delivering communication and engagement activities, as well as providing an accessible source of information for communities and industry regarding the adoption of the PFAS NEMP 3.0 once complete.

2.4 FEEDBACK ON THE PFAS NEMP 3.0 CONSULTATION DRAFT

Feedback related to the content of the Draft PFAS NEMP 3.0 was opened in September 2022. This included the release of the Draft PFAS NEMP 3.0, supporting documents (supplementary documents) as well as a series of National Consultation workshops which were held in November 2022. Responses on the consultation draft close 28th February 2023. This document constitutes the response to the Draft PFAS NEMP 3.0 on behalf of AORA.

3. The Recycled Organics Industry

Section headlines:

- The recycled organics industry includes processors and supporting businesses that collect and/or process organic waste streams using composting techniques to produce value added recycled organics products.

- The recycled organics industry provides an important amenity in the waste management sector and produces a product with significant benefit to the agricultural, horticultural and soil remediation sectors.

- The recycled organics industry is a lead industry in achieving resource circularity by diverting waste away from landfill and has been demonstrated to play a pivotal role in reducing national carbon emissions.

- The recycled organics industry is a significant contributor to the Australian economy, with substantial capacity for growth, potentially compounding the current benefits provided by the industry.

3.1 Recycled Organics

3.2.1 What are Recycled Organics

Recycled organics encompass a range of products derived from the collection and processing of organic waste streams. Recycled organics products as well as waste streams (feedstocks) have been grouped for the purposes of this document, the groupings are further explained in **Table 3.** Broadly organics that can be recycled include manures, green/garden wastes, agricultural wastes, food wastes (commercial and household), woody/forestry wastes, some industrial waste sludges, paper/cardboard wastes, biosolids and food processing wastes. Generally, these are turned in to a range of composted products, for use in, but not limited to, mine rehabilitation, agriculture, landscaping, forestry, and recreational fields. It is typically the view of industry that quality recycled organic products should comply with the Australian Standard for Soil Conditioners and Mulches (AS4454).

Australian Standard AS 4454—2012 Composts, soil conditioners and mulches applies to organic products and mixtures of organic products that have been treated by pasteurizing or composting procedures. This document adopts the broad definition of recycled organic products as “product suitable for incorporation or digging into the soil for a range of benefits”; the following are excluded from the scope:

- Raw mulches that have not been subject to temperature-based pasteurization
- organic fertilizers such as blood and bone
- liquid organic wastes and liquid seaweed products,
- non-organic mulches (e.g. gravel)
- non-organic soils and soil conditioners (e.g. gypsum and sand)
- non-compostable organic materials (e.g. plastics)
- materials variously described as ‘compost starters’ and ‘activators’.
- Shredded garden wastes that have not been subjected to either a pasteurization or composting.

There are other recycled organics certification schemes available, such as The National Association for Sustainable Agriculture Australia (NASAA) scheme, however for the purposes of this document ADE will reference AS4454 and only discuss compliance in terms of PFAS (which is at present not included within the scope of the AS4454 standard). All definitions and meaning of words, where suitable and not otherwise stated, are in line with AS 4454.

In 2018-19 Australia produced 14.6 million tonnes of organic waste, of which 5.6 million tonnes went to landfill, 7.5 million tonnes were recycled, and 1.5 million tonnes recovered as energy. Considering this, the national organic recycling rate for the 2018-19 period was 51.5% - roughly 298 kilograms of recycled organic material for every Australian (AEAS 2020).

A 2020-21 study found that the source of recycled organic feedstocks was predominantly from Councils (51.5%) and commercial contracts (47.4%), with the feedstock types being accepted by processors distributed as garden organics (52.2%); waste grease (14.8%); timber (7.7%); food organics (5.2%); and other organics (15.3%) AEAS (2021).

Primary end use markets for recycled organic products include urban amenity (52.5%) and intensive agriculture (26.2%), with the industry's major output products including composted soil conditioners (40.1%); soil and soil blends (33.7%); composted mulches (11.2%); and pasteurised mulches (10.7%) AEAS (2021).

Table 3 provides groupings of recycled organics product end uses and feedstocks used in this document. These groupings deviate to some degree as compared to the language used in standards or other documents, but have been used based on the responses received in the AORA survey (**Section 4.2**).

Table 3. Definitions and groupings used in this document.

Term	Description
Feedstocks	
Biosolids	Organic waste materials, of varying water content, acquired from Waste Water Treatment Plants (WWTPs).
FOGO	Mixed residential organic waste stream comprising garden waste and food waste that are typically co-collected.
Waste grease	Waste grease collected from grease traps.
Green Organics	Organic waste stream comprising of residential or commercial property garden waste such as grass clippings and tree prunings.
Paper waste/ Cardboard waste	Solid or sludge organic waste materials either as paper products or wastes from the paper manufacturing or recycling industry.
Manure	Organic wastes derived from recreational or agricultural animal wastes (faeces).
Woody and Timber Waste	Organic waste derived from waste wood, herbaceous plants, or agricultural wastes (such as nut hulls).
Food Waste	Commercial food wastes from the hospitality and food processing industry.
End uses	
Consumer Product (Potting Mix)	Bagged or bulk products intended for consumer use (households and businesses).
Agriculture	Product consumed for intensive or broadacre agriculture
Forestry	Product consumed for the purposes of forestry
Rehabilitation	Product consumed for the purposes of restorative activities undertaken at mines and other industrial sites.
Landscaping	Product consumed for the purposes of landscaping by councils, civil projects or other major works.

3.2.2 What is the Recycled Organics Industry

The recycled organics industry, for the purposes of this document, includes all businesses either directly or indirectly involved in the collection, transport, processing, or reuse of recycled organics products or feedstocks, including peripheral businesses that sell products or services to provide support to the business that engage directly in the collection or processing of organic wastes for recycling purposes to produce composts, soil conditioners or mulches. Further information on the industry is provided in **Section 3.4**

3.2 The Benefits of Recycled Organics Products

The benefits of applying processed recycled organics to land for the amendment of soils or for agricultural and horticultural purposes has been well established, showing increases in yield of a wide variety of crops as well as the restoration of ecological and economic functions of land from a remedial standpoint (Shiralipour 1992). Soil organic carbon is often used as a measure of soil health. Recycled organic products provide further organic carbon and nutrients when added to soils (Government of South Australia, 2021), in addition to this the use of recycled organics products provides several other benefits, including:

- Improved water holding capacity – which reduces the need for irrigation.
- Improved soil structure and lower bulk density – improved workability and reduced erosion.
- Better cation exchange – better nutrient retention and sustained productivity.
- Increased earthworm counts and microbiological activity.
- Reduced need for fertilizers and pesticides - greater productivity at lower cost and environmental risk.

3.3 AORA and the Recycled Organics Industry

The Australian Organics Recycling Association Limited (AORA) is the peak body representing organics processors and recyclers, and was established in 2012. Over the past decade AORA has held the vision that recycling and reuse of organic materials within a circular economy will be widely understood and supported by Australians. As such, AORA has made it their mission to work with all manner of stakeholders to facilitate an operating environment which maximises the recycling and reuse of organic materials, and promotes the benefits of compost, soil conditioners and mulches across Australian communities and businesses.

AORA membership as of 30 June 2022 included 62 individual organics processing businesses, 94 associate members and 43 individual members. AORA has worked on behalf of its members, including processors, associated industries, educators, and all levels of Government to raise awareness of the benefits of recycling organic resources, acting as an advocate for the wider organics resource recovery and beneficial reuse industries and to represent their views in a constructive dialogue with policy makers. It is in this capacity that AORA provides the present response to the Draft PFAS NEMP 3.0.

AORA envisages an industry where best practice is shared, standards are maintained and surpassed, and which makes a positive contribution to safeguarding the environment. Importantly AORA's VISION 2031 include increasing to 80% recycling of organics by 2026 and 95% by 2031, which requires significant growth of the organics recycling market and processing facilities.

3.4 THE RECYCLED ORGANICS INDUSTRY ECONOMIC CONTRIBUTION

A 2021-22 survey commissioned by AORA found that the industry, operating as 314 businesses across Australia, has a collective national turnover of over $2.1 billion and generates $1.9 billion in benefit across its supply chain. It contributes $781 million in industry direct value add to the Australian economy, with a further $624 million in value added through flow-on demand for goods and services (AEAS 2022). The industry employs 5,032 Australian residents and provides a further 4,227 indirect jobs through flow on activity. Collectively the industry pays over $386 million in wages and salaries and an additional $40.5 million towards superannuation, this provides an average livelihood to each employee in the industry of $76,710 which compares favourably to national average monthly earnings of $69,103 for the 2021-2022 period (AEAS 2022). It is estimated that one job is supported for every 1,538 tonnes of organic material recycled in Australia. A national recycling rate of 95% being realised estimates the industry would deliver a further 4,101 jobs; $314 million in wages; and $636 million in industry direct value to the economy annually (AEAS 2020).

3.5 THE RECYCLED ORGANICS INDUSTRY AND CLIMATE CHANGE

Data collected as early as 2007–08 suggested that Australia diverted an estimated 3.7 million tonnes (Mt) of garden and food organics and wood residue from landfill for recycling, preventing methane generation equivalent to ~ 4.28 Mt CO2-e. It was estimated that landfill emissions figures would be almost twice as large if the organics which are currently recycled were to be landfilled instead (DECCW 2021).

A 2022 report found that organics recycling directly reduces CO2 inputs into the atmosphere by 3.9 million tonnes annually, equivalent to planting 5.8 million trees or taking 876,663 cars off the road. The report concludes that a national organic recycling rate of 95%, would see the industry remove an additional 3.2 million tonnes of CO2 annually. This is equivalent to planting 4.8 million trees or taking 902,311 cars off the road. This is without including the impacts of reduced methane production in landfill or the benefits of the industry's products to agricultural productivity and soil quality, drought proofing, and reduction of chemicals and pesticides used in agriculture (AEAS 2021).

Considering that the waste industry is responsible for 2.7 percent of the 499 million tonnes of carbon dioxide equivalents generated by Australia annually (Australian Government 2020), equating to ~14.4 million tons, the above demonstrates that the organics recycling industry plays a significant role in reducing Australia's carbon emissions and that of the waste sector.

3.6 THE RECYCLED ORGANICS SECTOR CAPACITY

The AORA Vision statement aims to achieve 80% recycling of organics by 2026 and 95% by 2031. A 2021 study commissioned by AORA found that of surveyed organics processors in the industry, the average business currently occupies 49.2% of their operating sites, with room for expansion. It was estimated that the industry can process 51% more organic materials if unconstrained. If realised, the industry would, on average, invest $9.3 million per business over the next five years (AEAS 2021).

This suggests that if unhindered, the organics recycling industry has significant capacity to further increase in scale and therefor bolster its ability to provide the waste processing amenity for organic waste streams, further divert material from limited landfill space, provide increased economic benefit and further reduce Australia's carbon emissions. Key risks to securing industry growth and associated benefit largely lie outside the industry, and are related to government and policy, this includes the implementation of the PFAS NEMP 3.0 and more broadly the approach to the management of PFAS within the industry.

4. PFAS in the Recycled Organics Industry

Section headlines:

- PFAS are not used in the organics recycling industry, but are burdens in the organic waste stream from other industries or practices, including consumer inputs.
- PFAS concentrations in recycled organics are very low relative to levels in some consumer products, packaging, non-recycled waste streams (landfilled) and those found at contaminated sites.
- PFAS management requirements should consider the proportionality of each exposure pathway to PFAS mass input as relative to other PFAS mass inputs to humans or the environment.
- Presently, there are very few data available regarding the concentrations of PFAS in recycled organics feedstocks or recycled organics products, in Australia. Globally the state of knowledge is still evolving.
- Available literature strongly suggests that PFCAs and precursors (used here as "PFAS that transform into terminal PFAA") represent the greatest portion of PFAS mass in composts.
- PFAS mass in recycled organics products is a factor of the type of feedstocks accepted, blending proportions, the composting process and its impact and precursor transformation, and mass loss.
- Based on an AORA 2023 survey, it is unclear for many recycled organics processors how they can achieve environmental compliance for PFAS.
- The above survey also demonstrated that the impacts on processors vary due to differences in processor scale, type of feedstocks processed, and end use, all of which are diverse.

4.1 What are PFAS

The below section on PFAS has been included for document context and completeness.

4.1.1 PFAS Overview and Environmental Behaviour

PFAS is a collective noun applied to a class of over 4,700 fluorinated man-made chemical compounds that have been used or are currently still in use in a variety of industrial and consumer products, including firefighting foams, water resistant coatings and food contact materials. Their wide scope of use is brought about by PFAS having a unique chemistry that grants the compounds properties such as water- and oil-repellence and resistance to thermal, chemical and UV degradation (Johnson et al., 2021; NIEHS, 2020).

Buck et al. (2011) defined PFAS as aliphatic substances containing at least one perfluoroalkyl moiety (i.e., CnF_2^{n+1}–), with 42 families and subfamilies of PFAS identified, while this does not capture all PFAS species, other definitions such as the 2021 OECD definition which capture a range of other PFAS specie (i.e., cyclic species) (OECD 2021). The Buck et al. (2011) definition is suitable for the purposes of this document and is used throughout. The PFAS basic chemical structure of PFAS is a chain of at least two carbon atoms adjoining a charged functional group. Common functional groups include carboxylates or sulfonates, though several other forms are detected in the environment (ITRC 2022a).

Perfluoroalkyl acids (PFAAs) are most common subgroup of PFAS tested for in the environment, it has been noted that biotic and abiotic degradation of many polyfluoroalkyl substances (compounds only partially saturated with fluorine) may result in the formation of PFAAs when degraded. As such, the resultant PFAA is known as the terminal product and the PFAS congeners that degrade to PFAA's are known as precursors (ITRC 2022a, 2022b).

Many terminal PFAS species are difficult to degrade via chemical and biological processes due to their chemical structure, this results in PFAS persisting in the environment and accumulating in living organisms (Lazcano et al., 2018; U.S. EPA, 2018b). Buck et al. (2011) noted that Perfluoroalkyl sulfonic acids (PFSAs) have a greater tendency to bioconcentrate and/or bioaccumulate compared to a PFCAs with the corresponding number of carbon atoms (Buck et al.,2011). As such, PFAS environmental behaviour is greatly influenced by the PFAS congeners chain length and functional group, including behaviours such as their solubility in water or capacity to bind to soils and sediments.

4.1.2 PFAS Exposure and Toxicity

Internationally, multiple PFAS species have been found in food, drinking water, and various environmental compartments (FDA, 2020; Sinclair et al., 2020). When present in land-applied biosolids (composted or digestate), PFAS have the potential to enter the environment (via leaching of PFAS to surface and ground water) or be taken up taken by plants or animals including livestock and crops which can then be consumed by humans as produce (Costello and Lee, 2020; Wang et al., 2020; Ghisi et al., 2019).

PFAS have broadly been shown to bioaccumulate in fish, wildlife, and humans (Martin et al., 2003, Boisvert et al., 2019, ITRC, 2022b). Bioaccumulation potential is reported based on the direct uptake of a chemical by an organism from water or air (bioconcentration factor (BCF), the contaminant concentration of an organism relative to its diet (biomagnification factor (BMF)), and finally the combined effects of all uptake pathways (bioaccumulation factor (BAF)). Trophic magnification factors (TMFs) are also useful in characterising the bioaccumulation of PFAS across ecosystems as they provide a holistic measure of biomagnification as a multiplier.

Tomy et al. 2009 and Kelly et al. 2009 showed that avian and marine mammalian food webs can exhibit TMFs for PFAAs around a value of 20. Comparatively, Martin et al. (2004) and Houde et al. (2008) demonstrated that in piscivorous food webs TMFs can be lower, ranging between 1.9 and 5.9. A synthesis of over 1000 laboratory-based and field-based measurements found that PFCAs with a 12 - 14 carbon-chain length exhibit the highest bioaccumulation potential. The same study found that for PFCAs, whole-body BCF values ranged between 18 000 and 40 000 L/kg (Gobas 2020), where values greater than 1 indicate that accumulation in the tested organisms is greater than its environment. Most animal PFAS toxicity studies have focused on PFOS, PFOA and PFHxS. Collectively these studies have shown that PFAS present a very low risk of acute toxicity to most species at environmentally relevant concentrations (LD50 for rats 233-271 mg/kg PFOS per body weight (kg)). However, low doses of some PFAS species have been shown to cause behaviour effects (FSANZ 2017) as well as impacts such as developmental toxicity, immunotoxicity, hepatotoxicity, and hormonal disruption (Wang et al., 2021; NTP, 2020, 2019a, 2019b, 2016).

Similarly, the most studied PFAS in terms of human health effects are PFOA and PFOS (ATDSR, 2018). Epidemiological studies have found associations between exposure to PFOA and/or PFOS with testicular and kidney cancer, low birth weight, hypothyroidism, and decreased semen quality (Vaughn et al., 2013; Vested et al.,2013). Elimination half-lives for humans have only been estimated for PFOS, PFOA, PFHxS, and perfluorononanoic acid (PFNA), and are estimated to range between 2.1 and 8.5 years (Hu et al. 2019). This suggests that PFAS are likely to accumulate in the human body. Interestingly PFOS and PFOA concentrations in humans were observed to decrease after the 2000–2002 phase-out of perfluorooctane sulfonyl fluoride (POSF) production by 3M (D'eon JC & Mabury 2011), lending further credence to the concept of elimination of PFAS use being a key to reducing human and environmental exposure. However, despite this, increasing concentrations of the C9 and C10 PFCAs in humans suggest continued indirect exposure via the biotransformation pathways of precursor PFAS species (D'eon JC & Mabury 2011).

