Guideline

Best Practice Environmental Management

Environmentally relevant activity 53(a)

Organic material processing by composting

This Guideline provides best practice environmental management guidance for Environmentally Relevant Activity (ERA) 53(a) Organic material processing by composting. This Guideline will be used as a reference document for the regulation of ERA 53(a). The Guideline will also assist operators in designing and operating composting facilities to better manage the risk of environmental harm and to achieve environmental outcomes in accordance with the Environmental Protection Act 1994*. While composting activities conducted under the threshold for ERA 53(a) do not require an EA, operators undertaking composting below the activity threshold should seek to undertake best practice environmental management as outlined in this Guideline.*

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Queensland Government

Version history

Version	Date	Version details
1.00	09 July 2021	This document replaces the Guideline Open windrow composting under ERA 53(a) Organic material processing by composting — ESR/2015/1813 (formerly EM1138)

Prepared by: Regional and Regulation Support, Department of Environment and Science

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1. Introduction

Background

Composting is a significant industry in Queensland which annually converts over a million tonnes of organic residues and waste into products which generally improve soil health and quality. Without a composting industry, significantly more organic waste would be landfilled or otherwise disposed of without processing, resulting in a range of environmental and social impacts.

The Queensland Waste Management and Resource Recovery Strategy (the Waste Strategy) outlines a priority to transition towards a circular economy for waste, and the recovery of organic waste through activities such as composting is a major contributor to this transition. However, composting activities also have a high potential to impact the environment and local communities. In recent years, the Department of Environment and Science (the department) has seen an increase in the types and nature of organic and inorganic waste streams in composting. There has also been a considerable number of community reports received state-wide about odour nuisance potentially from composting operations. These matters have raised concerns about the suitability of some of the waste materials being accepted and consequently incorporated into composting processes.

The Queensland Government committed to commissioning an independent report to review environmental authority (EA) waste acceptance criteria for composting operations. The department engaged Arcadis Australia Pty Ltd (Arcadis) to deliver the independent report. The report titled Critical Evaluation of Composting Operations and Feedstock Suitability Report (the Report) was delivered by Arcadis and includes recommendations to better regulate the composting industry within Queensland.

The Report was recognised as a recognised entity report under section 215(2)(l) of the *Environmental Protection Act 1994* (EP Act) to assist the department in implementing the Report's recommendations.

The Report has been used to inform this Guideline.

Purpose

The purpose of this Guideline is to provide best practice environmental management guidance for Environmentally Relevant Activity (ERA) 53(a) Organic material processing by composting.

This Guideline provides clear and contemporary advice to the department's staff to ensure consistent regulation of composting activities under ERA 53(a) in Queensland. The Guideline has also been developed to set clear expectations for operators, communities and local governments regarding the department's regulatory standards. The Guideline provides guidance to assist in assessing the design and operational risks of environmental harm occurring as well as how to best comply with the general environmental duty (GED) per section 319 of the EP Act. While composting activities conducted under the threshold for ERA 53(a) do not require an EA, operators undertaking composting below the activity threshold should seek to undertake best practice environmental management as outlined in this guideline.

This Guideline should be read in conjunction with the department's Model conditions for ERA 53(a) Organic material processing by composting (ESR/2015/1665)[1] which have been developed to provide a framework of conditions that may be applied to new EAs for ERA 53(a). To access a copy of the Model conditions, refer to the Business Queensland website.

Conditions may be included on an EA that vary from the best practice environmental management practices outlined in this Guideline or the Model conditions for ERA 53(a) owing to site-specific considerations. In the

[1] This is the publication number.

event of any inconsistency between a facility's EA and the Guideline, the EA prevails as the legal requirement for the facility.

What is 'best practice environmental management?

'Best practice environmental management' is defined in s. 21 of the EP Act. For the purposes of this Guideline, 'best practice environmental management' means the techniques, methods, processes and activities that achieve an ongoing minimisation of the activity's environmental harm through cost effective and practical measures.

Guideline scope

This Guideline applies to composting operations that are regulated under ERA 53(a) that process 200 tonnes (t) or more a year of organic material (which includes organic waste) by composting. This Guideline does not apply to ERA 53(b) Organic material processing by anaerobic digestion.

About composting

Composting is the controlled biological decomposition of organic material under aerobic and thermophilic conditions.[2] The microorganisms (including a diverse range of bacteria and fungi) involved in composting need the right environmental conditions to thrive and control of the composting process is required to avoid:

- adverse environmental and public health impacts
- poor quality product.

In Queensland, composting more than 200 tonnes (t) of organic material per annum is classified as ERA 53(a) and an EA is required under the EP Act.

There are two phases of the composting process, shown in Figure 1:

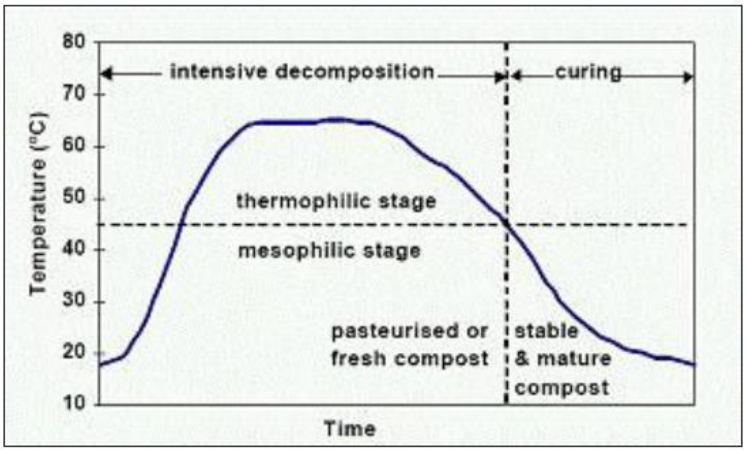

Figure 1 Phases of composting[2]

The first phase is the thermophilic phase - the interior of the composting material reaches temperatures above 45°C, significantly reducing the number of pathogens and weed seeds. The thermophilic phase of composting is not completed until maximum temperatures within the interior of the composting material starts declining below 45°C (usually between 3 and 9 weeks).

[2] Wilkinson, K., Tee, E., Hood, V. 1998. Composting Green Organics – Guide to Best Practice. EcoRecycle Victoria, North Melbourne, Victoria, Australia as referenced by Arcadis Australia Pacific Pty Limited, 2019. Critical Evaluation of Composting Operations and Feedstock Suitability Report, Phase 1 (Phase 1 Report), pg 21.

The second phase is curing or maturation - the temperature of the interior of the composting material declines (there may be the occasionally spike in temperature above 45°C) and the biological stability of the compost product becomes more stable. Compost piles should not be moved to the next stage of an operation (maturation or curing) until the thermophilic stage of composting has been completed.[3] There are a number of tests available to determine the maturity of compost and guidance about maturity tests is included in the Australian Standard (AS) 4454:2012 (Compost, soil conditioners and mulches).[4] The curing phase can take 1 to 6 months, depending on the feedstock.

Assuming that compost is properly cured, it can be stored in piles for an indefinite period without causing any odour issues. It is advisable to keep mature compost under cover to prevent cross-contamination with unfinished compost and the potential recolonisation of the mature compost with weed seeds. However, this is not always practical on large sites.

Composting Systems

The composting systems commonly used in Queensland include turned open windrows, forced aeration and enclosed systems. The composting system implemented on site will depend on the feedstock to be used in the composting process.

An EA may require that a specific composting system be implemented on site for a certain feedstock. For example, operators receiving waste generated from an abattoir may be required to implement an enclosed system due to the very high odour potential of the feedstock. Operators must comply with any such requirements included on their EA.