While the exposure of humans to PFAS is largely through dietary intake (food and water), this is often perceived to be via direct exposure, and less so investigated and contrasted against indirect (biotransformative and bioaccumulative pathways) (D'eon JC & Mabury 2011). Studies have found there is generally a low input of PFAS into terrestrial agricultural food chains as compared to point source inputs into the environment (Death 2021, Domingo 2019). Noting that the contribution of relevant exposure pathways to PFAS concentrations in food products is less well studied (Death 2021).

In juxtaposition to food inputs via produce, human exposure via food packaging or food contact materials (FCM) are being further investigated in recent times. Based on the FCM type and food preparation practices, consumption of popcorn was in one study associated with significantly higher serum levels of PFAS, and up to a 63% increase in PFDA among those who ate popcorn daily over a 12-month period (Sussman 2019). Investigations have revealed that PFAS in packaging have been found across the globe to range from the low ng/kg concentration up to the 1000's of µg/kg, with levels in food in contact with packaging ranging between 0.01 and 13.1 µg/kg for PFCA's, but contrasting other products such as microwave popcorn paper returning results as high as 18,200 µg/kg for total fluoro-telomer alcohols (FTOH). Transfer from packaging to food occurs based on several parameters including temperature, duration of contact, food matrix and PFAS species (Ramirez 2021). Interestingly, inverse associations between serum PFAS and food eaten at home suggests less contact between home-prepared food and FCMs (Sussman 2019).

In addition, humans are in contact with a variety of products every day that contain PFAS, some at elevated levels, suggesting a constant diffuse human exposure. Samples of consumer products collected in Norway and Sweden demonstrated that in 90% 0f the products tested for known polyfluorinated substances were detected, noting that unknowns and precursors were not tested (Herzke D et al., 2012). Comparatively, household dusts have been found to contain one species of PFAS, polyfluoroalkyl phosphates, ranging from 3.6 µg/kg to 1023 µg/kg (Eriksson & Karrman 2015).

Considering PFAS exposure routes holistically, guidance needs to place more emphasis on contextualising the relative input of PFAS from various exposure pathways and apportion the focus of management extent accordingly to prioritise the exposure pathways contributing the largest risk to human health and the environment and ensure that guidelines propose effective and proportionate management of PFAS.

4.2 KEY RECYCLED ORGANICS LITERATURE

4.2.1 PFAS in Recycled Organics

At present there is a very limited pool of literature related to the extent of PFAS contamination in recycled organic products in Australia, as well as globally. At time of writing in 2019, Arcadis (2019), noted that other than biosolids destined for direct land application no literature existed for PFAS concentrations in recycled organic products processed in Australia. Considering this, the understanding of PFAS impacts on recycled organics products is recent, limited and evolving. A review of European recycled organics data concluded that most did contain PFAS (WCA 2019).

The WCA study for NSW EPA reviewed data from 2011 provided by WRAP regarding Welsh Green waste and FOGO derived recycled organics products and found most of the PFAS compounds were below the limit of detection, with just perfluorooctanoic acid (PFOA) detected at 5.5 µg kg^{-1} in FOGO derived product. The same study made use of data provided by NSW EPA and found that, based on literature, green waste derived product had a mean of 6.30 µg/kg Sum of PFAS whereas Mixed Waste Organic Outputs (MWOO) from Australian samples had a mean of 51.3 µg/kg Sum PFAS, ranging 45 – 549 µg/kg. This is the earliest published data set readily available for recycled organics that does not include biosolids.

Internationally, studies such as Lazcano et al., 2020 assessed the occurrence of 17 perfluoroalkyl acids (PFAAs) present in a much broader study including 13 commercially available biosolid-based products, six organic composts (manure, mushroom, peat, and untreated wood), and one food and yard waste compost. The PFAA concentration ranges observed are as follows: biosolid-based products (9.0–199 µg/kg) > food and yard waste (18.5 µg/kg) > other organic products (0.1–1.1 µg/kg). It was clear that biosolids were a major contributor of total PFAS mass. Further, in the same study the total oxidizable precursor (TOP) assay revealed the presence of PFAA precursors in the biosolid-based products at much higher levels as compared to the other tested products (Lazcano et al., 2020)

To date, no data is available on digestates that would enable the determination if food waste digestates would have PFAS mass loads comparable to other recycled organics types (Kenny 2021).

More recently Choi et al (2022), investigated the mass loads of 17 perfluoroalkyl acids (PFAAs) in nine commercially available composts from the United States of America and one backyard compost. It was found that PFAA loads ranged from 28.7 to 75.9 µg/kg Sum PFAS for composts that included food packaging and from 2.38 to 7.60 µg/kg Sum PFAS for composts that did not include food packaging. This study demonstrated that the inclusion of packaging in recycled organics has a significant effect on PFAS mass loads to recycled organics products.

Sivram et al. (2022) presented the first comprehensive study of recycled organics products and PFAS mass loads in Australian recycled organics products. The study co-investigated commercial composts, potting mixes & garden soils which were tested for 38 PFAS and found the Σ38 PFAS ranged from 1.26 – 11.84 µg/kg, with PFAS detected in all products.

Much like previous studies, Sivram et al. (2022) found that ΣPFCAs was higher than other PFAS functional groups in all products and that short chain ΣPFCAs increased after total oxidisable precursor assay (TOPA), suggesting the presence of precursors. TOPA showed a 2-3-fold increase in the concentrations of PFCAs. The authors noted that while PFAS was detected, for all composts the concentrations of PFOA and PFOS in all the samples were below Australia's National Environmental Management Plan 2.0 (NEMP 2.0) guideline for the proposed human health soil screening level, which is 10 µg /kg for PFOS + PFHxS.

This study highlighted for the first time the occurrence of PFAS across Australian recycled organics products and the presence of potential precursor compounds of PFAS in commercially available composts, garden soils, and potting mixes.

4.2.2 PFAS in Feedstocks

The measurement of PFAS in organic waste feedstocks is important, as due to the persistence of PFAS, the PFAS mass load in feedstock not only remains in processed recycled organics products, but the processing of recycled organics may result in changes in the distribution of PFAS species in the material due to degradation of precursor compounds and changes in PFAS concentration based on product mass loss during processing. Loss of mass during composting (namely as water vapour and CO_2) of various feedstocks is an important consideration for compost operation management, where losses can average 19.4% of initial mass and range have been shown to range from 11.5% to 31.4% (Breitenbeck & Schellinger 2004). Mass loss can enrich PFAS in solid matrices on a mass per mass basis and needs to be considered insofar as transference of PFAS mass from feedstock to final recycled organic product is concerned.

Similar to **Section 4.2.1** on PFAS in recycled organics products, studies surrounding the occurrence of PFAS in recycled organics feedstocks are limited. Kenny (2021), noted in a study on behalf of the US EPA, that at the time of writing only one published study measured PFAS concentrations in food waste feedstocks. The Author suggested however that while data was limited, a number of studies reporting PFAS in food from non-contaminated areas, supported that PFAS was likely to be present in food waste. Further, no studies were identified that reported PFAS concentrations in mixtures of food waste with other wastes (e.g., green waste or biosolids).

Macrae (2020) investigated 25 samples of food waste from grocery stores, hospitals, schools, restaurants, retirement communities, and residences in Massachusetts and Vermont for 17 PFAS. Perfluorobutanoic acid (PFBA) was detected in 14 samples (0.11–1 µg/kg), PFHxS was detected in 2 samples (0.11– 0.15 µg/kg), and PFNA was detected in 1 sample (0.28 µg/kg) (MacRae et al., 2020). A 2022 follow-up study found that physical contamination of food waste feedstock with other materials (namely packaging) was found to be 57% of sampled feedstocks. Further testing found PFBA was detected in 60%, PFHxS in 8% and PFNA in 4% of samples tested (Thakali et al, 2022).

These is at present no literature available on the impact of the inclusion of compostable bin and caddy liners on PFAS concentration in commercial food wastes or "food organics green organics" (FOGO).

Packaging and food contact materials have had a growing pool of data and that has demonstrated them to contain PFAS. Phosphate diesters (diPAPs) have been measured in food contact materials from Canada and Denmark, with concentrations up to 600–9,000 µg/kg (Trier et al., 2017; Trier et al., 2011). Poothong et al., (2012) found PFOA and PFOS were detected in 30 out of 34 instant food cup, fast-food and dessert containers, baking paper, beverage cups, and microwave popcorn bags samples with mean PFAS concentrations 5.9 and 10.1 µg/kg, for PFOA and PFOS, respectively. Yuan et al. (2016) found the concentration of 6:2 FTOH in a single compostable cup sample was 499 µg/kg, which was considerably higher than the concentration in samples made from ivory board or plastic (which ranged from below the method quantification limit to 2.97 µg/kg).

The 2021 study by Australian Packaging Covenant Organization (APCO 2021) tested 74 samples of fibre-based packaging largely claiming to be compostable but not necessarily certified to be under 100 mg/kg fluorine as required to attain a certificate of conformance as "certified compostable" by the Australian Bioplastics Association (ABA). Considering this, the 2021 report found high fluorine concentrations (>800 ppm) in over a quarter of submitted samples. Roughly a quarter of the samples tested had no detectable PFAS, however, all bagasse packaging tested by APCO (2021) contained PFAS. The study selected samples with high total fluorine for further testing for 28 PFAS species, in most cases, PFAS were not detected. However, TOPA analysis confirmed the likely presence of unknown PFAS 'precursors' and other 'polymeric' PFAS, with Total PFAS by TOPA ranging between 8,343 and 32,730 µg/kg for the top 8 fluorine detections out of the 74 package samples, noting that Pre TOPA results ranged 3 – 28 µg/kg for the same samples. This supports the results outlined in **Section 4.2.1** where those composts made with and without compostable food packaging showed that, in general, concentrations of PFBA, PFPeA, PFBS, PFHxA, PFOA, PFNA, and PFDA were higher when compostable food packaging was present (Choi 2019).

In late 2022, APCO released is "Action plan to phase out PFAS in fibre-based food contact packaging", which took a strong stance in requiring packaging seeking to be certified compostable under AS4736-2006 for commercial composting or AS5810-2010 for home composting to attain a certificate of compliance from the ABA, validating that the product was below a 100 mg/kg fluorine threshold and declaration that the product had no Intentionally added substances such as PFAS or derivatives. Further the action plan provided detailed testing information for the identification of PFAS in packaging, and alternatives to PFAS (APCO 2022).

Over the past decade a body of evidence was growing to demonstrate that PFAS are present in biosolids in significant concentrations, most recently and in the Australian context Moodie et al. (2021) detected PFAS in 100% of the biosolids samples from 19 wastewater treatment plants (WWTPs). The study found that the sum of 44 PFAS had a mean concentration in biosolids of 260 µg/kg dry weight and ranged between 4.2 and 910 µg/kg (Moodie et al., 2021). Moodie et al (2021) also noted that di-substituted phosphate esters (diPAPs), a precursor compound, had the highest concentrations of PFAS detected. These findings compare with the recent international study, Munoz et al. (2022), which found that for a similar PFAS analytical suite that urban and industrial wastes, paper mill sludge, sewage sludge, or residual household waste composts had a median ∑46PFAS of 220 µg/kg. Munoz et al (2022) also tested for ∑46PFAS in agriculture-derived organic waste sludges such as pig slurry, poultry manure, or dairy cattle manure and found that PFAS concentrations were relatively lower than that of industrial and urban sludges (median: 0.66 µg/kg dry matter).

When results from Moodie et al. (2021), Munoz eta l (2022), Choi et al. (2019), Lazcano et al. (2019), and Lazcano et al. (2020) are considered together, the products organized in decreasing order of PFAS concentrations are: biosolids-based products (i.e., treated biosolids, composted biosolids) > food waste compost > green waste compost and manure. Over all, it is clear that there is a difference in PFAS concentration and type across feedstock matrices and sources, and as such these need to be considered as discreet batches for the purposes of assessing PFAS mass inputs at processing facilities. The PFAS NEMP 3.0 should rely on literature to align key contaminants of concern for the recycled organics industry with appropriate guidance.

4.3 STANDARDS AND REGULATION

While most states and territories in Australia have in place legislation that manages waste and waste reuse, or a recycled organics guideline for other non-PFAS contaminants, at present no Australian jurisdiction except for Queensland has developed PFAS regulations or guidelines that directly addressing PFAS in recycled organics. Model operating conditions ERA 53(a)—Organic material processing by composting is represented in **Table 4**, which outlines PFAS thresholds as presented by the model operating conditions. To contextualise this, other values have been appropriated in the past for recycled organics screening values, these have included the PFAS NEMP 2.0 threshold values for PFAS indirect ecological exposure or Victoria EPA 1669.4 limits included in **Table 4**. However, considering the values below and the information presented in **Section 4.2**, it is clear that a sensible grouping of PFAS species and the need for TOPA have indeed been includes in Model operating conditions ERA 53(a)—Organic material processing by composting. The calculation of these criteria and relation to risk presented by compost to human health and the environment is at this point in time unclear.

Further, national standards such as AS4445 – 2012 do not contain any guidance or limits for PFAS, but do set limits for other contaminants, as such Frontier Ag & Environment (2021) suggests that in its current state AS4454 no longer represents real-world risks with respects to PFAS. Collectively, standards and regulation for the assessment of PFAS in recycled organics product and or feedstock are limited in Australia, and need to be updated to manage PFAS risks.

Table 4 – Criteria for Model operating conditions ERA 53(a)—Organic material processing by composting, Victoria EPA Interim position statement on PFAS 1669.4, and ecological exposure-indirect PFASNEMP 2.0 Criteria (all values in µg/kg).

PFAS Congener/Group	ERA 53(a)—Organic material processing by composting	Victoria EPA 1669.4	PFAS NEMP 2.0 - Ecological Indirect
Category	**Recycled organics**	**Soil**	**Soil**
PFOS	1	2	10
PFHxS	1	1	-
PFOA	1	1	-
Sum PFBA, PFPeA, PFHxA and PFHpA (Above LOR)	1	-	-
Sum of all C9-C14 PFCAs	1	-	-
Sum of all Pefluorosulfonamides (above LOR)	1	-	-
Sum of all n:2 Fluorotelomer sulfonic acids (above LOR)	1	-	-
Sum PFOS+PFHxS	2 (calculated)	3 (calculated)	-
Sum PFOS+PFHxS+PFOA	3 (calculated)	4	-

4.4 2022 Survey

To the ends of providing some further context and information in this response to the Draft PFAS NEMP 3.0, ADE and AORA conducted a rapid survey of AORA processing members to collect data which may assist in better contextualising the recycled organics industries interaction with and understanding of PFAS contamination.

4.4.1 Responses and outlook on PFAS

Overall, 21 responses were received from AORA processing members (~ 33% of processing members) to a variety of set answer and open-ended questions. Depending on the questions and the nature of responses provided the reliability of data collected varied, with a number of responses either not including the required data or being in a format or measure unsuitable for comparison. Considering this, there is some uncertainty surrounding the snapshots (**Section 4.2.2**) and mass balances (**Section 4.2.3**) derived from the data collected in the survey. Regardless, these are designed to be general representations and do not aim to accurately capture all aspects of the entire industry. The sections below outline outcomes of the survey.

The respondents were constituted of recycled organics processors for across Australia (n=21), with principal businesses across Australia outlined in **Table 5**. Recycled organics processors responding to the survey suggested that 62% of all processors believe they will be greatly impacted by PFAS, with only 5% suggesting that they believe they will largely be unaffected. A similar proportion (62%) believe that the level of understanding surrounding PFAS and its management/risks across the industry is low, with 14% suggesting the understanding is unacceptable. A similar pattern emerged with respects to the industry's understanding of PFAS regulatory and compliance requirements for PFAS, with 62% stating that the understanding was low or 19% suggesting that it was unacceptable.

Overall, 71% of respondents felt that the cost of PFAS testing and management to mitigate risk and secure their feedstock/products is likely to have less impact on them than having blanket restrictions placed on certain end uses or feedstock types.

Suitability of data provided by respondents for inclusion in snapshots and a mass balance is detailed in **Table 6.**

Table 5 – Distribution of respondents across jurisdictions.

State	Proportion (%)
Active across multiple states	10 (Typically VIC, NSW, QLD)
Australian Capital Territory	0
New South Wales	14
Victoria	19
South Australia	5
Western Australia	14
Queensland	38
Tasmania	0
Northern Territory	0

Table 6 – Response data suitability matrix

Respondent	Feedstock Tonnage	Feedstock Proportion	Product Tonnage	Sufficient Data for Mass Balance
1	No	No	No	No
2	Yes	Yes	Yes	Yes
3	No	Yes	Yes	No
4	Yes	Yes	No	No
5	Yes	Yes	Yes	Yes
6	No	Yes	No	No
7	Yes	Yes	No	No
8	Yes	Yes	No	No
9	No	No	Yes	No
10	Yes	Yes	No	No
11	Yes	Yes	Yes	Yes
12	No	Yes	No	No
13	No	No	No	
14	Yes	Yes	No	No
15	Yes	Yes	Yes	Yes
16	Yes	Yes	No	No
17	Yes	Yes	Yes	Yes
18	Yes	Yes	No	No
19	Yes	Yes	Yes	Yes
20	No	No	No	No
21	Yes	Yes	Yes	Yes

4.4.2 Feedstocks and End Use Snapshot

The data set collected by ADE was used to provide a snapshot (n=11) of the feedstocks used by industry (**Figure 2**), the comparative tonnage of organic material processed by respondents on an annual basis (**Figure 3**), and the generalised end uses for recycled organics products (**Figure 4**). To achieve this, and to support the mass balance in **Section 4.4.3**, feedstocks and end uses where broken into broad categories (**Table 3**).