Where an EA does not specify the type of composting system to be used on site, operators are responsible for selecting and applying the best system/s for their particular location to meet the required environmental outcomes.

Turned open windrows

The most common type of composting system in Queensland and Australia is the turned open windrow.[5] Turned open windrow composting involves the feedstock being processed in long rows for efficient use of available area and for efficient batch management. The rows are formed and left in the open air (i.e. are not enclosed) during the composting process. The system involves turning the piles to aerate the mass, improve oxygen levels, alleviate compaction and avoid odour formation. Water may also be added to maintain suitable moisture content for microbial decomposition and to reduce dust generation when turning piles.

The size, shape and slope of open windrows will depend on the feedstock being composted and the type of machinery used to establish and turn the windrow. Windrows that have a height greater than 3.5 metres can overheat easily and develop anaerobic conditions which result in odour generation.[5] While windrows with a height of 1 metre or less, may fail to heat up at all due to heat loss from the windrow surface.[5]

Forced aeration and enclosed systems

Forced aeration systems can take a number of different forms, from aerated static piles (ASPs) or windrows, bag systems, bunker systems, agitated bays and in-vessel systems such as tunnels.[6] In forced aeration systems, oxygen is forced through the composting material reducing the need for turning. In enclosed or in-vessel systems, composting is undertaken within an enclosed structure or vessel.

[3] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 39.
[4] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 11.
[5] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 23.
[6] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 25.

Advantages of forced aeration and enclosed systems are considered to include:

- precise process control of composting conditions (e.g. temperature, aeration / air flow and moisture addition)[7]
- ensured continuous aerobic conditions[8]
- rapid pasteurisation and rapid rates of decomposition due to more uniform distribution of high temperatures occurring throughout the compost matrix[7]
- protection from the elements when are under a roof, in a building or vessel [7]
- improved systems for odour containment and control.[7]

For forced aeration systems, advantages include:

- more rapid decomposition, which can shorten the total composting residence time and reduce the land footprint required
- reduced need for turning.[7]

For Aerated static piles (ASPs), large volumes of organic materials can be processed on a smaller footprint than turned windrow systems. This is because ASPs can be as long as windrows, but many times wider since less room is required for access by turning equipment.[9]

Composting process and key process parameters

The proper management of the composting process requires monitoring and management to control key process parameters. Appendix A outlines the key process parameters and ideal range or ratio for composting. Each stage of the composting process requires different management, monitoring and control measures. This in turn manages risk of environmental impacts from dust, odour, leachate, vector attraction and access and contaminant levels.

AS 4454:2012 (Compost, soil conditioners and mulches) or the most recent or replaced version of that standard includes relevant information on requirements for pasteurisation, internal composting temperatures, temperature profile monitoring and methodologies for sampling compost piles.

C:N Ratio

The C:N ratio is the ratio of carbon (C) to nitrogen (N) by weight. Operators should understand and monitor the C and N content of their feedstocks. The ideal ratio of C:N for composting is generally thought to be in the range of 25:1 to 40:1.[10] Getting the ratio of C:N in a compost mix right requires knowledge of the individual C:N ratio of each feedstock in a compost mix which can be obtained through laboratory analysis for each individual feedstock. It is also important to consider the C:N of a total compost mix when multiple feedstocks are used. In this instance, online calculators[11] may be useful to calculate the C:N ratio of proposed composting mixes.[10] When using an online calculator, operators must ensure that accurate physicochemical input data is used and the calculator can be used for all relevant feedstocks. High C:N ratio mixes (i.e. low on nitrogen) will take longer

[7] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 26.
[8] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 37.
[9] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 27.
[10] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 30.
[11] For example, the online calculator published by Cornell Waste Management Institute available online at http://compost.css.cornell.edu/download.html

to mature and increase the risk of odour formation in the curing piles.[12] Low C:N ratio mixes (i.e. excessive nitrogen) can lead to loss of nitrogen as odorous ammonia gas.[12]

In preparing a composting mix, it may be difficult to balance the C:N ratio and moisture content from the outset. As a general rule, it is better to try to achieve an optimal C:N ratio while keeping the mix drier, for it is a lot more difficult to remove water from a composting mix without adversely raising the C:N ratio, than it is to add water.[13]

Moisture Content

The optimal moisture content for composting is typically thought to be around 50% to 55% depending on the composting process implemented (e.g. some forced aeration systems perform better at of 55%).[13] When moisture content of composting material exceeds 60%, the pore space between particles is filled with water, air flow is limited and the risk of anaerobic conditions increase.[13]

As a general rule, replenishing water in open windrows is best achieved just prior to, or during turning to ensure even distribution.[6] Sprinklers, soaker hoses or fine-mist sprays may be effective in replenishing water in open windrows. However, it may be difficult to achieve an even distribution of water within the windrow without turning.[6] Since many odorous gases dissolve in water, adding water as part of the turning strategy for a site may assist in reducing the odours released during turning events.[6]

Temperature

Temperature is an important parameter that should be monitored throughout the composting process.[3] The ideal temperature range for thermophilic decomposition is around 45°C to 75°C, while 55°C is considered the minimum to achieve pasteurisation.[3] Many microorganisms that are human and plant pathogens, and weed seeds are destroyed at temperatures 55°C and above. In most cases, the interior of composting material should reach temperatures above 45°C (i.e. thermophilic conditions) within 24 to 36 hours of the compost mix being formed.[14] The thermophilic stage of composting generally lasts between 3 and 9 weeks, during which time, temperatures in the interior of the composting material may reach the 60-65°C.[14] Due to the direct relationship between temperature and odorous emissions, the elevated temperatures during the thermophilic stage increases the potential for odour emissions from the composting material.

Moving the composting material to maturation or curing before the thermophilic stage of composting has been completed can lead to odour issues and increased risk of fires developing.[15] Compliance with pasteurisation standards on its own does not constitute the completion of thermophilic composting. The thermophilic stage of composting is not completed until maximum temperatures start declining below 45°C (assuming the composting process has been managed appropriately).[15] At this point, the curing or maturation phase of composting can begin.[15]

pH

Like temperature, pH should be monitored throughout the composting process.[3] The optimal pH level for most composting microorganisms is considered to be between pH 5.5 to pH 8.0.[3] Acidic conditions (i.e. low pH) are frequently noted in the initial phase of composting due to formation of organic acids.[3] However, extended periods of low pH conditions can lead to an increased release of volatile organic compounds.[3] High pH conditions can facilitate release of ammonia gas.[3] To manage pH levels in composting materials, operators should adjust the C:N ratio of the compost mix, rather than directly making adjustments (e.g. by adding lime).[3]

[12] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 38.
[13] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 31.
[14] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 32.
[15] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 34.

Aeration and Porosity

Porosity refers to the volume of free air space in a composting mix.[3] The porosity of the composting materials determines how freely air can move through the mix.[8] Porosity should be above 40% and ideally maintained in the range of 55%-65% to ensure that a compost material is maintained in an aerobic condition.[13] As there is a relationship between porosity and bulk density, bulk density can be used as an alternative measurement for porosity.[13] Bulk density refers to ratio of the total weight (mass) of compost to its volume. When bulk density is used as an alternative measurement for porosity, bulk density at the start of composting should be below 650 kg/m^3.[16]

A balance of finer and coarser particle sizes is required in a compost mix to ensure structural integrity and adequate porosity. Finer particles are essential to provide energy for the composting microorganisms while coarser particles, or bulking agents, provide structural support for compost piles.[13] Compost mixes that are too coarse will not be able to retain sufficient moisture or heat up to the temperatures required for composting.[13] Compost mixes that are too fine will retain too much moisture, limiting porosity and may rapidly become anaerobic.[13]

Five percent oxygen content is generally considered to be the minimum threshold for aerobic composting.[17] However, oxygen content above 10% is preferable.[17] The maintenance of aerobic conditions ensures that the temperatures required for composting are reached and maintained for a sufficient duration to kill pathogens and weed seeds.[18] Oxygen is rapidly depleted during the composting process and care must be taken to ensure that the compost does not dry out. Consequently, oxygen should be reintroduced into the composting material by physical agitation (e.g. mixing and turning), or by forced aeration.

A site-specific aeration strategy should be implemented on site that considers the composting process, feedstock in the composting mix and include monitoring methods and a process for re-introducing oxygen as necessary. For example, if green waste is being used as a bulking agent, the particle size must be sufficient to allow air flow through the windrow.[19] If liquids are being mixed with other feedstock, turning events must be at a frequency to ensure even distribution and absorption of the liquids.19 The optimal aeration strategy for a site and compost mix will often be identified through experience and trial and error by operators.19 Operators should undertake process trials including site measurements (e.g. porosity, temperature, moisture rates, oxygen levels) of the different aeration methods to carry out the necessary assessments and demonstrate that the chosen method is appropriate19 and can be relied upon on a larger scale. It is the responsibility of operators to determine the scale and length of process trials and ensure they hold all necessary approvals to conduct the trials. Operators must be able to demonstrate that the scale and length of trials are sufficient. The results of process trials should also be documented for reference to ensure that the current windrows are performing as expected.

For turned windrow composting, physical agitation (e.g. mixing, turning) serves numerous purposes:

- it loosens or ‘fluffs up’ a compost mix, reducing any impacts of compaction[18]
- it opens up new surfaces in the composting material that can be used by composting microorganisms, speeding up the progress of composting[18]

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[16] Coker, C. 2012. Odor Defense Strategy. BioCycle, Vol 53, No 5, as referenced by Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report), pg 31.

[17] Wilkinson, K., Tee, E., Hood, V. 1998. Composting Green Organics – Guide to Best Practice. EcoRecycle Victoria, North Melbourne, Victoria, Australia as referenced by Arcadis Australia Pacific Pty Limited, 2019. Critical Evaluation of Composting Operations and Feedstock Suitability Report, Phase 1 (Phase 1 Report), pg 33.

[18] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 33.

[19] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 24.

- when an optimal turning strategy is implemented, it ensures the entire mass is subjected to sufficiently high temperatures for a sufficient duration that all materials can be pasteurised, and decomposition can be more consistent throughout the windrow
- it allows heat to escape from excessively hot compost mixes[18]

Commonly for open windrow composting, the primary mechanism for introducing air into the windrow involves turning with a tractor, front-end loader or purpose-built windrow turner to loosen and mix the materials. Specialised windrow turners are more effective at distributing moisture and breaking up anaerobic clumps than generic plant such as front-end loaders or excavators.[8] However, the gentler agitation of a front-end loader may be beneficial for some feedstock mixes. [8]

For enclosed and forced aeration systems, operators must determine the optimal aeration rate and strategy for a particular compost mix through site trials and sampling to minimise the risk of odour emissions. While, increased rates of aeration are generally thought to decrease odour emissions, they may lead to an increase in total mass emissions. [8]

To ensure that the porosity of mature compost is maintained, compost should not be screened until the latter stages of curing.[3]

2. Regulatory requirements

Operators are responsible for achieving their environmental obligations including determining how to achieve the outcomes set by the department. This Guideline sets clear expectations for operators regarding the department's regulatory standards and should be considered by operators when determining how to achieve their environmental obligations. Operators that fail to meet their environmental obligations may be subject to enforcement action.

Licensing requirements

Under the Environmental Protection Regulation 2019 (EP Regulation), a development approval and EA are required to carry out the ERA of organic material processing by composting (ERA 53(a)).

ERA 53(a) is a concurrence ERA and under s. 115(2) of the EP Act a development application for a concurrence ERA is also taken to be an application for an EA.

An extract from the EP Regulation is included on the following page for convenience. However, operators should refer directly to the legislation to determine their legislative requirements.[20]

Feedstocks that are not included within the definition of organic material or organic waste must not be incorporated into composting under ERA 53(a) Organic material processing by composting.

[20] Legislation can be found at https://www.legislation.qld.gov.au/

EXTRACT - EP Regulation, ERA 53(a) Organic material processing by composting

Organic material processing (the relevant activity) consists of operating a facility for processing, by way of composting, more than 200t of organic material in a year.

The activity does not include:

a) manufacturing mushroom growing substrate; or

b) the composting of organic material from agriculture or livestock production if the organic material is either—

   i) composted at the site where it was produced; or

   ii) transported to another site, where agriculture or livestock production is carried out, and composted at that site; or

d) the composting of organic material at a site where intensive animal feedlotting (ERA 2), pig keeping (ERA 3) or poultry farming (ERA 4) is carried out.

Organic material means—

a) animal matter, including, for example, dead animals, animal remains and animal excreta; or

b) plant matter, including, for example, bark, lawn clippings, leaves, mulch, pruning waste, sawdust, shavings, woodchip and other waste from forest products; or

c) organic waste.

Organic waste is defined as including the following:

   i) a substance used for manufacturing fertiliser for agricultural, horticultural or garden use;

   ii) animal manure;

   iii) biosolids;

   iv) cardboard and paper waste;

   v) fish processing waste;

   vi) food and food processing waste;

   vii) grease trap waste;

   viii) green waste;

   ix) poultry processing waste;

   x) waste generated from an abattoir; but

does not include:

   i) biosecurity waste; or

   ii) clinical or related waste; or

   iii) contaminated soil; or

   iv) synthetic substances, other than synthetic substances used for manufacturing fertiliser for agricultural, horticultural or garden use.

Application requirements

Operators proposing to undertake ERA 53(a) Organic material processing by composting must be granted an EA prior to commencing the activity. When making an EA application, operators need to supply detailed information about the proposed activity and its potential environmental impacts. EA applications are assessed according to the level of potential environmental risk and the assessment provisions under the EP Act. For further information about making EA applications, refer to the Business Queensland website.

Environmental authority conditions

Each EA for a composting facility will set out conditions under which the facility must operate.

Operators must comply with the conditions set out in their EA. Failure to comply with the conditions of an EA is an offence under the EP Act.

Model conditions for ERA 53(a) Organic material processing by composting has been developed to provide a framework of conditions for new EAs for ERA 53(a). Model conditions are not mandatory.

As the model operating conditions provide a framework only, conditions can be modified to suit the particular operation. Additional conditions can be applied at the discretion of the department to address risks to environmental values that are specific to a particular operation or a particular site. Also, if a particular model operating condition does not apply to an operation, then it will not form part of the conditions placed on the EA.

For further information about making an application for an EA, EA conditioning, and to access a copy of the Model conditions for ERA 53(a) Organic material processing by composting (ESR/2015/1665), refer to the Business Queensland website.

General environmental duty (GED)

An operator must take all reasonable and practicable measures to prevent environmental harm. Under the EP Act, this is termed the 'general environmental duty' (GED).

In deciding the measures to be taken to prevent environmental harm the operator should consider a number of factors. These include:

- Physical, chemical and biological risks associated with the feedstocks being received for processing.
- Potential risks of environmental and community amenity impact from processing activities (e.g. potential odour, noise, dust, and water impacts at any sensitive or commercial places and below ground).
- Likelihood of harm occurring upon application of products to land, taking into account the sensitivity of the receiving environment.