Figure 2 supports that there is significant variation between processing operators and the types of feedstock materials processed, even using the broad categories of feedstocks used in this document. This variation between the types of feedstocks processed and reliance on different proportions demonstrates that processing businesses are all very different and as such are likely to have significantly different needs and pressures exerted upon them by PFAS and PFAS management requirements depending on the feedstock inputs and sources to their facility. Analysis of survey data found that one respondent business accounted for 59% of the total mass of organics processed by all respondents with viable data (n=11) and the smallest processing business only 1% (**Figure 3**) with total annual production ranging between 0.026 to 1.15 million tons per annum.

Overall feedstocks were apportioned as follows, woody waste timber (57% - significantly skewed by one processor), Green Organics (2%), Commercial Food Waste (6%), Cardboard/Paper Waste (5%), FOGO (5%), Biosolids (4%), waste grease (1%) and Manure (1%). If the outlier processors data is removed (n=10) the proportions are altered as follows: Green Organics (39%), Woody waste timber (14%), Commercial Food Waste (8 %), Cardboard/Paper Waste (13%), FOGO (5%), Biosolids (9%), Waste Grease (2%) and Manure (2%).

In a similar fashion, respondent data were used to estimate the proportions of end uses for four broad categories, **Figure 5** details that while some composters collect very different feedstocks, many have a similar spread of end uses across the four categories, with three of the eleven respondents wholly reliant on landscaping uses. Overall, end uses were distributed as landscaping (55%), agriculture (29%), consumer products (10%) and rehabilitation (6%).

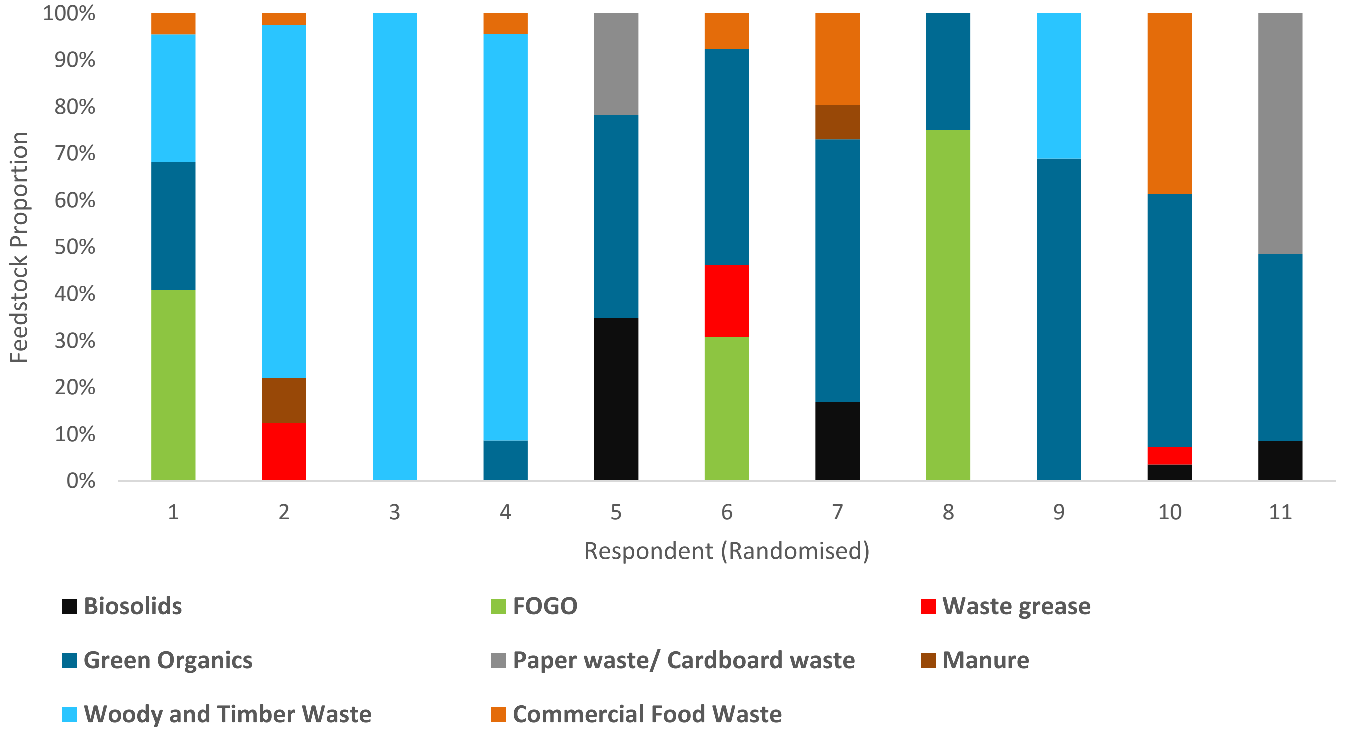


Figure 2 - Snapshot of the feedstocks used by respondents. Figure accounts for skewedness by apportioning and stacking values for each response individually.

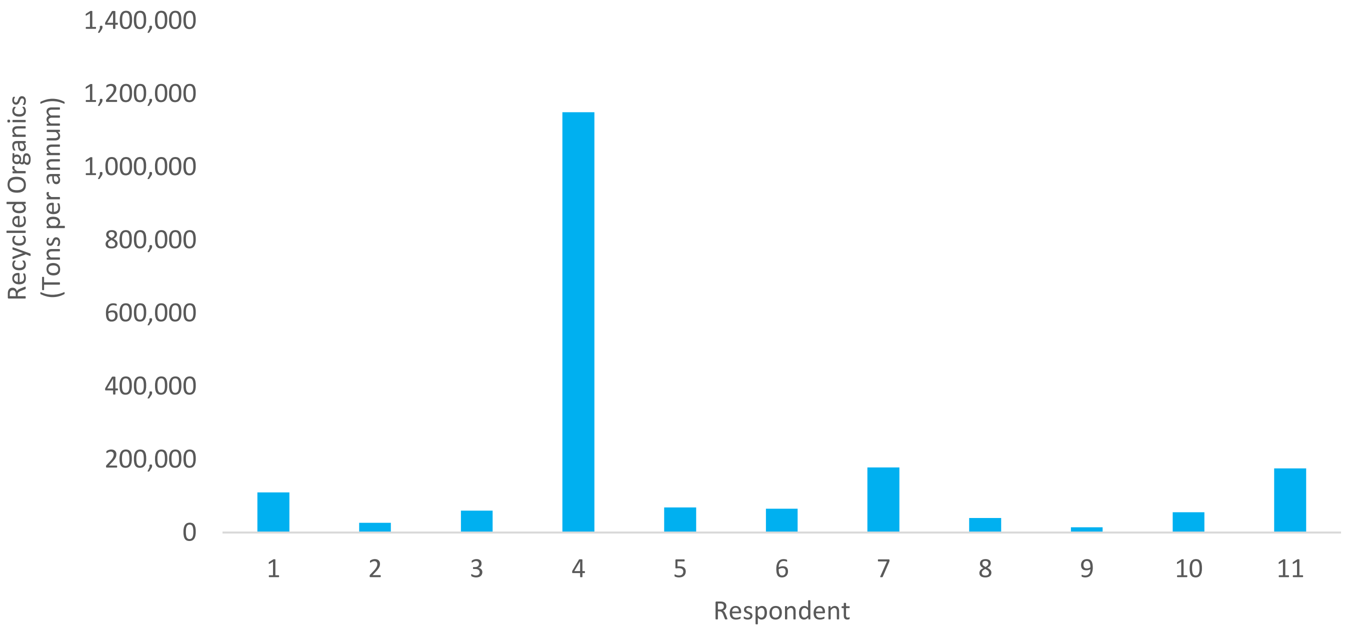


Figure 3 - Snapshot of the tonnage of organic waste recycled by respondents.

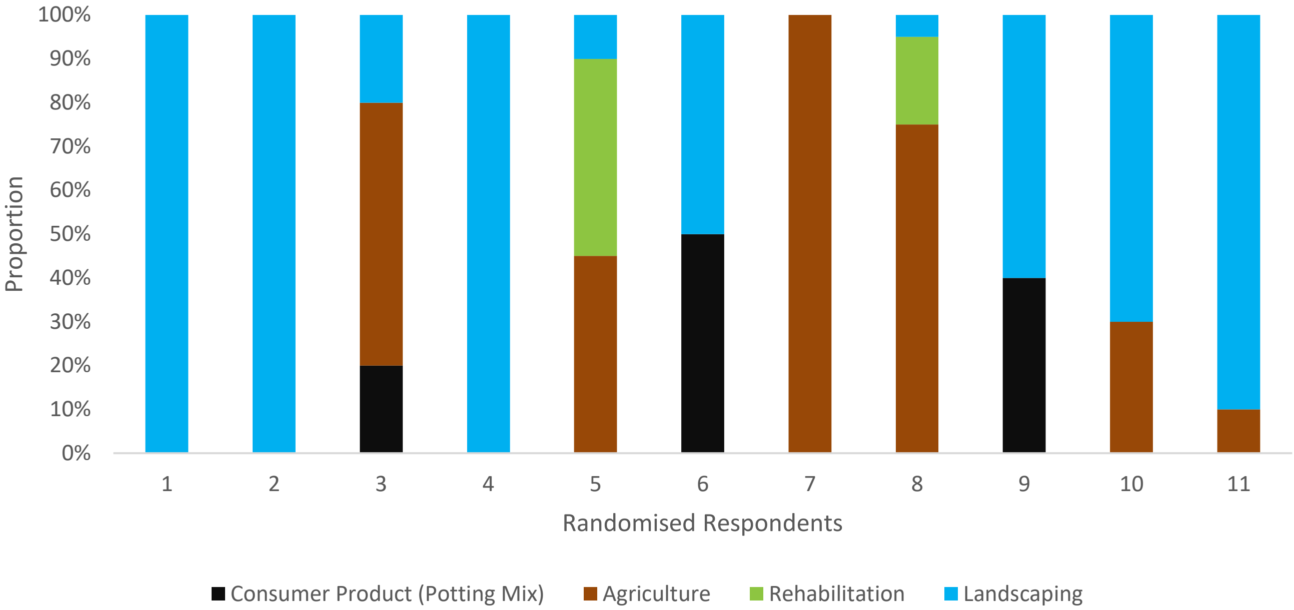


Figure 4 - Snapshot of the end uses of processed recycled organics as provided by respondents. Figure accounts for skewedness by apportioning and stacking values for each response individually.

4.4.3 Mass Balance Exercise

Using the broad categories presented in **Table 3** for feedstocks, and the adopted literature values in **Table 7** for each feedstock category, a very simple mass balance was constructed to estimate mean Sum of PFAS concentrations in recycled organics products across the seven processors who provided enough data to undertake this exercise (see **Table 6**).

The values adopted in **Table 7** have been used for Sum of PFAS, despite the literature values being for different assemblages of PFAS congeners in the various studies. In addition, precursor, or post TOPA values have not been considered, but calculated using a multiplier. Where data was not available for a given group, the closest data type with available literature values was appropriated.

The mass balance was undertaken by calculating PFAS mass inputs based on the tons per annum accepted for a given feedstock and the adopted literate value for the same feedstock group. The PFAS mass inputs for the feedstocks were then summed and recalculated for the decrease in mass of bulk material during processing; the value was acquired from tonnes produced per annum. Using these values, a rough mass balance was derived for each processor. The data for all processors was used to calculate estimated Sum of PFAS mean and range in recycled organics products. **Figure 5** provides a flow diagram of how this process was undertaken for one randomised example. Estimated TOPA loadings were calculated using a 2x multiplier in line with the findings of Sivram et al. (2022).

The outcomes of the mass balance calculations are provided in **Table 8.** These showed a mean Sum of PFAS in generalised recycled organics products (n=7) of 52 µg/kg, with mass balance values in product ranging 35 - 318.24 µg/kg. ADE acknowledges that the reliability of these values is limited based on the appropriation of literature values, where mean values were used that did not necessarily represent data for the feedstock group the mean value was applied to. Further, the mean value was used, therefore the resulting estimations do not present a worst case, nor do they represent a best case where some of the feedstocks were not PFAS impacted. As such, the calculated mass balances are at best a simple approximation, but as a range compare reasonably well with the value presented in **Section 4.2.1**

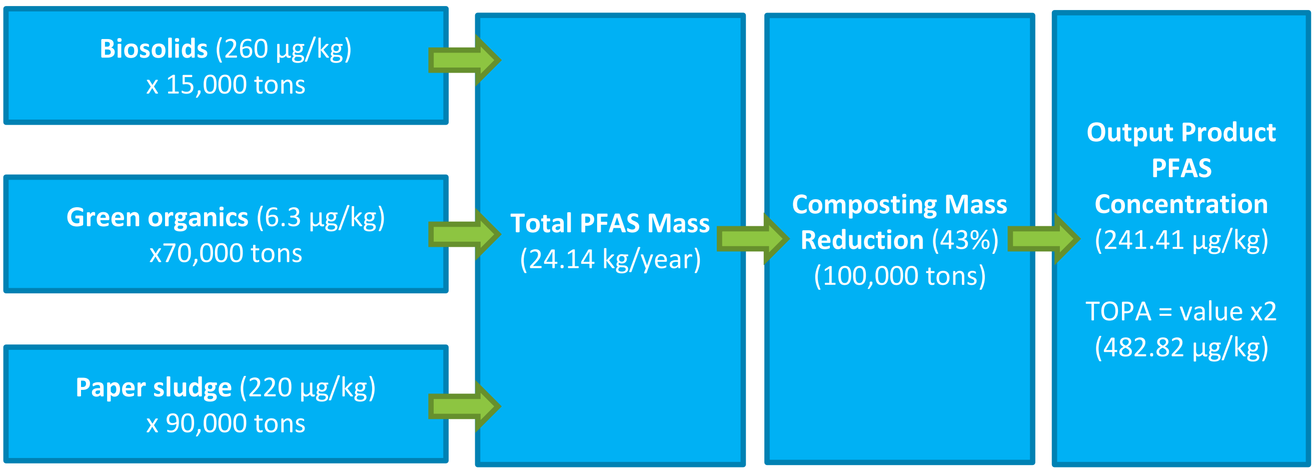
Table 7- Adopted Sum of PFAS concentrations for feedstock groups for input into mass balance. Appropriated values represent those that were not derived for the same grouping but are perceived to be similar.

Feedstock	Adopted PFAS (µg/kg)	Value Source
Biosolids	260	Moodie et al. 2022
FOGO	5.5	WRAP 2011
Waste grease	220	Appropriated – Munoz 2022
Green Organics	6.30	WCA 2019
Paper waste/ Cardboard waste	220	Appropriated – Munoz 2022
Manure	0.66	Manoz 2022
Woody and Timber Waste	6.30	Appropriated – WCA 2019
Commercial Food Waste	5.5	WRAP 2011

Table 8 – Mass balance exercise outcomes for each randomised respondent.

Randomised respondent	Estimated Total Sum PFAS Mass load (kg/year)	Mass Balance Estimated Product Sum PFAS Concentration (µg/kg)	Estimated Sum PFAS Concentration post-TOPA (µg/kg)
1	24.14	241.41	482.82
2	0.09	4.35	8.7
3	9.73	324.30	648.6
4	0.38	18.90	37.8
5	0.28	55.08	110.16
6	0.19	9.73	19.46
7	12.95	318.24	482.82

Figure 5 - Flow diagram exampling mass balance calculation process for one randomised processor for 1-year period.



4.5 LITERATURE AND 2022 SURVEY INTERPRETATION

Based on the outcomes of the review work undertaken in the above sections in both scientific literature and regulation, PFAS in recycled organics is an evolving space. Most significantly, there is a very little data available in the literature to inform feedstock selection and assess flow on PFAS impacts on product, with no data available to assess how these interact in-process which includes blending, precursor transformation extent, and drying/mass loss.

The literature demonstrated that there are many PFAS species and precursors found in recycled organics, with a significant impact on mass loading to receiving environments, though the risk of this pathway is still somewhat unquantified outside of biosolids. A more robust analyte list of PFAS species and approach to precursor detection, quantitation and interpretation will greatly assist in defining the extent of the problem and identifying ways to manage PFAS in feedstocks. Based on source, some feedstocks of the same type appear to present a variable extent of risk.

Considering the data collected in Sivram (2022) and the current model operating conditions in QLD, or application of Victorian EPAs Publication 1669.4 soil values as compliance end points to recycled organics, with many values in the 1 – 10 µg/kg range, it is likely that many recycled organics products are at risk of not being compliant for various PFAS species.