Financial assurance

Financial assurance is a security deposit held by the department to ensure the holder of an EA complies with the conditions of the EA and to cover potential rehabilitation costs. Not all prescribed ERAs are required to provide financial assurance. If financial assurance is required, it will be stated as a condition on the EA. For further information about financial assurance, refer to the Business Queensland website.

3. Overview of potential environmental risks

The types and quantities of feedstocks received, the location of the site, the infrastructure at the facility and the implemented composting processes will determine the potential risks that composting activities pose to the environment and community. Poor environmental management of composting facilities can result in environmental issues including:

- air quality impacts including odours and dust beyond the site boundary
- surface and ground water contamination
- excessive noise
- production of contaminated compost products
- fire risks
- pests and vectors that are attracted to the composting material
- litter beyond the site boundary.

The following sections provides an overview of each of these potential environmental issues.

Odour

Odour is the sensation response that is generated when volatile chemical species in the air are inhaled through the nose, interact with the olfactory system and register in the brain.[21] Offensiveness is a measure of the pleasantness and conversely unpleasantness of an odour at a certain concentration/dilution.[22] Offensive is subjective to each person.[22] However, common volatile species that give rise to unpleasant odours include sulphur compounds (e.g. sulphides, mercaptans), nitrogen compounds (e.g. ammonia, amines) and volatile organic compounds (e.g. esters, acids, aldehydes, ketones, alcohols).[23]

Odour is generally the main source of public complaints from composting facilities. Odour has the potential to have an impact on the amenity and well-being of the surrounding community. Odours form during the composting process. However, implementing best practice environmental management is likely to reduce odour emissions and reduce the noxiousness and offensiveness of odours associated with the activity.

Odour emissions can vary significantly throughout the composting process. Over the life of a stockpile, odour emissions typically start out relatively high, depending on the type and freshness of the feedstocks, and can increase further as the thermophilic stage progresses. Once the thermophilic stage has concluded and the compost enters the curing or maturation stage, odour emissions begin to decrease until they reach an earthy character of background concentration levels.[24]

Potential causes of odour from composting activities include:

- inadequate site planning and inadequate modelling of expected air emissions resulting in insufficient distance and terrain buffers to existing or zoned residential and other sensitive development areas
- inappropriate management methods and infrastructure for the type of feedstock being processed
- poorly developed or poorly implemented operating procedures
- inappropriate feedstock accepted into the composting process
- inappropriate proportions of feedstock mixed into windrows
- inadequate handling of raw feedstock particularly for putrescible and/or high moisture content feedstock
- inadequate aeration of windrows causing anaerobic conditions within the decomposing biomass

[21] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 65.
[22] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 69.
[23] Leonardos, G., Kendall, D., Barnard, N., 1969. Odor threshold determinations of 53 odorant chemicals. J. Air Pollut. Control Assoc. 19, as referenced by Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report), pg 65.
[24] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 79.

- windrows at heights too high to be effectively managed with available plant and equipment (above 3.5 metres generally not recommended)
- inadequate odour mitigation measures.

Dust

Dust, if not managed properly, has the potential to cause nuisance beyond the boundary. Organic dusts and bio-aerosols may also present an occupational health and safety risk. Causes of dust nuisance from compositing activities include:

- dry and/or hot weather
- insufficient moisture content in stockpiles and windrows
- screening materials that are excessively dry
- dry, unsealed roadways and inadequate ground spraying during heavy vehicle and equipment operation
- inadequate spray down of vehicles leaving the site to remove dirt and compost materials.

Water Contamination

Contamination of surface or groundwater can occur from the inadequate environmental management of composting operations via direct contaminated stormwater releases and/or indirect seepage. Surface and groundwater contamination can result in significant environmental harm and remediation costs.

Stormwater

Potential causes of stormwater contamination from composting activities include:

- release of leachate and/or contaminants
- inadequate segregation of clean and dirty catchments at the site
- inadequate diversion of clean stormwater flow around contamination sources
- inadequate erosion and sediment control measures
- inadequate maintenance of stormwater management infrastructure
- site slopes that are too steep and/or non-uniform slopes that prevent direction of contaminated stormwater to containment facilities
- inadequate design, insufficient capacity and/or no, or poor maintenance of containment facilities
- inadequate irrigation and stormwater re-use systems
- poor litter control
- inadequate bunding of chemicals
- inadequate storage of dirty plant and equipment.

Groundwater

Groundwater can be contaminated at composting facilities by contaminants including nitrates, pesticides, heavy metals, bacteria, pathogens and viruses leaching through the ground profile. Potential causes of groundwater contamination from composting activities include:

- inadequately sealed hard stand area

- inappropriate site selection including aspects such as:
    - shallow water table
    - highly permeable or cracked soils
    - surface rock with fractures or bedding planes
    - vulnerability to subsidence and structural instability
    - existing contamination or acid sulfate soils
    - low groundwater recharge
    - high impact of the unsaturated zone of the aquifer on permeability
    - high hydraulic conductivity of the aquifer
- pooling and percolation of leachate and/or contaminated stormwater.

Noise

If not managed properly, noise has the potential to cause nuisance for surrounding sensitive places. Causes of noise nuisance from composting activities can include:

- trucks loading and unloading and accessing the site
- equipment and machinery such as loaders, windrow turners, screeners and crushers inadequately sited on the property
- operating trucks, equipment and machinery without adequate noise mitigation devices, outside restricted hours
- poorly serviced and/or maintained plant and equipment
- inadequate site selection providing insufficient use of distance and/or terrain buffers to existing sensitive places.

Feedstock

Feedstock refers to the materials used for composting. Compositing activities licensed under ERA 53(a) are limited to feedstocks which meet the definition of organic material. It is recognised that with appropriate risk assessment and analysis of the materials, some inorganic materials may be safely incorporated into some composting processes without adversely affecting the composting process or the safety of the final compost product. However, the inclusion of inorganic materials into composting may require the operator to hold or act under additional regulatory approvals. If the inorganic materials are categorised as regulated wastes under the EP Regulation, an end-of-waste approval or an EA for ERA 55 Other waste reprocessing or treatment may be required to use the material as feedstock. Consequently, operators that propose to use inorganic regulated waste in the composting process should contact the department prior to using the material in the composting process.

The selection and management of feedstock are key factors in determining the potential environmental and community impacts from composting activities. The appropriateness of a feedstock for a composting facility is dependent on the capacity of a facility to manage risk factors embodied in the raw materials and to achieve acceptable environmental performance. However, some feedstocks have been deemed unsuitable for composting. These feedstocks are listed in Appendix B. Feedstocks listed in Appendix B should not be used in composting unless further analysis can demonstrate that the feedstock can be safely used in composting.[25]

Inadequate selection or management of feedstock has the potential to:

- generate significant odour impacts
- attract vermin and other vectors (birds and insects)
- generate harmful leachate that could, unless contained, be released and cause contamination of surface water, groundwater and/or soil.

There are many potential contaminants that may be present in feedstocks including:

- biological contaminants (pathogens)
- chemical contaminants (e.g. heavy metals, organic pollutants)
- physical contaminants or impurities (e.g. glass, metal, rocks, microplastics).

Microplastics are very small plastic pieces that measure less than 5mm in length that can enter ecosystems from a variety of sources. Primary sources of microplastics are plastic fragments purposely made to be ≤ 5mm before entering the environment (e.g. microbeads used in cosmetic products and plastic pellets). Secondary sources of microplastics are created from the degradation of larger plastic products through natural weathering and degradation processes. A third emerging source is objects that give off microplastics though use (e.g. from the road wear of synthetic tyres, washing synthetic clothes, or synthetic grass pitches and sports grounds).[26]

Compost contamination overwhelmingly occurs due to the presence of contaminants in the feedstock used to process the compost.[27] In general, as the level of human intervention involved in the generation of the feedstock increases, the risk that the feedstock will be contaminated also increases.[28] It is possible that air-borne contaminants may be introduced into feedstocks by dust, rain or wind or that metal abrasion from shredding equipment could add to the heavy metal load.[27] However, these sources are negligible compared to the contamination loads of feedstocks.[27]

Feedstock contamination poses risks to the environment and community. There are numerous ways that people or the environment can be exposed to contaminants as part the composting process. These include:[29]

- collection and transport to the composting facility (e.g. spillages, accidents, leaks, dust)
- storage and handling at the facility (e.g. operational staff handling, seepage to soil and groundwater, stormwater runoff or leachate)
- exposure to neighbouring properties (e.g. surface water discharges, groundwater migration, windblown dust and vapours)
- exposure from soils containing the final compost products, either through direct contact or via stormwater runoff and groundwater migration
- consumption of food grown in or indirectly affected by the final compost products.

Table 1 provides a summary of feedstock descriptions and the general odour and contamination risks of the feedstock. For further odour rating information for feedstocks refer to Appendix C.

[25] Arcadis Australia Pacific Pty Limited, 2019, Critical Evaluation of Composting Operations and Feedstock Suitability Report, Phase 2 (Phase 2 Report), Table 53: Summary of qualitative contamination risk assessment results.
[26] Arcadis Australia Pacific Pty Limited, 2019, Phase 2 Report, pg 86.
[27] Arcadis Australia Pacific Pty Limited, 2019, Phase 2 Report, pg 80.
[28] Arcadis Australia Pacific Pty Limited, 2019, Phase 2 Report, pg 182.
[29] Arcadis Australia Pacific Pty Limited, 2019. Phase 2 Report, pg 145.

Table 1: Summary of feedstock categories and general risks[30]

Category	Description	General Risks
Animal matter	Animal / livestock processing wastes including all residues from abattoirs and subsequent processing of tallow and hides; egg and milk waste, manures from intensive farming.	High odour risk but assumed to be low contamination risk (no chemical residues). However, there is uncertainty about the chemicals used in hide curing effluent and the contamination risk they pose.
Plant matter	Predominantly clean plant material with minimal contamination. Includes green waste, gross pollutant trap (GPT) waste and clean (untreated) timber which may contain physical impurities, but otherwise includes mostly crop and forestry residues.	Generally, low odour risk. Many of these materials can be used as bulking agents to balance / mitigate the odour risk of other materials. Potential for trace pesticides and herbicides, but generally low contamination risk.
Food and food processing waste	Wastes predominantly containing food and residues from food processing (predominantly crop / vegetable sources).	Odour risks vary depending on the specific waste but generally food and food processing wastes present a high odour risk. Household and commercial food organics may contain physical impurities. Food processing wastes are assumed to contain minimal chemical contaminants except organics extracted from municipal solid waste (MSW) which are predominantly food but can be highly contaminated.
Sewage and sewage treatment plant (STP) residues	Sludges and solids arising from the collection and treatment of human waste (sewage) including biosolids and septic tank sludges.	High potential for odour issues. Potential for varying degrees of chemical contamination (including metals and PFAS) and pathogens, depending on the degree of prior processing.
Chemical fertiliser residues	Chemical residues and effluents from the manufacture of chemical fertilisers including wash waters and non-conforming product.	High risk of ammonia odours and concentrated nutrients.
Industrial residues	A broad catch-all category for a range of solid, liquid and slurry wastes from industrial manufacturing processes or otherwise highly processed / treated materials.	Odour risk is generally low although they may contain sulphur and nitrogen compounds that increase the odour risk. Contamination risk varies widely but is generally high, particularly for those materials that are poorly described.

[30] Adapted from Arcadis Australia Pacific Pty Limited, 2019. Phase 2 Report, Table 1: Summary of feedstock categories and general risks pg 8.

Category	Description	General Risks
Wastewater and washwaters	Another broad catch-all category for liquid effluent streams, contaminated stormwaters and washdown waters, mostly from commercial activities.	Odour risk is generally low although they may contain sulphur and nitrogen compounds that increase the odour risk. Contamination risk varies but is generally high, particularly for the many materials in this category that are poorly described.
Earthworks and mining waste	Includes inert soils and slurries from earthworks and mining activities, as well as drilling mud from coal seam gas activities and mineral additives that can be beneficial soil conditioner additives (e.g. limes, gypsum).	Odour risk varies but is generally low. Contamination risk is generally low with the exception of chemical additives in drilling mud and residual contamination in treated soils. Other streams may contain naturally occurring contaminants (e.g. sulphate in acid sulphate sludge; heavy metals in earthen material; natural salts in drilling muds). Potential for extreme pH levels (lime, acid sulphate sludge).

Fire Risks

Various gases are produced during the composting process some of which are flammable (e.g. methane, carbon monoxide and hydrogen sulphide). Inadequate environmental management practices resulting in the incomplete collection or ventilation of flammable gases may create an explosion or fire risk at composting facilities. Fires at composting facilities pose risks of significant environmental harm, physical harm to workers and firefighters and damage or loss of equipment. Possible causes of fires at composting facilities include:

- sparks from onsite activities (e.g. welding)
- severe whether (e.g. lightning strikes)
- poor equipment maintenance (e.g. build-up of matter in engines and exhaust pipes)
- bushfires
- deliberate or reckless human actions (e.g. arson or inappropriate disposal of cigarette butts)
- spontaneous combustion.

Spontaneous combustion can occur when decomposing organic materials self-heat to ignition temperatures. Spontaneous combustion is generally more prevalent within large feedstock storages, curing compost or finished compost rather than actively composting materials.

Pests and Vectors

Composting activities have the potential to attract pests and vectors. For example, sites with exposed storages of rapidly biodegradable organics may attract significant numbers of flies, rats and birds. Birds can be a source of noise and may spread food waste, litter and weed seeds beyond the boundary of the site. Weed seeds may also be transported and spread via the tyres of vehicles entering or leaving the site. Weed spread can have significant environmental and economic impacts by altering ecosystem function and reducing agricultural productivity and profitability.

Litter

As per s. 103 of the *Waste Reduction and Recycling Act 2011*, littering is the unlawful deposit of any type of waste material that is less than 200 litres in volume. Litter pollutes the environment and significantly diminishes the use, enjoyment and value of community areas. Causes of litter from composting activities can include:

- wind-blown litter
- vehicles entering or leaving the site (e.g. from uncovered loads or tracking litter in the wheels of the vehicle).

4. Planning and Design

The planning and design of a composting facility is complex. There are numerous matters that determine the appropriate site, the facility size and layout, site infrastructure and the composting process. The environmental impacts of each of these matters (including the cumulative impacts of these matters) should be considered in the design phase of a compost activity to assess and minimise potential environmental impacts. This section provides guidance on best practice planning and design processes for composting facilities. It covers site suitability and layout, preliminary site assessments and site infrastructure.

Site suitability and layout

A composting facility should be sited so that the potential impacts from odour, dust and water contamination beyond the site boundary can be prevented.

To reduce the risks of environmental harm or nuisance, site selection and the design process should consider:

- separation distances from sensitive or commercial places, public roads and surface and groundwater sources
- site topography
- proposed composting system (e.g. enclosed facilities may be able to be located closer to sensitive or commercial places than turned open windrow composting facilities)
- meteorological data including rainfall, flooding risks, temperature, wind strength and prevailing wind directions
- relevant local information (including community interest)
- proposed environmental impact mitigation measures.