The brief survey demonstrated that composters very in size and receive a variety of feedstocks, with some more reliant on certain feedstocks than others, and some processors more diversified. Using the respondent's data, a very simple mass balance using literature feedstock values was used and mean Sum of PFAS in recycled organics products estimated to be 52 µg/kg Sum of PFAS, with a range of 4.35 - 318.24 µg/kg. This figure is likely to double if considering post TOPA values. This means that there is likely to be a significant mass load of PFAS in recycled organics and extension of regulation to Sum of PFAS compliance point is likely to pose a significant challenge, particularly for those PFAS species where toxicity is poorly understood and hence the risk not well characterised.

Overall, it was found that a variety of PFAS are likely to be present in recycled organics and that the current state of knowledge is not up to the task of characterising risk for predominant species holistically. To address this a better understanding of PFAS across the recycled organics industry is key to ensure successful management of PFAS, and contextually - without disrupting the industries growth and ability to divert organic waste resources from landfill in a manner that benefits Australia's economy and drive to reduce the national carbon emissions.

5. Response to the Draft PFAS NEMP 3.0

Section headlines:

- **Key objectives for AORA's review of the Draft PFAS NEMP 3.0 and provision of a response were to address or clarify issues related to the recycled organics industry and PFAS compliance, problem definition, the suitable application of existing data towards derivation of guidelines, establishing principals of net environmental benefit, and safeguarding the industries short- and long- term viability.**

- **Review outcomes largely covered 4 critical themes:**

  - **That source control should be a priority and will ultimately assist in reducing the burden of PFAS management at "end of pipe" operations.**

  - **The need for nationally consistent guidance on the analytical methods, PFAS suites and LORs, measures, data and uncertainty representation, and quality control methodologies for PFAS in recycled organics feedstocks, products and biosolids.**

  - **The need for the PFAS NEMP 3.0 to provide a more detailed risk-based and end-use focused framework which can be used to derive guideline values or in the interim assess the suitability of recycled organics products for land application.**

  - **Concerns surrounding conservative guidelines, or the adoption of conservative guidelines, that are not proportionate to risk rendering products and feedstocks PFAS non-compliant. In turn rendering businesses non-viable or directing large volumes of organics to landfill and hence passing PFAS burdens on to other "end of pipe" operators and back into the recycled organics circular economy.**

- **Impacts and recommendations as well as a detailed breakdown of reviews was provided for all the above themes in *Section 5* or the associated *Appendix 1*.**

5.1 AORA Response - Target Outcomes

Detailed below are the "target outcomes" as workshopped with AORA members, these detail the core objectives of the feedback provided by AORA for the Draft PFAS NEMP 3.0, and broadly state what AORA hopes to achieve by providing this feedback. These statements may be further developed for input into the AORA PFAS position statement. Target outcomes are detailed in **Table 9.**

Table 9 - Response Target outcomes developed with AORA

Target Outcome	Description
Compliance	Support the PFAS NEMP 3.0 with sufficient information and industry feedback so that the document can be further amended to ensure the framework is positioned in such a manner that the guidance contained within, when adopted by various jurisdictions, provides practical, clear and concise guidance for the recycled organics industry and recycled organics consumers can understand what is required from processors to be environmentally compliant.
Problem definition	Highlight that to suitably reduce risk associated with PFAS in recycled organics in a proportionate manner, further industry relevant data is required to better

Target Outcome	Description
	understand the extent of the problem and characterise the risk. This includes a comprehensive understanding of the sources and concentrations of PFAS contamination, noting that the organics recycling industry does not produce PFAS but is the recipient of the contamination through various feedstock sources.
Suitable Data	Demonstrate that where decision makers apply the precautionary principal to develop policy relying on only the limited available published data, there are likely to be perverse outcomes which will significantly impact on the short and long-term viability of the recycled organics industry.
Net Environmental Benefit	Raise concerns around the adoption of conservative regulation driving feedstock material previously recycled to landfill and increasing the national carbon footprint and forfeiting the benefits of circularity. Conservative management of PFAS at the organics recycling industry level poses a real risk of significantly reducing the commercial success and long-term viability of organic processing facilities.
Industry viability	Provide direction that there is a significant need to reduce uncertainty for recycled organics processors. Allow the industry to plan and better understand the impact of management of PFAS within the wider industry and for individual businesses to reduce the unfair regulatory burden away from the endpoint of contamination control and further towards contamination control through source control measures.

5.2 Draft PFAS NEMP 3.0 Detailed Response

On behalf of AORA, ADE has reviewed the Draft PFAS NEMP 3.0 and provided detailed feedback and recommendations for key sections as pertinent to the recycled organics industry. **Table A1.1** in **Appendix 1** details the full review provided by ADE, noting that this feedback is focussed on relevant sections of the Draft PFAS NEMP 3.0 and supporting documents. While the whole document was reviewed, **Table A1.3** details the focus areas based on changes to the Draft PFAS NEMP 3.0 as well as relevance to the recycled organics industry, this is a useful quick reference to find the most important sections with changes or information that may impact the recycled organics industry.

In addition, the review information for the Draft PFAS NEMP: 3.0 Supplementary Document (biosolids) is included in **Appendix 1** -**Table A1.2** alongside the relevant quick reference table (**Table A1.4**). The interpretation of focus issues and impact of the PFAS NEMP 3.0 on the recycled organics industry is included in **Sections 5.4 – Table 10**.

5.3 AORA Stakeholder Engagement

Following ADE's review of the Draft PFAS NEMP 3.0 and preparation of a draft version of this response, AORA members have been engaged via a round table event to provide feedback on items that need clarification in this document, or the inclusion of further recommendations based on their own understanding of the Draft PFAS NEMP 3.0. Roundtable engagement sessions have been used, in collaboration with AORA, to improve the target outcomes, response feedback and develop impact statements assist in highlighting key issues. This iterative approach has taken the form of feedback provided on the written draft, as well as a roundtable session held on the *22 of February 2023* - all AORA feedback and recommendations have been incorporated into this draft.

5.4 Draft PFAS NEMP 3.0 Review Outcomes

Detailed below in **Table 10** is a summary of the major outcomes of the draft PFAS NEMP 3.0 review, these observations are provided alongside impact statements for each key outcome. Responses are provided in **Appendix 1** - **Table A1.1** and **A1.2**. Recommendations for each item are included in the table in **Bold Blue**.

Table 10 – Key Draft PFAS NEMP 3.0 Review outcomes and impact statements for the recycled organics industry.

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
1	Review confirmed that guidance has been developed with very little supporting literature relevant to recycled organics. This has been reflected and is noted in the Draft PFAS NEMP 3.0 **Section 12.4** as a limiting factor and has been considered in providing general guidance. However, the net effect is that no clear guidance or assessment criteria have been put forward for recycled organics feedstocks or products, and these have not considered the wide variation in end use risk profiles.	While the general nature of the guidance recognises that PFAS are a likely risk in certain recycled organics feedstocks and products more than others, there is significant uncertainty surrounding how the provided guidance will be adopted by the various state jurisdictions. Based on its generality, its likely to be adopted very differently in each jurisdiction based on the Draft PFAS NEMP 3.0 guidance being so broad. Further, there may be significant public perception issues related to the uptake of recycled organics if the messaging surrounding how PFAS enters recycled organics products is not clear and supported by a sufficient body of literature. **Recommendations:** • **Further research is needed to expand the current state of knowledge to allow more specific guidance to be included in the PFAS NEMP 3.0.** • **Guidance needs to apply literature and Australian data to take into account end use of recycled organics materials, as the risk associated with use of recycled organic products potentially containing PFAS for mine rehabilitation or landscaping is not the same as agricultural applications. Further, the likely risks of using the same recycled organics product for livestock versus growing barley are likely to present very different risk profiles.** • **It is the role of the PFAS NEMP to provide guidance on key matters relating to PFAS, as such "Given the diversity of organic waste types, source and potential reuse scenarios, detailed guidance on how to appropriately assess and manage PFAS for specific waste types cannot be provided here" does not seem an appropriate position for the PFAS NEMP 3.0. Granted specific guidance can't be given, at a minimum: details for an appropriate risk-based framework or assessment approach for recycled organics end uses would be sufficient.**
2	**Section 12.4** has not included sufficient definition on the key PFAS species requiring management or suitable for inclusion in guideline criteria when	The later inclusion of additional PFAS species, or PFAS measures (i.e., ASLP, TOF or TOPA) or groupings, are likely to result in yet another shift in PFAS management goals and disrupt the organics recycling industry in a manner that is avoidable considering the existing state of knowledge.

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
	adopted by the various jurisdictions. This is likely to need to be realigned with the current literature which very broadly details which PFAS species are most prevalent in recycled organics (PFCAs and precursors).	Considering that at present in Australia the application of TOPA varies based on jurisdiction, and that overseas other PFAS are already requiring management, it would be prudent to make clearer the reasoning behind including or not including these in the current version of the PFAS NEMP to assist in streamlining and solidifying guidance that is likely to be adopted by the jurisdictions. In The United States, Illinois has provided guideline values for three additional PFAS in groundwater and put in place interim criteria for Perfluorononanoic acid (PFNA), Perfluorobutanesulfonic acid (PFBS) and Perfluorohexanoic acid (PFHxA) via a health advisory (Illinois EPA 2023). It would seem prudent to consider these more strongly now, rather than have industry re-adapt to every iteration of the PFAS NEMP based on the trickle-down effects of new guidelines for additional PFAS species. In addition, adding further consideration later can result in retrospective liabilities where duty holders are required to re-manage contaminated sites or materials and may be held accountable by other parties for pollution or damages. **Recommendations:** • **The PFAS NEMP 3.0 needs to make stronger consideration of the direction being taken in overseas jurisdictions, as well as literature strongly suggesting the prominence of exposure or equitable risk profiles for other PFAS species in the environmental and human health context. It would make more sense to include other PFAS species for consideration in guidance (or at least monitoring) as soon as is practicable. This is particularly true for biosolids and recycled organics where the key risk are not posed by PFOS and PFHxS, but by the PFCAs.**
3	Guidelines such as the new PFOA 0.05 µg/kg screening criteria for ecological indirect impacts are likely to present significant challenges and possibly be unattainable if set as recycled organics product compliance points.	PFCA guidelines in soil are not available, baring the 0.05 µg/kg indirect exposure ecological soil guideline for PFOA. However, even just this value is, without considering other PFCAs or a sum thereof, sufficiently low and restrictive enough to likely have downstream impacts via their use in the derivation of guideline values or risk-based assessment of suitable recycled organics product end uses by employing the guideline value as a Tier 1 criteria. This outcome will see the volume of acceptable feedstocks or end uses of recycled organics products significantly limited and may render certain organics recycling operations non-viable. This will also divert an increased volume of waste organics material unsuitable for recycling by these criteria to landfill to achieve compliance, where they will likely contribute to further PFAS mass flows to WWTPs, and hence to biosolids, at greater cost the recycled organics industry. **Recommendations:** • **Caution needs to be provided as related to the adoption of the indirect exposure ecological soil**

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
		guidelines for PFOA to assess recycled organics feedstock/product compliance as these are likely to result in many recycled organics products not being compliant – which may not necessarily represent risk based on the proposed end use. This is also the case for other PFCA's which may be added later. Collectively these will significantly reduce the suitability for recycled organics and see large volumes of organic waste resources being sent to landfill. The same is also likely if very conservative values are adopted for other PFAA species.
4	There is a considerable focus on downstream operations, where the entire PFAS mass load is largely applied by upstream sources. This places significant responsibility and burden on recycled organics processors to manage PFAS. Key wastes exerting these pressures include biosolids, paper and packaging wastes, some industrial sludges, and food waste streams containing compostable packaging.	The cost burden of managing PFAS largely falls to the end of pipe or circular operations within the waste sector, this will significantly impact the feasibility of several operations. If this is to remain the case, and in addition to other mitigation measures, financial support may be needed to offset the cost of PFAS management to prevent all the costs of managing this emergent issue being the responsibility of organics processors, in turn threatening their viability or need to increase gate fees and diminish the recycled organics market. **Recommendations:** • **Stronger recognition needs to be had that staunch source control and bans (commercial and consumer use) on a variety of PFAS species currently found making their way to end of pipe operators (e.g., WWTPs, Landfills, Organics recyclers) is critical in reducing PFAS mass flows to the environment.** • **Further, it needs to be recognised that considering the breadth of PFAS contamination in organic wastes, end of pipe operators are being required to take responsibility for the management (both risk and cost) of PFAS mass flows that have been generated external to their businesses.**
5	**Section 12.4**, which covers reuse of PFAS impacted materials, including recycled organics, is very general and while identifying the reasoning behind the risk generated by PFAS, it is not qualified in a meaningful way that gives readers an understanding of the data behind the risk drivers, making it hard to understand what aspects are likely to be adopted by various Australian jurisdictions and why.	This renders it very hard for organics processors to plan, and generates uncertainty surrounding the risk posed by certain feedstocks, leaving some operators in limbo as well as impacting the industries growth by acting as a barrier to new business commencing or existing businesses expanding until their viability can be assessed based on the acceptance or rejection of feedstock groups, feedstocks from certain sources, or end uses. **Recommendations:** • **While it is understood that specific guidelines cannot be given, a clearer framework is needed for the assessment of recycled organics products, this needs to take into account the feedstocks used (leveraging the Feedstock Management Plan), the composting process including blending and mass loss, and the proposed end use. Such an assessment needs to take into account the mass flow based on the above and allow risk-based decisions or form the basis for criteria selected by various jurisdictions.**

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
6	The Draft PFAS NEMP 3.0 puts forward the concept of a feedstock management plan (FMP) to assist in the management of PFAS by aiming to reduce PFAS contaminated feedstocks being accepted into organics recycling facilities. While this is certainly a useful tool, it fails to recognise that there are two key issues at play, the first being that a wide variety of recycled organics feedstock have diffuse but relatively low PFAS impacts. Secondly, that organics processing typically reduces mass of feedstocks resulting in higher PFAS mass proportions in the final product as compared to the feedstocks (not a 1:1 input to output ratio).	While there are no criteria to validate this impact in most jurisdictions, the adoption of conservative guidelines and the feedstock management plan may collectively serve as a tool that significantly reduces the type of feedstocks operators can accept, possibly impacting business viability – there is no guarantee without considering end use that this is risk proportionate. Further, there is the potential for the Feedstock Management Plan to generate significant barriers to the acceptance of materials that are made available an ad hoc or opportunistic basis if adopted as part of licencing or permit agreements – hence diverting these to landfill. **Recommendations:** • **It should be stressed that the feedstock management plan needs to be flexible to accommodate the changing nature of feedstocks, and not be incorporated as conditional based on the specifics contained in the FMP into licencing by the various jurisdictions.** • **State jurisdictions need to carefully consider any feedstock or product PFAS guideline values and if the selected value adequately represents the proportionate risk versus the benefits of recycled organics reuse, as compared to other PFAS exposure routes currently active. If guidelines are too conservative, these combined with the feedstock management plan will simply serve to demonstrate a great proportion of feedstocks and recycled organic products are not compliant, ultimately seeing them disposed of. This is a significantly negative outcome and not commensurate with the risk posed by these exposure pathways.**
7	While alluded to in the text, the interaction of blending (currently a common practice in the processing industry) and the concept of dilution are not adequately explored.	Recycled organics processors need to understand the role of blending and dilution in the PFAS NEMP 3.0 to facilitate the drafting of FMPs, but also to assess the compliance of their current processing approach. Further, there may be under some circumstances the ability to optimise feedstock acceptance and blending to still satisfy guideline values for PFAS, while at the same time maximising reuse of organic waste streams. Without clarification either the industry cannot be compliant, and optimisation of organic waste acceptance cannot be realised. **Recommendations:** • **Clarify language surrounding the blending of feedstocks as part of the organics recycling process, noting that this was already industry practice before the inclusion of PFAS as an environmental consideration and used as a tool to achieve optimum composting and product characteristics.**
8	The PFAS NEMP does not adequately characterise the end uses for recycled organics and how these would feed into an end-use specific risk-based approach,	Places significant risk of guideline criteria being generated and adopted that do not consider the end use and application method specific risk for recycled organics products. This has the potential to devalue or disallow certain markets and render certain recycled organics business models unviable by virtue of their feedstocks as

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
	especially where there are a variety of products that are used in different manners (i.e., Compost, soil conditioner, mulch and amended soils).	opposed to the actual risk posed. **Recommendations:** • **Provide a risk-based assessment framework as discussed in item 5 of this table.** • **Alternatively provide further guidance around the importance in considering recycled organics product end use in the derivation of guideline values to avoid the adoption of conservative catch all guidelines which render recycled organics product non-compliant in a manner that is not commensurate with risk.**
9	The guideline clearly suggests that some organic feedstocks are likely to be unsuitable for reuse in the organics recycling process, however this poses the question of what the fate of these materials will be, with only likely options being landfilling, pyrolysis or incineration.	This is at cross purposes with national resource recovery objectives, and contradictory to initiatives to improve circulatory, reduce carbon emissions and derive value added products from an increasing proportion of Australia organic waste streams. **Recommendations:** • **The document should elucidate the fate of these non-compliant or rejected materials clearly, and that adopted guidelines need to consider that if not recycled, the materials fate is landfill or destruction, at increased cost and at diminishing environmental value both of the waste resource materials in the circular economy and in terms of carbon emissions reductions.**
10	No treatment options that are tangible for the recycled organics industry are put forward in the DRAFT PFAS NEMP 3.0 to assist organic waste handling and recycling facilities in the management of PFAS.	This provides the organics recycling as well as handling industry with no options to mitigate risk or treat materials, rendering disposal the only option. **Recommendations:** • **Further information is required to detail the options available to the recycled organics industry for PFAS management. At present the document only includes the FMP and feedstock rejection as viable options, noting that these provide no benefit and are at the cost of the industry.** • **The document needs to explore currently available treatment or management option, plus those that could be further developed. These may include the role of blending, mass flux calculations, addition of agents to reduce leaching and bioavailability, pyrolysis, or other available technologies for the management of PFAS that may be applicable.**