The term ‘separation distance’ refers to the distance between the compost site and the closest sensitive or commercial place. In most instances, the separation distance for a compost site should be measured from the boundary of the compost site to the boundary of the sensitive or commercial place (Refer to Figure 2). This measurement method provides an operator with the flexibility to move or expand activities within the site, without impacting the separation distance.

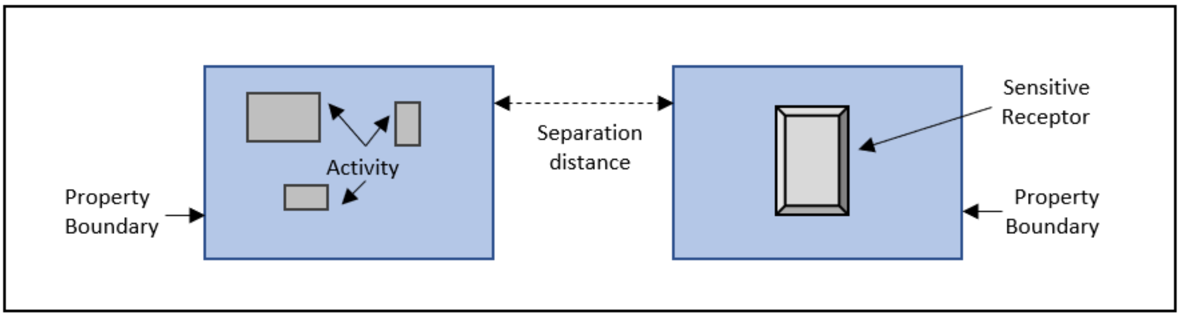

Figure 2 Separation distance measured at site boundary[31]

Where a compost site is sited away from sensitive or commercial places (e.g. in rural areas), it may be appropriate to measure the separation distance from the boundary of the activity to the boundary of the sensitive or commercial place (Refer to Figure 3). The activity boundary is an imaginary boundary that encloses all activities, plant, buildings or other sources from which residual emissions may arise.[31] When the activity boundary is used to measure the separation distance, any changes to the location of site infrastructure will impact the separation distance.

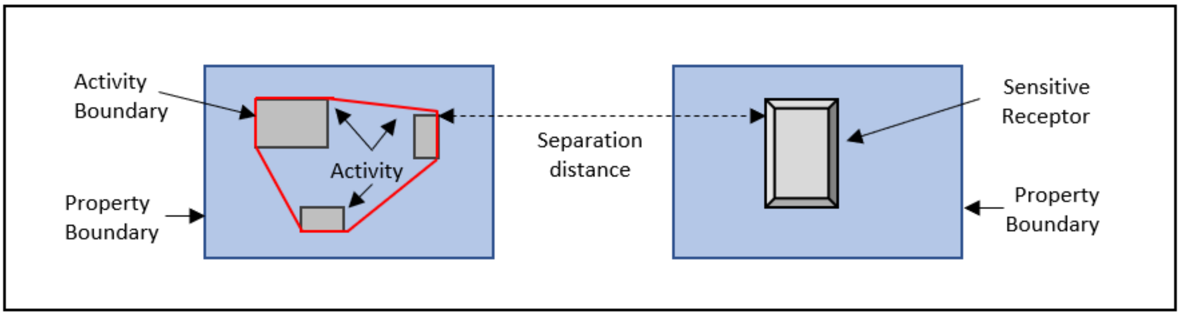

Figure 3 Separation distance measured at activity boundary [31]

Operators are responsible for selecting the appropriate separation distance measurement method and should justify their selection as part of their EA application.

Separation distances are not an alternative to implementing measures to control potential emissions from composting sites. Rather, separation distances protect the local environment and community from accidental or unforeseen emissions that may occur due to equipment failure, human error, accidents or abnormal weather conditions.[32] Consequently, separation distances are one of many risk management measures that should be implemented to address unexpected or accidental emissions a compost site. It is not sufficient to rely solely on separation distances as the primary emission mitigation measure for a compost site.

In addition to selecting an appropriate site location, operators should also consider the location of site infrastructure and process areas to minimise potential environmental and community impacts. For example, where a composting site is bounded by sensitive or commercial places on one or two sides, infrastructure or process areas that are of risk of generating odour, water quality, noise or dust impacts should be located on opposite side of the site.

Performance outcomes for compost site selection and layout are listed in Table 2.

[31] Replicated from Environmental Protection Agency Victoria, 2017. Designing, constructing and operating composting facilities pg 8.
[32] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 113.

Table 2: Performance outcomes for compost site selection and layout

Performance outcome	***Acceptable solutions***
The activity will be sited and operated to prevent adverse odour, water quality, noise and dust impacts at sensitive and commercial places	Adequate planning and consultation with local authorities for appropriate site selection has been undertaken including the consideration of prevailing wind direction, local structures and landform, appropriate buffer distances and terrain barriers to existing or zoned residential areas, and any other sensitive receptors to prevent adverse odour, water quality, noise and dust impacts at sensitive and commercial places. Appropriate site selection may also be demonstrated through the results of small-scale trials below ERA thresholds. Site selection and design considers water table depth, soil characteristics and geology, slopes, any existing contamination and acid sulfate soils, groundwater recharge rate, impact of the unsaturated zone of the aquifer on permeability, and hydraulic conductivity of the aquifer. Unless sufficient control measures are implemented, compost sites are not located between the prevailing wind direction and any sensitive or commercial places Unless sufficient control measures are implemented, compost sites are not located in flood prone areas The submitted application information and/or modelling show that groundwater quality can be managed. Site infrastructure and process areas are located to minimise potential environmental and community impacts. Application information and / or noise modelling references the local planning scheme and indicates that noise impacts from the site can be mitigated to meet Environmental Protection (Noise) Policy 2019 acoustic quality objectives for sensitive receptors. The location and design of noise generating activities on site have been considered to minimise the potential for noise. For example: • Avoid constructing tracks or roads on severe gradients or where speed changes are required. • Route onsite roads as far away from sensitive and commercial places as possible. • Minimise the distance that materials need to be moved by conveyors or trucks. • Minimise the height from which materials are dropped into storage bins or trucks. • Avoid placing staff lunch areas or vehicle queuing areas near sensitive and commercial places. • To help determine if neighbours might be impacted by noise, engage an acoustic consultant to conduct a noise impact assessment before commencing a new noise generating operation.

Performance outcome	***Acceptable solutions***
	An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems -Requirements with guidance for use (or most recent versions).

Preliminary Site Odour Assessments

Potential odour issues from a composting facility should be anticipated and addressed at the design and planning stage of a new facility or when proposing a facility expansion, as it is difficult to manage odour issues retrospectively.[33] The potential odours issues and required best practice environmental management approach for a proposed composting operation will depend on the:

- compost facility site including topography and distance from sensitive or commercial places
- direction, speed and frequency of winds at the site
- scale of the composting activities
- feedstocks proposed for inclusion in the compost
- estimated odour emission rate
- odour removal technology proposed for the site
- whether the composting process will be enclosed or open-air.

Best practice environmental management for preventing odour impacts occurs at the planning and design stage and involves an odour impact assessment. Odour impact assessments should be prepared by a suitably qualified and experienced person.

The *Odour impact assessment from developments Guideline*[34] provides operators, government agencies and the public generally with a procedure for assessing the likelihood of odour nuisance from development proposals for new facilities, modifications of existing facilities and land developments.