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
11	No standardised testing has been put forward to support the Feedstock Management Plan.	AORA members wishing to engage in further testing of their materials (feedstocks and products) or commence with preparing FMPs do not have any consistent approach regarding the kind of data that should be collected, including the types of PFAS species, LORs, or requirements for TOPA that require inclusion. This will also interplay with guideline values adopted in each jurisdiction, where the measure used in laboratory reporting, FMPs and guidelines need to be consistent. Further, there the little information surrounding the testing of feedstocks and products at or near the detection limit and how reliable the data is considering uncertainty is likely to drive inconsistency in the application of data across the industry to decision make. **Recommendations:** • **Standardised suites of testing, including analytes, measures (like TOPA), and LOR need to be stipulated for recycled organics feedstocks and products to bring consistency across testing, FMPs and regulation. This needs to include information to bring consistency and a national approach to data processing and interpretation for measures like TOPA.** • **Data quality objectives, quality control, and statistical or data processing methodologies should be stipulated to ensure reliable decision making can be made for recycled organics products tested both in feedstocks and products when tested at considerably low detection limits in what is a relatively difficult analytical matrix (interference with extraction and analysis and quite heterogeneous), and that the data is comparable.**
12	There is not sufficient information surrounding the managing of recycled organics processing sites with respects to PFAS, as well as information for the management of leachate and rejected feedstocks.	Recycled organics processing facilities have not been provided with information detailing the key risks likely to require compliance monitoring (if any) for their facilities. At present there is risk of the treatment, storage and disposal of leachates and rejected feedstock or product not being compliant, notably when considering the specific classes of compounds known to be present in organic waste streams and their management differing to those typically discussed in the PFAS NEMP (PFOS, PFOA, and PFHxS). Leachate management poses a particular risk, where stringent PFAS compliance points are becoming unattainable for recycled organics processors. Considering some Water Authorities are implementing total PFAS limits at 1 µg/L Sum of PFAS or enforcing that PFAS needs to be either non-detect or PFOS below the 0.00023 µg/L – this presents a significant challenge to facilities receiving PFAS impacted material, in particularly where the Sum of PFAS is concerned. In some cases, this issue is halting operations as wastewater cannot achieve the compliance value. The Draft PFAS NEMP 3.0 does not issue guidance that is likely to assist with this matter, as water treatment options discussed in the document are likely not suitable for the range of PFCAs, short chain PFAS, and PFAA precursors present in wastewater derived from some recycled organics processing activities.

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
		The recycled organics industry is aware that PFAS discharged to WWTPs presents the industry a cyclic PFAS contamination management issue where PFAS re-enter the recycled organics circular economy in biosolids, as has been seen to be the case with biosolids sent to landfill due to PFAS contamination contributing to future biosolids PFAS mass loading via discharge of landfill leachates to WWTPs for treatment. **Recommendations:** • **Provide further information surrounding options and procedures for the management of organics recycling processing facilities with respects to rejected wastes streams (feedstocks/products) and leachates that contain PFAS. These may include disposal routes to avoid placing the contaminated material back into the circular economy, but also should focus on storage and handling considerations to prevent contamination and to reduce PFAS mass flow to the environment or other end of pipe receivers such as WWTPs.** • **Elaborate on disposal options, as all current options appear to result in passing the PFAS burden (at a cost) on to other end of pipe operators who are facing similar problems, whilst re-introducing PFAS mass back into the recycled organics circular economy.**
13	Language on the requirement for implementation and the development of state/ territory-based guidelines is not clear enough to drive action that is consistent and highlights the responsibility of the various jurisdictions to provide guidelines and not simply reference the NEMP 3.0.	Renders it possible that some jurisdictions will not adopt a clear position with suitable criteria and instead simply reference the PFAS NEMP leaving the organics recycling industry unclear on its compliance requirements with respects to products or the viability of their reuse. Currently the draft is at risk of creating a feedback loop where the PFAS NEMP places the onus of clarifying and adopting jurisdiction appropriate guidelines on each jurisdiction, and as at present, the jurisdiction referring to the final PFAS NEMP 3.0, leaving duty holders within the jurisdiction without guidance. This pattern is has already emerged across Australian jurisdictions and is current. Further, considering that nationally the NEMP is progressing to its third version and some jurisdictions are yet to release appropriate guidelines for soil, water and various waste streams, it is clear that stronger drivers are needed to push jurisdictions to produce guidance and disambiguate PFAS management for duty holders. **Recommendations:** • **Very clear language needs to be placed in the NEMP to drive the development of state and territory guidance of the management of PFAS for each jurisdiction. At present, many states do not have guideline values for several critical PFAS waste streams or exposure routes, and simply refer to the PFAS NEMP, which does not provide the required detail.**

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
14	New guidance on biosolids land application as related to PFAS is simple to follow and clear, however in reviewing the supporting document, there was some concern that a very high degree of conservancy had been built in and may restrict the use of some biosolids as well as biosolids based recycled organics products. These conservancy factors will be compounded should further PFAS species or additive guidelines for current and future regulated PFAS species be considered.	Some biosolids based products may be subject to disproportionate screening criteria based on the margins of safety, conservancy and assumptions used in derivation of guidelines not being relevant to end use and end use mechanism, though it is noted the MASCC and CBLAR approach is useful and could be applied across a range of recycled organic derived products. It needs to be recognised that this approach in itself introduces a safety margin by using the mean + Standard Deviation to address uncertainty in results on top of a range of other assumptions and conservancy factors, further compounded by the margin of safety. Further, there is a significant risk that biosolids limits will be adopted as de facto guideline values for recycled organics products across the whole organics industry. This is based on development of previous standards (e.g., AS 4454 mirrors the NSW Biosolids Guidelines, except allows higher Cu and Zn concentrations). Considering the Draft NEMP 3.0 references the 'Supporting documentation on Biosolids' when considering PFAS in recycled organics derived from biosolids, this logic is already applied to recycled organics in NSW i.e., the Biosolids Guidelines covers biosolids and any biosolids containing products (e.g. composts). This would mean that the same issues surrounding margins of safety, assumptions and conservancy impacting biosolids land application would have significant impacts on recycled organics, largely rendering most products non-compliant. Composting is widely used by wastewater industry in NSW and across Australia as an alternative to direct land application for additional treatment processing, management of odorous biosolids or during wet weather when direct land application is not possible. The nutrients in the biosolids compliment the high carbon value of the green waste and result in a more complete soil conditioner and allow for the beneficial use of both green waste and biosolids as one product. Such low limits for Unrestricted Use products have the potential to impact both the compost and wastewater industry as well as reducing the use of recycled organic products in agriculture to benefit productivity. Wastewater Treatment Plant biosolids rarely meet Unrestricted Use criteria without blending/ processing (dilution) with other materials due to Cu and Zn levels. If the PFAS NEMP 3.0 Supporting document is used to assess recycled organics (or those containing biosolids) in a similar manner to the NSW Biosolids Guidelines, the Unrestricted Use criteria becomes most appropriate with how most recycled organics are used. The use of the low Unrestricted Use thresholds comparative to soil limits is due to the risk assessment of Unrestricted Use biosolids assuming that the materials will be surface applied (therefore no dilution with soil) and there is no limit to application rate. In practical terms this simply isn't the case: • Compost is rarely applied at 'unlimited' application rates due to economic reasons and because landowners are generally trying to achieve a specific agronomic goal (improve soil organic carbon, improve soil microbiology and nutrients, retain moisture, prevent weeds). • While many organic amendments may be incorporated into the soil, many farmers are using minimum

Outcome	Key Draft PFAS NEMP 3.0 Review outcomes	Impact Statement
		till techniques and therefore will choose to surface apply compost but at a limited rate. Considering the above, unrestricted use is the preference for recycled organics products, but soil thresholds are very low and are unlikely to be attainable based on feedstock, blending, or cost of achieving compliance. This will result likely result in many biosolids, composts or any materials under the influence of such guidance being deemed unfit for purpose and requiring disposal to landfill or further management. An outcome born out of conservancy and assumptions (**See Appendix 1 Table A1.2**) that do not holistically consider the risk posed by the various recycled organics end uses. This has a net negative environmental impact due reduced material circularity and the removed the agronomic benefit currently derived for the reuse of recycled organics as soil amendments. **Recommendations:** • **The full nature of all impacts on the wastewater treatment industry as well as the recycled organics industry need to be considered before adopting new guideline values for PFAS.** • **Biosolids guidelines should not be adopted for all recycled organics products.** • **Any guideline limits need to take into account the risks associated with different end use settings rather than assume home consumption produce, which is a very limited segment of the end use market.** • **Processors need a risk assessment process or framework which could be used for biosolids and other recycled organics products to determine land application suitability that is simple and affordable.**

6. Conclusion and Closing

Based on the outcomes of the PFAS NEMP 3.0 review, literature review and AORA survey, it is clear that PFAS management and regulation in the organics recycling industry is still an evolving space that requires very careful consideration to preserve an industry that provides significant economic benefits, carbon emission reduction, a diversion pathway for waste from landfill for beneficial reuse, a critical amenity for many residential and council customers and agronomic or environmental benefit by improving Australian soils. It's crucial that this is reflected in the PFAS NEMP 3.0 as this will drive the adoption of sensibly environmentally protective guidance across Australia that fosters the growth of the recycled organics industry.

Considering the frequency at which the PFAS NEMP is likely to be updated and then adopted by other jurisdictions, it is important that guidance in the PFAS NEMP 3.0 is complete, considered, and as fit for purpose. Any changes that need to be made after completion of the PFAS NEMP 3.0 will be hard to reverse and the impacts on the recycled organics industry while the regulation is rebalanced will be both significant and protracted. As such, it is crucial that the concerns raised through this response are duly addressed before the PFAS NEMP 3.0 is finalised.

Unclear guidance that is disproportionate and overly conservative will actively disrupt the organic recycling industry, prevent growth, reduce public amenity, but more so, result in the diversion of large volumes of organic waste to landfill. While managing PFAS impacts on the environment is important, the net impact on carbon emissions needs to be accounted for alongside the net environmental impact generated by PFAS. Further, PFAS impacted materials entering landfill are known to impact leachates, which are often discharged WWTPs, in turn perpetuating the PFAS contamination cycle through PFAS contaminated biosolids or recycled water. As such our national PFAS practices need to be considered holistically, and not be the burden of "end of pipe" resource recovery operations.

To build on this, the national focus must be strongly centred on significantly reducing the mass flow of PFAS into the environment to begin with, this should include the removal of PFAS from products either manufactured or imported into Australia, and the adequate management of legacy PFAS impacted sites. This "turning off the tap" will have meaningful and sustained downstream benefits, but more importantly, reduces the intensity of ongoing PFAS management for a wide range of industries in the future. Attention can simultaneously be paid to end of pipe solutions, noting that PFAS contamination in the recycled organics industry is based on inputs contaminated by other sources.

To achieve the above, the final version of PFAS NEMP 3.0 needs to:

- Encourage research to address data gaps and both characterise and quantitate risk to ensure the impact of guidelines and mitigation measures are suitably proportionate to the risk of end uses.
- Provide regulators and industry users with a clear set of objectives, including testing requirements and target PFAS species to disambiguate and reduce uncertainty around compliance.
- Support that disproportionate or overly conservative regulation will likely drive significantly undesirable outcomes such as increasing carbon emissions, or transferring PFAS management obligations onto other industries in the waste management sector (i.e., landfills and WWTPs) thereby increasing the cost of managing the national PFAS issue, with minimal benefit.

ADE and AORA recognise and celebrate the efforts of the National Chemicals Working Group of the Heads of EPAs in keeping the PFAS NEMP up to date, and would like to thank all involved for the opportunity to provide a response. We look forward to further engaging with relevant parties toward supporting the update of the document in a manner that is meaningful, and supportive of the best interests of the Australian environment, people, and economy.

7. REFERENCES

Agency for Toxic Substances and Disease Registry (ATDSR) 2018, What are PFAS? viewed 20 January 2023, https://www.atsdr.cdc.gov/pfas/overview.html

Australian Packaging Covenant Organization (APCO) 2021, PFAS in fibre-based packaging.

Australian Packaging Covenant Organization (APCO) 2022, Action plan to phase out PFAS in fibre-based food contact packaging.

Arcadis 2019, Critical evaluation of composting operations and feedstock suitability phase 2 – contamination department of environment and science contract DES18070 final.

Australian Economic Advocacy Solutions (AEAS) 2022, The economic contribution of the Australian organics recycling industry, August 2022.

Australian Economic Advocacy Solutions (AEAS) 2021, Australian organics recycling industry capacity assessment: 2020-21, published January 2021.

Australian Government 2020, National greenhouse gas inventory – December 2020 update.

Boisvert, G, Sonne, C, Rigét, FF, Dietz, R, & Letcher, RJ 2019, 'Bioaccumulation and biomagnification of perfluoroalkyl acids and precursors in East Greenland polar bears and their ringed seal prey', Environmental Pollution, vol. 252, pp. 1335–1343.

Buck, RC, Franklin, J, Berger, U, Conder, JM, Cousins, IT, De Voogt, P, Jensen, AA, Kannan, K, Mabury, SA, & van Leeuwen, SP 2011, 'Perfluoroalkyl and polyfluoroalkyl substances in the environment: terminology, classification, and origins', Integrated Environmental Assessment and Management, vol. 7, no. 4, pp. 513-541.

Choi, YJ, Lazcano, RK, Yousefi, P, Trim, H, & Lee, LS 2019, 'Perfluoroalkyl acid characterization in U.S. municipal organic solid waste composts', Environmental Science & Technology Letters, vol. 6, no. 6, pp. 372-377, doi: 10.1021/acs.estlett.9b00280.

Costello, MCS & Lee, LS 2020, 'Sources, fate, and plant uptake in agricultural systems of per- and polyfluoroalkyl substances', Current Pollution Reports, viewed 20 January 2023, https://doi.org/10.1007/s40726-020-00168-y

Death, C, Bell, C, Champness, D, Milne, C, Reichman, S, & Hagen, T 2021, 'Per- and polyfluoroalkyl substances (PFAS) in livestock and game species: a review', Science of the Total Environment, vol. 774, 144795, ISSN 0048-9697, doi: 10.1016/j.scitotenv.2020.144795.

D'Eon, JC & Mabury, SA 2011, 'Is indirect exposure a significant contributor to the burden of perfluorinated acids observed in humans?', Environmental Science & Technology, vol. 45, no. 19, pp. 7974–7984, doi: 10.1021/es200171y.

Department of Environment, Climate Change and Water (DECCW) 2020, Short report: the benefits of using compost for mitigating climate.

Domingo JL, Nadal M. (2019). Human exposure to per- and polyfluoroalkyl substances (PFAS) through drinking water: A review of the recent scientific literature. Environmental Research, 177, 108648. https://doi.org/10.1016/j.envres.2019.108648

Eriksson U, & Kärrman A. (2015). World-wide indoor exposure to polyfluoroalkyl phosphate esters (PAPs) and other PFASs in household dust Environmental Science & Technology, 49(24), 14503-14511. https://doi.org/10.1021/acs.est.5b00679

Frontier Environmental and AG. (2021). Review of regulations and standards for recycled organics in Australia: Final report for Department of Agriculture, Water and Environment June 2021.

Food Standards Australia New Zealand (FSANZ). (2017). Hazard assessment report – Perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorohexane sulfonate (PFHxS).

Breitenbeck, G. A., & Schellinger, D. (2004). Calculating the reduction in material mass and volume during composting. Compost Science & Utilization, 12(4), 363-371. https://doi.org/10.1080/1065657X.2004.10702206

Gobas, F. (2020). A framework for assessing bioaccumulation and exposure risks of per- and polyfluoroalkyl substances in threatened and endangered species on aqueous film forming foam (AFFF)-impacted sites. Strategic Environmental Research and Development Program, Alexandria, VA, USA. https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER18-1502

Government of South Australia. (2021). SA organics sector analysis summary (2021).

Herzke, D., Olsson, E., & Posner, S. (2012). Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in consumer products in Norway – A pilot study. Chemosphere, 88(8), 980-987. https://doi.org/10.1016/j.chemosphere.2012.03.035

Houde, M., Czub, G., Small, J. M., Backus, S., Wang, X. W., Alaee, M., & Muir, D. C. G. (2008). Fractionation and bioaccumulation of perfluorooctane sulfonate (PFOS) isomers in a Lake Ontario food web. Environmental Science & Technology, 42(24), 9397-9403. https://doi.org/10.1021/es802200h

Hu, X. C., Andrews, D. Q., Lindstrom, A. B., Bruton, T. A., Schaider, L. A., Grandjean, P., Lohmann, R., Carignan, C. C., Blum, A., Balan, S. A., Higgins, C. P., & Sunderland, E. M. (2016). Detection of poly- and perfluoroalkyl substances (PFASs) in U.S. drinking water linked to industrial sites, military fire training areas, and wastewater treatment plants. Environmental Science & Technology Letters, 3(10), 344-350. https://doi.org/10.1021/acs.est

Illinois Environmental Protection Agency. (2023). PFAS statewide health advisory. https://www2.illinois.gov/epa/topics/water-quality/pfas/pages/pfas-healthadvisory.aspx

Interstate Technology Regulatory Council. (2022a). Naming conventions for per- and polyfluoroalkyl substances (PFAS) 2022.

Interstate Technology Regulatory Council. (2022b). Fate and transport of per- and polyfluoroalkyl substances (PFAS).

Ghisi, G., Vamerali, T., & Manzetti, S. (2019). Accumulation of perfluorinated alkyl substances (PFAS) in agricultural plants: A review. Environmental Research, 169, 326-341.

Johnson, M. S., Buck, R. C., Cousins, I. T., Weis, C. P., & Fenton, S. E. (2021). Estimating environmental hazard and risks from exposure to per- and polyfluoroalkyl substances (PFAS): Outcome of a SETAC focused topic meeting. Environmental Toxicology and Chemistry, 40, 543-549. https://doi.org/10.1002/etc.4784

Kelly, B. C., Ikonoumou, M. G., Blair, J. D., Surridge, B., Hoover, D., Grace, R., & Gobas, F. (2009). Perfluoroalkyl contaminants in an Arctic marine food web: Trophic magnification and wildlife exposure. Environmental Science & Technology, 43, 4037–4043. https://doi.org/10.1021/es900212d

Kenny, S. (2021). Emerging issues in food waste management: Persistent chemicals. U.S. EPA Office of Research and Development.

Lazcano, R., De Perre, C., Mashtare, M., & Lee, L. (2019). Per- and polyfluoroalkyl substances in commercially available biosolid-based products: The effect of treatment processes. Water Environment Research, 91, 1669-1677. https://doi.org/10.1002/wer.1077

Lazcano, R. K., Choi, Y. J., Mashtare, M. L., & Lee, L. S. (2020). Characterizing and comparing per- and polyfluoroalkyl substances in commercially available biosolid and organic non-biosolid-based products. Environmental Science & Technology, 54(14), 8640-8648. https://doi.org/10.1021/acs.est.9b0728

MacRae, J., Nayak, B., Isenhour, C., Blackmer, T., & Silka, L. (2020). The emergent risks of food waste recovery: Characterizing the contaminants in MSW organics from different sources. Environmental Research and Education Foundation.

Martin, J. W., Whittle, D. M., Muir, D. C. G., & Mabury, S. A. (2004). Perfluoroalkyl contaminants in a food web from Lake Ontario. Environmental Science & Technology, 38, 5379–5385. https://doi.org/10.1021/es049419k

Moodie D, Coggan T, Berry K, Kolobaric A, Fernandes M, Lee E, Reichman S, Nugegoda D, Clarke BO (2020), Legacy and emerging per- and polyfluoroalkyl substances (PFAS) in Australian biosolids, Chemosphere, volume 270, 2021, ISSN 0045-6535, https://doi.org/10.1016/j.chemosphere.2020.129143

Munoz M, Michaud AM, Liu M, Duy SV, Montenach D, Resseguier C, Watteau F, Valérie Sappin-Didier V, Frédéric Feder F, Thierry Morvan T, Sabine Houot S, Mélanie Desrosiers M, Jinxia Liu J, and Sébastien Sauvé S (2022), Target and nontarget screening of PFAS in biosolids, composts, and other organic waste products for land application in France, Environmental Science & Technology 2022 56 (10), 6056-6068 DOI: 10.1021/acs.est.1c03697

National Institute of Environmental Health Sciences (NIEHS 2020), Perfluoroalkyl and polyfluoroalkyl substances (PFAS). https://www.niehs.nih.gov/health/topics/agents/pfc/index.cfm

National Toxicology Program (NTP 2016). NTP Monograph: Immunotoxicity associated with exposure to perfluorooctanoic acid or perfluorooctane sulfonate. Research Triangle Park, NC: U.S. Department of Health and Human Services, National Institutes of Health, National Toxicology Program. https://ntp.niehs.nih.gov/ntp/ohat/pfoa_pfos/pfoa_pfosmonograph_508.pdf

National Toxicology Program (NTP 2019a), Toxicity studies of perfluoroalkyl carboxylates administered by gavage to Sprague Dawley (HSD:Sprague Dawley SD) rats. (TOX-97). Research Triangle Park, NC. https://ntp.niehs.nih.gov/ntp/htdocs/st_rpts/tox097_508.pdf

National Toxicology Program (NTP 2019b), Toxicity studies of perfluoroalkyl sulfonates administered by gavage to Sprague Dawley (HSD:Sprague Dawley SD) rats. (TOX-96). Research Triangle Park, NC.

https://ntp.niehs.nih.gov/ntp/htdocs/st_rpts/tox096_508.pdf

National Toxicology Program (NTP 2020), Toxicology and carcinogenesis studies of perfluorooctanoic acid administered in feed to Sprague Dawley (HSD:Sprague Dawley SD) rats. (TR-598). Research Triangle Park, NC. https://ntp.niehs.nih.gov/ntp/htdocs/lt_rpts/tr598_508.pdf

Organisation for Economic Co-operation and Development (OECD 2018). Toward a new comprehensive global database of per and polyfluoroalkyl substances (PFAS): summary report on updating the OECD 2007 list of per and polyfluoroalkyl substances (PFAS). https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV-JM-MONO(2018)7&docLanguage=EN

Organisation for Economic Co-operation and Development (OECD 2021). Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance

Ramírez AC, Lestido-Cardama A, Vazquez PL, Barbosa-Pereira L, Rodríguez AB, Sendón R (2021), Presence of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Food Contact Materials (FCM) and Its Migration to Food. Foods, 10, 1443. https://doi.org/10.3390/foods10071443

Shiralipour A, McConnell DB, Smith WH (1992), Uses and Benefits of MSW Compost: A Review and an Assessment, Biomass and Bioenergy, Volume 3, Issues 3–4.

Sinclair, G; Long, S; Jones, O. (2020). What are the Effects of PFAS Exposure at Environmentally Relevant Concentrations? Chemosphere 258: 1-15

Sivaram AK, Panneerselvan L, Surapaneni A, Lee E, Kannan K, Megharaj M (2022), Per- and Polyfluoroalkyl Substances (PFAS) in Commercial Composts, Garden Soils, and Potting Mixes of Australia, Environmental Advances, Volume 7, 2022, ISSN 2666-7657, https://doi.org/10.1016/j.envadv.2022.100174

Susmann HP, Schaider LS, Rodgers KM, and Rudel RA (2019), Dietary Habits Related to Food Packaging and Population Exposure to PFASs, Environmental Health Perspectives, vol. 127, no. 10, https://doi.org/10.1289/EHP4092

Thakali A, MacRae JD, Isenhour C, Blackmer T (2022), Composition and Contamination of Source Separated Food Waste from Different Sources and Regulatory Environments, Journal of Environmental Management, Volume 314, 2022, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2022.115043

Tomy GT, Pleskach K, Ferguson SH, Hare J, Stern G, Macinnis G, Marvin CH, Loseto L. 2009. Trophodynamics of Some PFCs and BFRs in a Western Canadian Arctic Marine Food Web. Environ Sci Technol 43:4076–4081

U.S. Environmental Protection Agency (U.S. EPA 2018B). Basic Information on PFAS. https://www.epa.gov/pfas/basic-information-pfas

Vaughn, B; Winquist, A; Steenland, K. (2013), Perfluorooctanoic Acid (PFOA) Exposures and Incident Cancers Among Adults Living Near a Chemical Plant. Environmental Health Perspectives 121: 1313-1318.

Vested, A; Ramlau-Hansen, C; Olsen, S; Bonde, J; Kristensen, S; Halldorsson, T; Becher, G; Haug, L; Ernst, E; Toft, G. (2013), Associations of in utero exposure to perfluorinated alkyl acids with human semen quality and reproductive hormones in adult men. Environmental Health Perspectives 121: 453-458.

Waste & Resources Action Programme (WRAP 2011), New markets for digestate from anaerobic digestion. (ISS001-001). https://www.wrap.org.uk/sites/files/wrap/New_markets_for_AD_WRAP_format_final_v2.c6779ccd.11341.pdf

WCA Consulting (2019), Review of scientific literature on compost produced from food and garden organic waste final report to New South Wales Environment Protection Authority from WCA June 2019*

Appendix 1 – Review and Quick Reference Tables

Table A1.1 – Draft PFAS NEMP 3.0 Review Table. Recommendations related to the impacts described for each item are included in the table in **Bold Blue**.

Identifier (Section/line/point/paragraph/table)	Comment/Question
General	Throughout the document PFAS guidance is considered in terms of concentration. While this is a standard approach for both contaminated land and waste, it has significant limitations for highly mobile, persistent and bioaccumulative compounds such as PFAS. **Recommendations:** • **It is recommended that a section detailing the concept of mass flux is added, noting that instantaneous measures such as concentrations (in groundwater or via leaching protocols such as ASLP) are, on their own, static measurements and do not provide adequate representation of PFAS environmental behaviour. Mass flux approaches consider contaminant mass store, leaching extent and timeframe, dilution, and can factor in transformation and half-life.**
Section 1.1 dot point 3: "Recognises that production processes and products change over time and the definitions of what constitutes PFAS change to reflect this"	As definitions change, so will the need for management requirements based on the new compound of interest. Broadly, industry cannot reposition every time a new PFAS species is included. I.e., for short chain, it would be more suitable to have these included in NEMP as soon as possible to avoid a scenario of constantly shifting the goal posts. Further, additional complexity is generated when the changing NEMP is to different extents across jurisdictions – constant changes will result in increasing disagreement between regulation and guidelines implemented across states. **Recommendations:** • **Flagging PFAS species for likely future inclusion in the PFAS NEMP now will allow industry sufficient time to adequately prepare.**
Section 1.1 dot point 7: "Recognises that PFAS other than PFOS, PFOA, and PFHxS are likely to be present in greater proportions in situations where historic contamination has not significantly degraded and where modern replacement PFAS, which are not based on PFOS, PFOA, and PFHxS and related compounds, are predominant (e.g., Weiner et al. 2013)"	Especially important for diffuse sources or matrices that are sinks for PFAS, such as sediments, waste water, biosolids and other organic matrices where PFAS diffuse sources are concentrated. Not necessarily historic contamination, but highlights a need for greater focus on secondary and end of pipe contamination as document is largely point source focused. Addressed to some degree in dot point 9. **Recommendations:** • **Include wording on diffuse contamination and its concentration in certain matrices (sinks) to form secondary sources.**
Section 2.1: "PFHxS, its salts and PFHxS-related compound"	Does this mean we can expect ecological guidelines such as in Table 6 to expand to PFOS+PFHxS. Should this have happened in this version of the NEMP to align with the inclusion? Or is there a toxicological or data-based reason that PFHxS has not been included in Ecological guideline values for soil and water? **Recommendations:** • **Clarify reasoning behind this for the reader. A general note or notes to**

Identifier (Section/line/point/paragraph/table)	Comment/Question
	relevant tables would be sufficient.
Section 4	While the adoption of aspects of the PFAS NEMP by Australia's various jurisdictions is outside the scope of the PFAS NEMP, stronger and clear language is required to drive jurisdictions to adopt the NEMP and produce guidance material as supported by the NEMP that is clear and specific. Particularly, issues in wording around state and territory jurisdiction's referring to "adopting" or "in line" with the NEMP without providing further material guidance. It needs to be abundantly clear that the NEMP provides general guidance, and specific guidance such as criteria need to be provided or adopted by each jurisdiction. This is a key issue and needs to be strongly considered, as it will both serve to strengthen the position and functionality of the NEMP and drive jurisdictions to produce their own guidelines and engagement activities with industry and the public. This will create regulation that is relevant to a given jurisdiction as opposed to a blanket statement leaning on the NEMP which does not contain these details. Noting that throughout the document it is stated that the details of many guidelines and the framework are to be clarified, or confirmed with the local authority insofar as compliance criteria/requirements are concerned. **Recommendations:** • **Strengthen wording to prevent risk of state jurisdictions referring to the NEMP as opposed to formulating jurisdiction and problem specific guidance or positions.**
Section 5.2.1 – Table 1	It seems that there should be an industrial ambient category. Since Industrial areas are known to be impacted by PFAS and PFAS are indicators of industrial activities, it would make sense to acknowledge that we expect these areas to be impacted and as such have a land use class and associated measures to match. **Recommendations:** • **Assess need for an ambient category for industrial areas, since these are likely to have significantly elevated ambient PFAS from diffuse industrial sources and are somewhat excluded from the current ambient groupings.**
Section 5.3 "Due to the bioaccumulative and biomagnifying nature of PFAS, additional PFAS-specific considerations include the need to sample aquatic and other biota and animal/human food sources wherever a plausible transport pathway from a contamination source exists. Note that sampling exposed aquatic biota is necessary for effective assessment even if water concentrations are below the limit of reporting (LOR) (refer NSW EPA (2016) for further information)".	How will industry know if ecological receptors have been exposed? Is this in reference to a particular (known) acute but short-lived event? Or is it suggesting this based on the variations in PFAS mass load (external factors driving variation) in water, which may render water samples an unreliable measure as single discrete measurements. Surely, it's not being suggested that biota is to be sampled for any potentially completed pathway, even if the pathway does not have data to suggest completeness or PFAS presence (where variation is accounted for). **Recommendations:** • **Clarify if this is a driver to test biota for PFAS where results are <LOR and there are no other lines of evidence for PFAS impacts in analytical data – but perhaps a known spill event or historical source.**
Section 6.1 – Point 5	Would this likely include sites where reuse of other recycled organics including or not including biosolids have been applied? **Recommendations:**

<table>
<tr><th>Identifier (Section/line/point/paragraph/table)</th><th>Comment/Question</th></tr>
<tr><td></td><td>Clarify if this includes sites where reuse of other recycled organics including or not including biosolids have been applied.</td></tr>
<tr><td>Section 8.1 – Paragraph 1
“The identification of PFAS above relevant guideline values acts as a trigger to undertake further investigations (such as site-specific risk assessment, as opposed to the assumption that harm will have occurred)”,</td><td>This presents an issue in the wording versus what in practice. Guideline values are often applied by some jurisdictions as compliance values as opposed to trigger values for more detailed assessment.

How can there be such discrepancy between the screening values (i.e., ecological indirect) and the compliance points for matrices such as soils, biosolids and composts, for two of which the guideline value (compliance) is 10x less than the screening value in some jurisdictions. Many guideline values adopted or used by jurisdictions don’t appear to have taken contextual assessment of risk into consideration.

Recommendations:
Stronger wording is needed to support that these guidelines are triggers for further investigation and not compliance or remedial criteria, and that compliance criteria or remedial criteria need to be set in context with the risk of a given activity (or as determined by the triggered investigation).</td></tr>
<tr><td>Section 8.6</td><td>Does not at present provide much guidance or narrative around PFAS entering the food chain via agriculture, either on contaminated land, using contaminated water or through biosolids production and inclusion in soils. The section covers home grown and wild caught foods to some degree but does not consider how the guidelines interact with PFAS impacted produce on a broader scale – which is increasingly becoming a consideration.

Recommendations:
A greater deal of focus needs to be paid to secondary sources of PFAS entering the food chain as well as their role in potential PFAS exposure in an agricultural and produce settings.</td></tr>
<tr><td>Section 8.7.3 – Table 8</td><td>The 0.23 ng/L is a very low value, and at timed wrongly applied as an aspirational target or treatment criteria in water. Considering this, more language needs to be placed around comparing target values to this guideline, and noting that this is a guideline at receptor and therefore cannot be applied to leachabilities (or in many cases, drinking water), without accounting for DAF factors and mass flux sustenance. Direct comparison is not appropriate as it is without context of the exposure route, and extent over a timeframe.

Recommendations:
0.23 ng/L is very restrictive, and language should be placed in the PFAS NEMP 3.0 detailing the uncertainty and conservancy of this value and how this should impact its utilisation by the various jurisdictions in PFAS guidance, where it certainly should not be used as a compliance value or compared to leachability values directly or as the default position.</td></tr>
<tr><td>Section 8.8 – Paragraph 2</td><td>Is this directly suggesting the application of the precautionary principal to other PFAS, and if so, this would be a major step suggesting environmental monitoring and potentially management is required for other PFAS.