An odour impact assessment will vary depending on the risk posed by the scale of proposed composting activities, intended feedstock and facility location and should generally include the following components:

- An assessment of background odour in the existing environment. The assessment should include all sources of odour emissions from other existing activities in the local area with specific attention given to activities that may generate odours of a similar character or degree of offensiveness. This is to understand the current odour situation in the area, the frequency of potential odour episodes and the likelihood of the community being sensitised to odour.
- A representative odour dispersion model which assesses the odour footprint of proposed activities under all site-specific operating and meteorological conditions. The meteorological model's performance should be evaluated against observed data or be developed from observations collected by an installed weather station. The model should adequately represent the important features of the site's topography, land surface characteristics and distance to sensitive and commercial places.[35]

[33] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 22.
[34] Available online at https://environment.des.qld.gov.au/
[35] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 132.

As composting activities have many potential sources of odour and are often located in complex areas where wind channelling, slope flows or calm wind conditions may be present, an odour dispersion model that can suitably address these complexities is recommended.[36] When selecting a model for an odour impact assessment, the following matters should be considered: [36]

- distance from the facility to sensitive and commercial places[36]
- steep or complex site terrain
- topography and land surface features influencing odour dispersion
- consistency of regional meteorology
- wind intensity typical of the area
- whether re-circulation issues are important.

Odour emissions measurement, and in particular the method used to calculate emissions, is a critical part of odour dispersion modelling. In Queensland, composting facilities often use open windrow methods, which present significant challenges in sampling and measuring air emissions.[37] A standard non-mechanically aerated compost stockpile is considered a passive emission source. [38] However, during the active composting phase, the heat generated during thermophilic composting can develop a convective flow of air within and out of the windrow.[38] Consequently, odour modelling of open windrow composting should consider this effect.

Performance outcomes for preliminary site odour assessments are listed in Table 3.

Table 3: Performance outcomes for preliminary site odour assessments

Performance outcome	Acceptable solutions
Potential odour issues from a composting facility are anticipated and addressed at the design and planning stage of a new facility or when proposing a facility expansion	An odour impact assessment is undertaken during the site planning stage which considers the *Odour impact assessment from developments Guideline*[34] and includes: • an assessment of background odour in the existing environment • a representative odour dispersion model which assesses the odour footprint of proposed activities under all site-specific operating and meteorological conditions. Modelling has shown that odour will not be an issue. Where an odour plume is known to exist, field odour surveys are undertaken by appropriately trained people to quantify and delineate the odour plume.[39]

Producing quality compost suitable for market

Producers that sell or distribute a composting product must have a solid understanding of the pathogens, virus, bacteria and other contaminants that may be present in the compost product and be assured that they are at concentrations that are appropriate for the intended end use. Certain compost may be more appropriate for food

[36] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 74.
[37] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 76.
[38] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 77.
[39] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 91.

production or residential use while other compost will be more suitable for use in commercial developments or rehabilitation of industrial sites.

The sale or distribution of compost that is found to have caused or contributed to environmental harm may result in enforcement action being taken against the operator.

Producers should ensure that the compost product is labelled in accordance with the requirements AS 4454:2012 (Compost, soil conditioners and mulches) or the most recent or replaced version of that standard.

5. Best practice environmental management

Feedstock selection

Each operator in the end-to-end waste management process (i.e. generating, providing, transporting, receiving, storing, recycling or disposing of a waste material) is required under the GED to understand and manage potential risk impacts. Operators must make all reasonable efforts to provide an accurate description of the waste materials delivered to another operator as feedstock.

Various organic feedstocks may be suitable for composting. The appropriateness of a feedstock is dependent on the capacity of a facility to:

- manage risk factors embodied in the raw feedstock
- achieve acceptable quality of the final compost product
- achieve effective management of environmental risks.

It is the responsibility of the operator to ensure that waste materials received onsite for feedstock can be effectively managed, are suitable for use in composting and will not negatively impact compost quality or the environment.

Prior to accepting and using a feedstock, the risks associated with the feedstock must be understood including:

- odour potential (as a separate feedstock and in a composting mix with other feedstocks)
- potential contaminants
- any other potential issues that may impact compost quality[40] or cause environmental impacts (e.g. particle size and leachability).

An operator's EA may also include conditions regulating feedstock acceptance, storage and assessment that an operator must comply with when selecting feedstock for use in compost.

Numerous feedstocks are considered to have a very high odour potential including:[41]

- abattoir and animal processing waste
- animal waste, including egg waste and milk waste
- hide curing effluent
- tallow waste
- organics extracted from mixed household waste / MSW

[40] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 28.
[41] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 64.

- food processing effluent, solids and treatment sludges
- grease trap (both untreated and treated / dewatered grease trap sludge)
- nightsoil, septic wastes and sewage sludge or treatment tank residues
- sewage treatment tank or treatment pit liquids, solids or sludges
- landfill leachate.

The very high odour rating of these feedstocks does not mean that they are not suitable for composting. However, additional control measures, such as those listed in Section 5 of this Guideline, may be required for their storage, mixing and processing.[41]

Compost facilities should have a protocol for selecting potential new feedstock, preferably before an applying for an EA. A protocol for selecting new feedstock should include:[40]

- Obtaining a sample of the feedstock from the generator for analysis by a certified laboratory. Analysis will provide information about the feedstock's carbon and nitrogen content, moisture content and identify potential contaminants of concern.
- Retaining another sample of the feedstock and sealing it in a plastic bag to simulate the decomposition process in the event the process turns anaerobic. The bag can be kept in a warm place for two to three days before it is opened by someone whose sense of smell has not been compromised. This person should give an indication of the intensity and unpleasantness of the smell using a recognised odour intensity scale. For example, the German VDI 3882 odour intensity scale.[42] If unpleasant odours are noticed, the operator of the composting facility will know to be prepared to process the feedstock promptly when it arrives and ensure anaerobic conditions are prevented.[40]

Operators should not accept feedstock which are of unknown origin or composition.[43]

Where the origin or composition of a feedstock is unknown, a precautionary approach should be adopted, and the feedstock considered high risk until shown otherwise.[43] If the waste generator or transporter fails to provide information about the feedstock origin or composition, operators should reject the feedstock and inform the department so that actions can be taken to prevent inappropriate use of the feedstock. Furthermore, feedstock should not be accepted for the purpose of dilution in composting.

Per- and polyfluoroalkyl substances (PFAS)

PFAS are synthetic organic compounds used in a wide range of consumer products and commercial/industrial applications for which there is no natural background level. Due to their widespread use, persistence and high solubility in water it is possible that PFAS may be present in some feedstocks. The PFAS National Environmental Management Plan (NEMP)[44] provides that dilution of PFAS contaminated waste into compost is not permitted. Feedstock originating from activities or sites associated with PFAS contamination (e.g. those listed in Appendix B of the PFAS NEMP) have a higher likelihood of containing PFAS and must be fully characterised prior to considering its use in manufacturing compost or soil conditioner products.