Recommendations:</td></tr>
</table>

Identifier (Section/line/point/paragraph/table)	Comment/Question
	• **Other PFAS species should either be included in the PFAS NEMP 3.0 or flagged now for future inclusion to give industry adequate time to prepare, but also to direct appropriate research.**
Section 8.8	It would seem prudent that the groupings are centred on not just toxicity, but how we measure them and how they transformation in the environment. A middle ground between an additive and grouping PFAAs with precursors makes sense and applies a relative degree of adequate conservatism. It does not allow for synergist effects, but very little literature documents these even existing (little evidence to suggest). Further, values can be divided into sub group on behaviours such as the “other risk factors” related to chain length or functional group. TOF unlikely to be adequately sensitive. Total PFAS is superseded by an additive approach, grouped by precursors and sub grouped by mobility/risk/tox in so far as usefulness of data is concerned. Total PFAS is useful as a screening tool. **Recommendations:** • **Groupings need to consider toxicity, but also environmental behaviour and transformation.**
Section 9.3.2 – Line 1595 “It is also important to note that the level of additional impact/disturbance permitted in aquatic ecosystems may be set by the environmental regulator and that the use of a value providing a lower level of protection may not be permitted”.	Needs more explanation as to how or why this may happen. This generates significant uncertainty. **Recommendations:** • **In discussing additive PFAS impacts to already impacted systems, a greater degree of explanation is required to assist in better understanding what is and is not appropriate. This will assist in not creating guideline values or regulation that is too restrictive while also avoiding a scenario where it is allowable to “pollute to the guideline” and the additive effects at secondary sources/sink (i.e., sediments) become unsustainable, even at the guideline value at point of release, over time.**
Section 10.1 “Where the volume of material is minimal (for example, less than 10m^3 taken together or in aggregate), the proposed storage is transient (less than 48 hours) and rain is not predicted, then a practical approach to managing the material may be considered.”	Does not apply to materials received and perhaps rejected from composting process, likely to be far lower than the 50 mg/kg mark. A threshold at which the more stringent requirements for stockpile management do/don’t apply is needed. i.e., holding stockpiles. Further the Total Concentration (TC) is not a good triage point, as leachability is often the limiting factor limits when material is too high for reuse, too high for landfill, and requires staging for other destructive/immobilisation technologies– this material may still be a relatively low PFOS +PFHxS total concentration. **Recommendations:** • **A concentration threshold (total or leachable concentration) at which the more stringent requirements for stockpile management do/don’t apply is needed.**
Section 12 – Paragraph 1: “Materials containing low levels of PFAS may be considered by environmental regulators for reuse under some	Soils amended with recycled organics are likely to contain some form of PFAS. Clearer guidelines around reuse of low level PFAS impacts soils is required across many jurisdictions. There is also a discrepancy between recycled organics products for incorporation, and those added to soils at low ever levels for non-agronomic

Identifier (Section/line/point/paragraph/table)	Comment/Question
circumstances, particularly for the purpose of resource recovery in accordance with the waste hierarchy presented in the National Waste Policy (Commonwealth of Australia 2018)".	benefits to meet specifications or general use. i.e., recycled organic product with 5 µg/kg PFOS may be consider unsuitable as a compost product, but considering that the process to produce some products (soils) involves blending the compost with soil at a maximum addition of 10% to make a conditioned reclaimed soil to meet landscaping specification (as an example), where the mass dilution would be reducing concentration to 0.5 µg/kg and the soil product is the final product. **Recommendations:** • **While it is understood that blending to reduce classification is unacceptable, there is a need for further clarity around where blending is already a part of the process and if this will satisfy regulators to treat these existing blending activities as part of the process and not as dilution.**
Section 12.4 - Paragraph 1	Paragraph makes a very general but critical statement without a reference for a subject that cannot be considered common knowledge in the industry, while true, it's critical to highlight the lack of data in this area. This may also assist stakeholders in understanding why there is not as much detail in this section as compared to sections on WWTPs or remediation. **Recommendations:** • **Critical need to highlight the lack of data in this area and thus the uncertainty.**
Section 12.4 - Paragraph 2	Note that the incorporation of recycled organics into soil, where the soil is the product, is a common practice. This has ramification for testing and how blending is factored in to the process. Here, the organics is used as a soil conditioner, but undertaken on site to meet specification, and the recovered blended soil and recycled organics material the product for beneficial reuse. **Recommendations:** • **Detail how soil products that are part of the organics recycling process are included in the current framework.**
Section 12.4 - Paragraph 3	Couldn't the same mass loading approach as suggested in Section 15 (CLBAR) be applied (maybe differently, considering end uses to derive compliance points) to all recycled organics products. Note around the current approach of assessing finished product but not taking into account end use, i.e., QLD guidelines can result in outcomes being very conservative and the disallowed use disproportionate to the actual risk. **Recommendations:** • **An end-use specific set of guideline values is required for recycled organics, alternatively a risk-based assessment to determine suitability end use suitability could achieve a similar but more flexible outcome.**
Section 12.4.1 Paragraph 3	Can a reference to study be provided. **Recommendations:** • **Make study available.**

Identifier (Section/line/point/paragraph/table)	Comment/Question
Section 12.4 - Table 10	How was the qualitative risk ranking derived, if it general, was there a qualitative matrix or similar used? While it makes sense and is likely fairly accurate, is there a data-based decision process here. For example, biosolids depends on the WWTP. Rural plants can have VERY low PFAS, there are far more of these than WWTPs with significant PFAS burdens. Again, while the NEMP acknowledges this, the current hierarchical risks blanket bans of those items on the top or perception issues for products derived from feedstocks higher up the hierarchy of risk just by virtue of source and not extent of contamination. **Recommendations:** • **Include a description on how the risk ranking was derived and note more strongly that these rankings are still dependant on source to mitigate perception risks or blanket regulation of feedstocks types which may not be equally impacted based on geography or other contextual parameters.**
Section 12.4.2: "PFAS NEMP general obligations in Section 3.1 requires persons to ensure proper disposal of PFAS contaminated waste, for example, by properly characterising waste and sending it to a facility licensed to accept it, noting dilution is not acceptable in soil, air, compost or other wastes or products. However, with proper screening of inputs, beneficial reuse of some organic wastes through their incorporation into resource recovery products can be supported.	The wording used in this section can generate confusion, particularly where the nature of recycled organics processing is to acquire a variety of organic waste materials for processing (which almost always involves blending and proportioning) and then potentially adding to soil in some cases to produce a organics/soil product. There needs to be an appreciation for this, and the allowable thresholds need to note this blending and clarify, if this is not considered dilution. **Recommendations:** • **Clarify what is meant by the term blending as this is currently practiced by the recycled organics industry and note how this interacts with the concept of dilution. Acceptable parameters in this regard would also be useful, and could be derived by understanding current or pre-PFAS feedstock blending practices.**
Section 12.4.2 "Licensed to accept it, noting dilution is not acceptable in soil, air, compost or other waste"	This means that those that are not acceptable, which depending on the above point, may be a great volume of material will either be incinerated, pyrolyzed or landfilled. **Recommendations:** • **Clarify what is meant by the term blending as this is currently practiced by the recycled organics industry and note how this interacts with the concept of dilution. Acceptable parameters in this regard would also be useful, and could be derived by understanding current or pre-PFAS feedstock blending practices.**
12.4.2 – Paragraph 2	This contradicts or is at cross purposes with paragraph one, above. At present there is little to no PFAS based restriction for recycled organics in most jurisdictions, Paragraph 1 suggests that alternatives are required for "some" input materials that are screened out based on reuse suitability (PFAS concentration). This will most likely directly result in these materials diversion to landfill. Paragraph 2 discusses diverting materials away from landfill, the exact opposite outcome of the preceding statement of paragraph 1 – and is not consistent with what paragraph 1 is suggesting. While literally this makes sense, and practicality with respects to how it translates in the real world, these two concepts are currently opposed.

Identifier (Section/line/point/paragraph/table)	Comment/Question
	Recommendations: • **Clearly state or recognise that the rejection of feedstocks based on PFAS concentrations will drive materials to landfill and is in opposition to sustainability and circularity goals. Highlighting this will assist in generating practical and balanced guidance across jurisdictions that recognise the net environmental benefit of organics recycling and hence do not adopt overly conservative guidance that is disproportionate to risk.**
12.4.2 – Paragraph 3	Implementable to some degree for PFOS, PFHxS and PFOA, however if considering precursors, total PFAS and PFCAs as a group, this is a significant challenge. Further, current criteria in some states, such as QLD, do not consider risk-based approach for end use. Instead provide blanket limits. **Recommendations:** • **The PFAS NEMP 3.0 should provide a framework for developing management and controls to ensure products are safe, fit-for-purpose and do not harm environmental values in use. This can then be adopted for national consistency, rather than having the onus of executing the design and implementation of the guidance, as well as management and control based assessments on the various jurisdictions and operators, respectively. Not providing a consistent approach is likely to result in widely inconsistent practices across the industry, with large impacts on multiple businesses operating across state borders.**
12.4.2 – Paragraph 4	See comments above in Section 12.4 - Table 10. This paragraph goes some way to clarify, but still risks further blanket regulations by regulators as opposed to a risk-based approach. At present this is too open ended and likely to result in inconsistency and very different approaches being taken across the country. **Recommendations:** • **The PFAS NEMP 3.0 needs to provide more clarity on an appropriate end-use based framework which can be built on and adopted by various jurisdictions to provide a nationally consistent approach to the reuse of recycled organics without causing harm to human health or the environment.**
12.4.2 – Paragraph 5	Contrives the above paragraphs. A stronger position is needed to be taken by the NEMP 3.0 in taking a risk-based approach that assesses feedstocks, provided robust rational guidelines that are based on the risk to the end use for a material. This statement enables blanket conservative regulation that will ultimately drive more material to landfill. **Recommendations:** • **The PFAS NEMP 3.0 needs to provide more clarity on an appropriate end-use based framework which can be built on and adopted by various jurisdictions to provide a nationally consistent approach to the reuse of recycled organics without causing harm to human health or the environment.**

Identifier (Section/line/point/paragraph/table)	Comment/Question
Feedstock Management Plans	The Feedstock Management Plan (FMP) presents a useful tool, but only if jurisdictions have not applied a blanket approach to recycled organics, otherwise these just present another hurdle and become compliance documents that serves no purpose as the allowable PFAS concentrations applied as a blanket will remove the ability of the FMP to minimise risk while optimising beneficial reuse. **Recommendations:** • **The PFAS NEMP needs to integrate the FMP into an appropriate end-use based assessment framework which can be built on and adopted by various jurisdictions to provide a nationally consistent approach to the reuse of recycled organics without causing harm to human health or the environment.**
Feedstock Management Plans	If poorly implemented, this may prevent opportunistic receival of material. Many processors have variable materials used as inputs or receive material on an ad hoc basis, if the FMP is entered into the EMP, there may be some regulatory restrictions in acting within the scope of the EMP or even the conditions based on the EMP/FMP that prevent acceptance of some opportunistic materials outside of the scope – this may drive material to landfill. **Recommendations:** • **It must be clarified that the FMP is not designed to be implemented in a conditional manner that:** **a). In conjunction with conservative guidelines purges any feedstocks with PFAS detected to landfill or significantly reduces the capacity for organics to be recycled.** **b). Locks organics processors into only receiving certain types of feedstocks, preventing the recycling of materials that were not included in the FMP. As such an ad hoc assessment process needs to be established as reissuing an FMP for the varying organics waste streams is cost prohibitive.**
Feedstock Management Plans	Noting that dot points set out in lines 2443 to 2450: the PFAS NEMP could stipulate some recommendation on sampling, particularly considering the heterogeneity of the feedstock and compost matrix, their relative variability in source and quality, and it likely being a difficult matrix to analyse (interferences etc). Further, procedures to determine suitability cannot be realised until appropriate guidelines are published in each jurisdiction. **Recommendations:** • **The PFAS NEMP 3.0 needs to provide more substantial guidance on the types of PFAS, measures and data processing required for the assessment of recycled organics and biosolids, this should be done towards reaching a nationally consistent language and agreed PFAS suite and LOR for assessing these materials.**
Feedstock Management Plans	Noting that dot points set out in lines 2443 to 2450. The 3rd dot point acknowledges that blending is a key part of the recycled organics resource recovery process – see point 14.2.2. **Recommendations:** • **Clarify what is meant by the term blending currently practiced by the**

Identifier (Section/line/point/paragraph/table)	Comment/Question
	recycled organics industry and note how this interacts with the concept of dilution. Acceptable parameters in this regard would also be useful, and could be derived by understanding current or pre-PFAS feedstock blending practices.
Section 12.5	The use of recycled water in process such as recycled organics processing is a consideration, mentioned in section paragraph 4 dot point 5, not entirely sure if prevalent. **Recommendations:** • **Further information should be captured to assess the relevance of recycled water use and its impact on flagging certain feedstocks as potentially PFAS-impacted or if recycled water is used in the composting process.**
Section 15, Generally	Section has limited information on leachate and leachate management as referenced from section 14.3 Leachate Management Practices – likely to become more important as we better understand PFAS species in recycled organics processing. **Recommendations:** • **Further information on leachate management is required, in particular that pertinent to the PFCA and precursor species typically dealt with the organics recycling context.**
Section 15.4.1	Characterisation of biosolids – paragraph 3 and 4. All the testing requirements are sensible; the bottle neck is the interpretation of the data and comparison to some kind of screening values. i.e., if a large concentration of DiPAPs was detected, there is no standard approach or guidance in the NEMP or in general at state level (published) on what this means or what values it should be screened against. **Recommendations:** • **The PFAS NEMP 3.0 needs to provide more substantial guidance on the types of PFAS, measures and data processing required for the assessment of recycled organics and biosolids, this should be done towards reaching a nationally consistent language and agreed PFAS suite and LOR for assessing these materials.**
Section 15.4.3 "Note that given the presence of a range of PFAS in biosolids some jurisdictions may set limits on other PFAS compounds and require additional analytes to be tested and may set compliance outcomes against these (e.g. short chain PFAS and Total Extractable Organic Fluorine in Queensland)."	It is exactly this that is causing uncertainty, in QLD with the conservative criteria in model condition, that do not take a NEMP risk-based approach, but also in jurisdictions without any published guideline values where processors and end users are confused regarding what they are required to do to achieve environmental compliance or render risk acceptable. **Recommendations:** • **The PFAS NEMP 3.0 needs to provide more substantial guidance on the types of PFAS, measures and data processing required for the assessment of recycled organics and biosolids, this should be done towards reaching a nationally consistent language and agreed PFAS suite and LOR for assessing these materials.** • **The PFAS NEMP 3.0 needs to provide more clarity on an appropriate end use based framework which can be built on and adopted by**

Identifier (Section/line/point/paragraph/table)	Comment/Question
	various jurisdictions to provide a nationally consistent approach to the reuse of recycled organics without causing harm to human health or the environment.
Section 18.2.3	The sections considerations for sampling different environmental media – in need of an update for recycled organics, biosolids and dust. **Recommendations:** • **Include appropriate considerations for emerging matrices of concern, including recycled organics, biosolids and dust.**
Section 19.1	Standard and non-standard analysis methods section would ideally also serve to standardise language around methodologies particularly around total and sum PFAS, water and methanol extractable as opposed to total and leachable concentrations, and have labs use standardised terms for trace and standard analysis which often vary in LOR. Noting LOR not considered in Table 15 comparison. IF NEMP sets the language, this will be adhered to by labs, rather than citing a range of LOR and approaches taken by labs. The PFAS NEMP could provide a national position, and clarity and leadership in this regard. **Recommendations:** • **More generally, the PFAS NEMP 3.0 needs to provide more substantial guidance on the types of PFAS, measures and data processing towards reaching a nationally consistent language and agreed PFAS suite and LOR. This can then readily be adopted by the jurisdictions.**
Section 19.2.2	Managing uncertainty is an important section – but needs to extend to cover more statistics and note that when measuring ever so close to LOR the error is significant. Further, depending on the matrix, that variation is likely to be encountered. Analytical methods use between 0.5 and 2g of soil for PFAS analysis. Depending on how the jar was filled and sample collected, the variation in a single sample is likely to be large. **Recommendations:** • **More generally, the PFAS NEMP 3.0 needs to provide more substantial guidance on the types of PFAS, measures and data processing towards reaching a nationally consistent language and agreed PFAS suite and LOR. This can then readily be adopted by the jurisdictions. This includes data quality assessment and inclusion of measurement uncertainty – particularly where this is used to make risk-based decisions or included in derivation of guideline values.**
Section 19.3	Consideration of non-standard methods including relevance to site assessment and broader environmental assessment again, sees a section where the NEMP should be proposing a standard approach for methods like TOPA, how to interpret data and how the analytical method is to be standardised in Australia (cycles, oxidation method etc). While maybe not drafting it, at least calling for national consistency. **Recommendations:** • **More generally, the PFAS NEMP 3.0 needs to provide more substantial**

Identifier (Section/line/point/paragraph/table)	Comment/Question
	guidance on the types of PFAS, measures and data processing towards reaching a nationally consistent language and agreed PFAS suite and LOR. This can then readily be adopted by the jurisdictions.
Section 19.4	While this guidance is a good start, the PFAS NEMP could go further to stipulate a method or methods for certain matrices rather than noting that there are a few available. At some point this will have to be standardised; might as well be now. Studies mentioned but none cited. The very broad nature allows different analytical approaches to generate very different outcomes. A far more detailed and prescriptive approach is required. Even if the prescription allows multiple standardised options. **Recommendations:** • **The PFAS NEMP should nominate the suitability of analytical methods based on specific applications.** • **More generally, the PFAS NEMP 3.0 needs to provide more substantial guidance on the types of PFAS, measures and data processing towards reaching a nationally consistent language and agreed PFAS suite and LOR. This can then readily be adopted by the jurisdictions.**
Section 19.4.3	Measurement of ‘total PFAS’ in solid organic wastes- HRMS and detailed PFAS assessment methodologies are useful for exploratory work, but for an industry much like a waste soil resource recovery industry, the variation in the material and associated cost due to throughput and sampling rates is likely to make this infeasible based on reclaimed resource value. **Recommendations:** • **Consideration of commercial feasibility and practicality to be included.**
Section 19.4	Overall, the approach to feedstocks is likely to be different to recycled organics products. There is also a notable lack of mass balance approach to managing PFAS in the Feedstock to product treatment process. **Recommendations:** • **Consider the feasibility of providing a section on mass balance and mass flux approaches and methodologies both more generally, but also how these can be included in a framework to assess the risk of land application of recycled organics products, including biosolids.**
Section 20	Significant work required in the resource recovery sector towards characterising waste streams due for reuse. A stream on analytical standardisation would support both industry and regulators, even if it just standardises measures. **Recommendations:** • **The PFAS NEMP should nominate the suitability of analytical methods based on specific applications.** • **More generally, the PFAS NEMP 3.0 needs to provide more substantial guidance on the types of PFAS, measures and data processing towards reaching a nationally consistent language and agreed PFAS suite and LOR. This can then readily be adopted by the jurisdictions.**

Identifier (Section/line/point/paragraph/table)	**Comment/Question**
Section 21	Considering the movement of this field and the implications – define regularly. **Recommendations:** • **Quantify regularity of review.**

Table A1.2 - Draft PFAS NEMP 3.0 - PFAS NEMP Supporting Document (Derivation of biosolids criteria) Review Table. Recommendations related to the impacts described for each item are included in the table in **Bold Blue**.

Section	**Impact or consideration**
Background "These criteria were based on the outcomes of a human health and ecological risk assessment (HHERA) for PFOS+PFHxS, and PFOA in biosolids undertaken for the NSW Environment Protection Authority (EPA) by the Contaminants and Risk Team of the NSW Department of Planning and Environment (formerly NSW Department of Planning, Industry and Environment)"	Is this document publicly available? **Recommendations:** • **Make document publicly available for review.**
Scope	The DRAFT PFAS NEMP 3.0 suggests consulting guidance in the supporting document for recycled organics derived from biosolids, but the scope for the supplementary document excludes products derived from biosolids (recycled organics, amended soils and composts for example) – or at least these are not named in the scope. The comments below tis entry, for the purposes of revering this document, assume that recycled organics of all natures are in scope. **Recommendations:** • **Clarify if recycled organics products containing or not containing biosolids are to be considered "in scope" for this document".**
Summary of the PFAS Biosolids HHERA	How do the land application rates align with industry application and historical records. Similarly for depth of incorporation and bulk density derived from. **Recommendations:** • **Historical data should be used to generate a mean value or groups of mean values based on end use type.**
Summary of the PFAS Biosolids HHERA: "Although other PFAS were detected in the biosolids, the potential risks from these were not assessed in the HHERA".	Doesn't this seem like a significant oversight considering most of the mass in this organics waste stream are other PFAS species. **Recommendations:** • **Ideally the PFAS species contributing the majority of the PFAS mass should be considered. Where there is insufficient data, the precautionary principal should be applied or they should be considered in line with the toxicological profiles of the next closes PFAS species with data available**.

Summary of the PFAS Biosolids HHERA: "The risk assessment only considered home consumption of produce. Market supply of produce was not assessed. However, market supply is likely to result in lower exposure due to dilution of products in the market."	These appear to be critical considerations that are due consideration as most of the PFAS mass in biosolids is other PFAS, and the explicit use criteria in scenarios 3 and 4 are related to use on agricultural land and hence potential mass loading to agricultural land and uptake by produce grown for commercial purposes. **Recommendations:** • **End use and endpoint receptors need to be practical and reflective of industry activity to be fit for purposes insofar as risk characterisation and derivation of guideline criteria are considered for recycled organics (which contain biosolids).**
Equation 1	How does the 5-fold margin of safety interact with bioaccumulation factors and biomagnification? Will the 5-fold factor be sufficient to account for this accumulation, as this will not have been factored into the TDI, and will not be represented by the exposure concentration or dose in the biosolids, where it can be considered at its ground state (unmagnified or un-accumulated). **Recommendations:** • **Elucidate how the margins of safety or the risk assessment interact with the bioaccumulation or biomagnification and if this has been factored in at any stage of the forward or back calculation used later in the works.**
2 Criteria derivation	What is the rationale behind a 5x safety margin? **Recommendations:** • **Outline, if possible, how a 5x margin of Safety was arrived upon, and did it take into account all the other conservancy factors and assumptions.**
2.1 Derivation of the PFOS+PFHxS criteria: " The 'solver' function was used to back calculate the biosolids (or soil) concentrations that resulted in the acceptable daily intake (TDI minus background) via this pathway"	Based on this it's clear that significant modelling including uptake etc has been completed, however is there any assessment on how applicable or representative the datasets used for this were and what the uncertainty was for each model based on the selected values? **Recommendations:** • **Clarify what were the uncertainties in these models and how was that compound by applying further uncertainty mitigation measures through the margin of safety?**
Table 2	Selecting input values for models which include additional levels of conservatism (i.e., 35 ton per hectare extended to 50 ton per hectare) quickly become over protective. In this case there is almost a 2x factor of conservancy, if one goes further and factors in a MoS of 5, there is then already a ~10x buffer value. This is without accounting for other assumptions and variations in values selected for other parameters. Further CLBAR in the biosolids guidelines was designed to introduce a further safety margin into the calculation using mean + Standard Deviation to account for uncertainty. Have the assumptions in the biosolids guidelines been held to actual data accrued over the past few years to cross check validity. Errors in these assumptions have significant and multiplicated impacts on the calculation, by example; a difference in depth of incorporation alone of 2.5cm (7.5 cm versus 10) results in a 25% overestimated of mass load. Factor in a density which can vary from 1.0 for less

	dense topsoils to 1.7 for compacted clays or dense shales and suddenly another 25-30% error can be factored in. As such, data from actual historic records of biosolids applications should be compiled, analysed, and input into the models to determine mean bulk density and incorporation depth and application rate, to generate applicable values calculated based on mean, max and a single standard deviation above and below. **Recommendations:** • **While there is a need for a degree of conservancy as well as inclusion of assumptions the appropriateness and impact of these need to be assessed and scaled.** • **Undertake an assessment of stacked conservancy factor and assumption outcomes on actual margin of safety.** • **Comparison of assumptions and receptor selection to applicable end uses for the recycled organics industry and assessment of if these are fit for purpose.**
Section 4.1 - Final paragraph	While the purpose of this statement is clear and meaningful, it will unlikely age well, as instruments become more sensitive, it drives costs of analysis where the existing standard LOR is sensitive enough to decision make. As such, a minimum LOR should be stipulated based on what currently acceptable to characterise risk, or can be back calculated from the lowest value that can't exceed stipulated criteria. **Recommendations:** • **Provide an appropriate LOR based on back calculated risk value which determines what concentration must be measured in soils or organics to be applied to soils and can scaled for uncertainty.**

Table A1.3 - Draft PFAS NEMP 3.0 Relevance Quick Reference

Sections	Relevance of changes to Recycled Organics Industry
Introduction	**Low**
1. Scope	**N/A** - No text or changes
1.1 What the NEMP does	**Low**
1.2 An introduction to PFAS	**Low**
2 Australia's international obligations	**Low**
2.1 International obligations in relation to PFOS and PFOA	**Low**
2.2 Potential future obligations in relation to other PFAS	**Low**
3 Guiding principles	**Low**
3.1 General environmental obligations concerning PFAS	**Low**
4 Communication and engagement	**High** – lack of change
4.1 Roles and responsibilities	**High** – lack of change
4.2 Principles for effective engagement	**Low**
4.3 Approaches for environmental regulators	**Low**
5 PFAS monitoring	**Low**
5.1 Planning and design of environmental monitoring programs	**Low**
5.2 Ambient monitoring programs	**Moderate** – assessment of receiving soils
5.3 Site-specific monitoring programs	**Moderate** – suggests monitoring programs in line with NEPM. Considerations for testing uptake or transport into food chain.
6 PFAS inventory	**Low**
6.1 Scope of a PFAS inventory	**Moderate** – Where PFAS inventory extends to recycled organics
6.2 Conducting a PFAS inventory	**Low**
6.3 Case study – firefighting foam survey	**Low**
7 PFAS contaminated site prioritisation	**Low**
7.1 Site prioritisation process	**N/A** - No text or changes
7.2 Next steps after prioritisation	**N/A** - No text or changes
7.3 Case study – preliminary PFAS prioritisation	**N/A** - No text or changes
8 PFAS environmental guideline values	**Low**
8.1 Considerations for using guideline values	**Low**
8.2 Basis for selection of the guideline values included in the NEMP	**Low**
8.3 Exposure pathways for human health assessments	**Low** – ongoing highlights of food chain inputs.
8.4 Exposure pathways for ecological assessments	**Low**– ongoing highlights of food chain inputs.
8.5 Consideration of bioaccumulation	**Low**
8.6 Human health guideline values	**Moderate** – does not account for agricultural exposure – POFAS entering food chain via recycled organics.
8.7 Ecological guideline values	Moderate -PFAs leaching to sensitive receptors.
8.8 Information on alternative approaches to the risk assessment and environmental management of PFAS Compounds and Mixtures	**High** – considerations for the future of what or how PFAS may be included in regs.
9 PFAS contaminated site assessment	**N/A** - No text or changes
9.1 Site investigation process	**N/A** - No text or changes

Sections	Relevance of changes to Recycled Organics Industry
9.2 Risk assessment	**N/A** - No text or changes
9.3 PFAS-specific considerations	**Low-** some consideration of bioaccumulation principals
10 On-site stockpiling, storage and containment	**Low** – rejected feedstocks?
10.1 Risk-based management	**Low**
10.2 Design considerations	**Low**
10.3 Detailed guidance on design, construction and management of on-site stockpiling, storage and containment	**Low**
11 Transport of PFAS-contaminated material	**N/A** - No text or changes
11.1 Waste code for PFAS contaminated materials	**N/A** - No text or changes
11.2 Considerations for transport	**N/A** - No text or changes
12 Reuse of PFAS-contaminated materials including soils and water	**N/A** - No text or changes
12.1 Reuse of soil	**N/A** - No text or changes
12.2 Reuse with a detailed risk assessment	**N/A** - No text or changes
12.3 Reuse requiring consultation with the environmental regulator	**N/A** - No text or changes
12.4 Organic waste and resource recovery materials	**High** – broad considerations.
12.5 Reuse of PFAS-contaminated water	**Moderate**- use of recycled water in process
13 PFAS Remediation and Management	**Low**
13.1 Context – International obligations	**Low**
13.2 Australian jurisdictional requirements	**Low**
13.3 Why and when site remediation may be triggered	**Low**
13.4 Considerations in setting remediation goals and objectives	**Low**
13.5 Preferred remediation hierarchy and treatment options	**Low**
13.6 Demonstrating remediation success	**Moderate** – only relevant where PFAS is present on site and additional mass loading may occur. i.e., mine rehab.
13.7 Long-term management strategies	**Low**
14 PFAS disposal to landfill	**Low** – only relevant when disposing of contaminated feedstocks rejected from process.
14.1 Landfill siting and design	**Low**
14.2 Landfill operation	**Low**
14.3 Leachate management practices	**Moderate** – no changes but relevant to processing leachates – see section 15.
14.4 Monitoring at landfills	**Low**
14.5 Closure considerations	**Low**
14.6 Landfill acceptance criteria	**Low** – only relevant when disposing of contaminated feedstocks rejected from process.
15 PFAS in the wastewater treatment system	**Low**
15.1 PFAS management framework	**Low**
15.2 Additional management tools	**Low**
15.3 Case study – PFAS contamination of a wastewater treatment system	**Low**
15.4 PFAS Criteria in biosolids	**High** – for recycled organics contain biosolids.
16 Data sharing	**Low**

Sections	Relevance of changes to Recycled Organics Industry
17 PFAS notification	**Low**
17.1 Case study – General environmental duty	**Low**
18 PFAS sampling	**Medium** – consideration for developing SAQP and FMPs
18.1 Sampling and analysis quality plans	**Low**
18.2 Sampling and quality assurance and quality control	**Low**
18.3 Assessing PFAS leachability	**Medium** – consideration for developing SAQP and FMPs
19 PFAS analysis	**Low**
19.1 Standard and non-standard analysis methods	**Low**
19.2 Considerations for selecting an analysis method	**Low**
19.3 Consideration of non-standard methods including relevance to site assessment and broader environmental assessment	**Low**
19.4 Guidance on the analysis of PFAS in solid organic waste and resource recovery materials	**High** – Testing considerations
20 Future work	**Low**
20.1 Theme 1 – The PFAS chemical family	**Low**
20.2 Theme 2 – Environmental data and monitoring	**Low**
20.3 Theme 3 – Water	**Low**
20.4 Theme 4 – Soil	**Low**
20.5 Theme 5 – Resource recovery and waste management	**Low**
20.6 Theme 6 – Site-specific application of the NEMP guidance	**Low**
21 Review	**N/A** - No text or changes
21.1 Informal review	**N/A** - No text or changes
21.2 Formal review	**N/A** - No text or changes
Appendix A The PFAS chemical family	**Low**
Appendix B PFAS Ambient sampling guideline	**Low**
B.1 Objectives	**Low**
B.2 Background	**Low**
B.3 Sampling design	**Low**
Appendix C Activities associated with point sources of PFAS contamination	**Medium** - to be aware of feedstock from given source activities
Appendix D Treatment technologies potentially available in Australia	**Low**
Appendix E Matters to inform selection of management and remediation options	**Low**
E.1 The likelihood of the hazard or the risk occurring	**Low**
E.2 The degree of harm that might result from the hazard or the risk, and/or the level of protection that may be required	**Low**
E.3 The availability and suitability of practical mechanisms to eliminate or minimise the risk	**Low**
E.4 The costs and benefits associated with available ways of eliminating or minimising the risk	**Low**
Appendix F Example stockpiling, storage and containment checklist and framework	**Low**
Appendix G Example PFAS Management Framework for a Water Utility	**Low**
G.1 Introduction	**Low**
G.2 Governance	**Low**
G.3 Purpose	**Low**
G.4. Scope	**Low**

Sections	**Relevance of changes to Recycled Organics Industry**
G.5 Risks	**Low**
G.6. Monitoring and analysis	**Low**
G.7 Input stage	**Low**
G.8 Processing stage	**Low**
G.9. Outputs stage	**Low**
Appendix H Overview of laboratory-based leaching methods commonly applied and commercially available in Australia	**Low**
Appendix I Abbreviations and Glossary References	**Low**

Table A1.4 - Draft PFAS NEMP 3.0 - PFAS NEMP Supporting Document (Derivation of biosolids criteria) Relevance Quick Reference.

Section	Impact
Introduction	**N/A** - No text
Purpose	**Low**
Background	**Low**
Scope	**Low**
1 Summary of the PFAS biosolids HHERA	**Medium** – Explains outcomes and derivation – not direct to recycled organics use in all instances
2 Criteria derivation	**Medium** – Explains outcomes and derivation – not direct to recycled organics use in all instances
2.1 Derivation of the PFOS+PFHxS criteria	**Medium** – Explains outcomes and derivation – not direct to recycled organics use in all instances
2.2 Derivation of the PFOA criteria	**Medium** – Explains outcomes and derivation – not direct to recycled organics use in all instances
3 Summary of other currently available biosolids guidance and criteria	**Low**
3.1 Overview of approach used to derive Queensland PFAS trigger values	**Low**
4 Potential framework for screening restricted use biosolids for land application in agriculture	**Medium** – useful for calculating and assessing reuse feasibility and setting product standards for products that contain biosolids
4.1 Data and information needed to screen biosolids for land application in agriculture	**Medium** – useful for calculating and assessing reuse feasibility and setting product standards for products that contain biosolids
4.2 Step 1 – screening biosolids and in-situ soil concentrations	**Medium** – useful for calculating and assessing reuse feasibility and setting product standards for products that contain biosolids
4.3 Step 2 – calculation of the contaminant limited biosolids application rate (CLBAR)	**Medium** – useful for calculating and assessing reuse feasibility and setting product standards for products that contain biosolids
4.4 Step 3 – determine if reuse will be beneficial	**Medium** – useful for calculating and assessing reuse feasibility and setting product standards for products that contain biosolids
References	**Low**
Appendix A: PFAS exposure pathways and receptors assessed in the human health and ecological risk assessment	**Low**
Scenario 1 – unrestricted use biosolids in residential gardens	**Low**
Scenario 2 – unrestricted use biosolids for land rehabilitation	**Low**
Scenario 3 – restricted use biosolids in agriculture	**Low**
Scenario 4 – unrestricted use biosolids in agriculture	**Low**
Appendix B: consumption of milk from dairy cows grazing on biosolids-amended soil – summary, calculations, and assumptions	**Medium** – useful for calculating and assessing reuse feasibility and setting

Section	Impact
	product standards for products that contain biosolids
Appendix C: examples for applying the framework for screening biosolids for land application in agriculture	**Low**
Example 1	**Low**
Example 2	**Low**
Appendix D: PFOS soil to plant transfer factors from the literature for plants relevant to the grazing pathway	**Medium** – useful for calculating and assessing reuse feasibility and setting product standards for products that contain biosolids or amended soils or compost.