[42] Available online at http://www.beuth.de (recommend searching for the keyword "olfactometry").
[43] Arcadis Australia Pacific Pty Limited, 2019. Phase 2 Report, pg 24.
[44] The PFAS NEMP is available online on the Australian Government Department of Agriculture, Water and Environment website at https://www.environment.gov.au/

Feedstock assessment

Where there is a potential of environmental risk from adding the feedstock received onsite to the compost, the operator must assess the risk and characteristics of the feedstock and source before inclusion. This risk and characteristics assessment should consider:

- The physical characteristics of the feedstock including moisture content, total degradable carbon content, total nitrogen content, pH, electrical conductivity and mineral salts.
- The chemical composition of the raw feedstock likely to be received at the composting facility.
- The expected degree of variability in the composition between loads and over time. Where the feedstock is highly variable, the risk assessment should conservatively focus on the worst-case maximum contaminant concentrations.
- The expected maximum proportion of the feedstock in the initial compost mix (by weight).
- The proposed end use for the compost product. A precautionary approach is to assume that all compost products should be suitable for unrestricted use.
- Whether the feedstock is likely to add beneficial components to the final compost product such as carbon content, nutrients (nitrogen and other macro nutrients), essential metals and trace elements and physical structure / porosity.
- The likely reduction in contaminants through the composting process applying a precautionary approach but assuming a standard composting practice. Reduction may occur through bio-degradation, decomposition, mineralisation or volatilisation. Contaminants should be assessed on a dry matter basis to eliminate the effects of moisture loss / addition during the composting process. For each potential contaminant in each feedstock, the contribution of each contaminant to the overall concentration in the final product can be calculated as: *Raw concentration in feedstock x Proportion in mix (%) x (100% - Expected reduction factor (%))* It is then a matter of totalling the contributions of a particular contaminant across all feedstocks in the mix, to estimate the total final product concentration.[45]

The consistency (i.e. homogeneity) or variability (i.e. heterogeneity) of the feedstock will determine the frequency and parameters requiring ongoing analysis. The higher the variability in the composition of the feedstock, the more frequent the requirement to characterise the feedstock to ensure that management practices are appropriate. For feedstocks that are known to be consistent, an initial characterisation assessment and quarterly sampling may be adequate.[46]

Industrial waste streams can be highly heterogeneous in composition and can be variable between loads due to factors such as time, location, season and the specific activity that generates the feedstock. Industrial waste streams, both solid and liquid, are often complex mixtures of compounds and contaminants, both organic and inorganic. Due to high variability, the risk assessment must consider the initial characterisation of the primary compounds and contaminants of concern in the feedstock in order to determine the highest environmental risks from managing and processing the feedstock.

Before introducing new or changed feedstock to a composting facility, small-scale trials should be undertaken to assess and monitor the performance of the feedstock in the composting process. [47] To begin with, new feedstock should be added gradually to tried and trusted compost mixes, starting with small volumes (e.g. 10% of the mix) before consideration is given to increasing its proportion in the mix.[47]

[45] Arcadis Australia Pacific Pty Limited, 2019. Phase 2 Report, pg 206.
[46] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 15.
[47] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 29.

Best practice environmental management practices for feedstock selection are listed in Table 4.

Table 4: Best practice environmental management practices for feedstock selection

Performance outcome	Best Practice Environmental Management Practices
Accepted feedstocks are beneficial to the composting process and can be managed to avoid adverse environmental impacts (including odour nuisance and contamination risks)	The environmental risks of feedstocks (including odour nuisance and contamination risks) are assessed including representative sampling, small scale trials and analysis to characterise the chemical, physical and biological nature of the feedstock before the feedstock is selected and received for use on site. Where necessary, the operator has requested information from the provider of the feedstock to complete the feedstock characterisation. A feedstock testing program is implemented to determine that: • the feedstock is suitable for the processing techniques being used • the feedstock is lawfully able to be accepted, including under the conditions of relevant environmental authority • each batch of feedstock is homogeneous • the feedstock does not have any characteristics or constituents that adversely affect the composting process or the finished compost. It has been demonstrated that the feedstock can be effectively composted by the facility whilst managing the risks of adverse environmental impacts such as odour nuisance, contamination of surface and ground water or environmental harm through the end use of the compost product. Before introducing new or changed feedstock, small-scale trials are undertaken to assess and monitor the performance of the feedstock in the composting process. Systems are implemented to reject unacceptably odorous materials and eliminate troublesome feedstock sources. Operators understand the carbon, nitrogen and moisture content, porosity and odour potential of each feedstock. Systems are implemented on site to ensure that optimal feedstock mixes for C:N ratio, moisture and porosity are achieved and documented. Operators are familiar with industry standards for processing each feedstock and can determine a maturation period of sufficient length to produce stable and mature products that are safe and beneficial for use without risk of adverse impact on environment or health. For any inorganic wastes suitable for composting which are also categorised as regulated wastes under the EP Regulation, the operator has: • investigated whether there is an end of waste code for the waste or

Performance outcome	Best Practice Environmental Management Practices
	• consulted with the department to determine whether an application for an end of waste approval or licence for ERA 55 Other waste reprocessing or treatment' is required. An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems – Requirements with guidance for use (or most recent versions).

Feedstock storage and preparation

The decision to store incoming feedstock or immediately mix it with other materials will depend on the putrescibility, odour risk, leachate generation potential and the vector attraction potential of that batch of feedstock.

Feedstock preparation is a key factor for odour control and can alter final contaminant levels in finished compost products. Particle size reduction, feedstock blending, screening, the addition of water, and/or carbon or nitrogen amendments may be undertaken as part of feedstock preparation.

Compost facilities should keep a sufficient volume of bulking agent on site to be mixed with incoming finer feedstocks as soon as possible to limit the potential of odour emissions. Bulking agents typically include ground-up wood waste or green waste. If the immediate mixing of feedstocks with bulking agents is not possible, such feedstock should be covered with a thick layer (i.e. 75 to 100 mm) of unscreened compost or woody grindings.[48]

Depending on the quality and physical size of feedstock received, mechanical material handling is commonly required. Dust, odour and noise impacts of feedstock handling should be considered in the facility layout and design to achieve suitable buffers from sensitive or commercial places.

Physical contaminants can be reduced to a certain degree by removing them mechanically or by manual picking as part of feedstock preparation.[27] An area-based assessment of impurities should be considered rather than weight or item number based measures to better account for highly visible light weight impurities such as film plastics, which are likely to break down into microplastics over time.[40]

Best practice environmental management practices for feedstock storage and preparation are listed in Table 5.

Table 5: Best practice environmental management practices for feedstock storage and preparation

Performance outcome	Best Practice Environmental Management Practices
Feedstock storage and preparation is managed to avoid adverse environmental impacts (including odour nuisance and contamination risks)	Feedstock volumes stored on site are kept to the minimum volume necessary for the composting process and mix used at the facility as demonstrated by processing volume records and plans. A process of 'first in, first out' of feedstock is implemented on site. Compost operators, feedstock generators and transporters work together to increase feedstock collection frequency.

[48] Coker, C. 2012. Odor Defense Strategy. BioCycle, Vol 53, No 5, as referenced by Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report), pg 32.

Performance outcome	Best Practice Environmental Management Practices
	Stockpiles of bulking agents or high carbon material are kept at the receiving area so that these materials are available to immediately mix with or cover deliveries of odorous feedstock. Odorous feedstock or rapidly biodegradable organics are uniformly mixed with bulking agents immediately upon receipt, or by no later than the end of the day of receipt or otherwise: • placed into enclosed storage containers or sheds fitted with exhaust air purifiers; or • covered with a 15cm thick layer of compost that is in the curing stage.[49] If is a site is receiving odorous materials or rapidly biodegradable organics, or located close to sensitive and commercial places, the receival areas and the initial mixing operation are enclosed with appropriate ventilation and biofilter systems. Feedstock is prepared through mixing and/or shredding to establish a mix that is within the parameter ranges / ratios outlined in Appendix A or other ranges / ratios demonstrated as ideal for the feedstock and processing techniques being used on site. Management practices are implemented to ensure that shredding and feedstock handling does not cause dust, odour and noise nuisance at sensitive or commercial places (refer to the Best Practice Environmental Management Practices for these risks for further information). Physical contaminants are removed mechanically or by manual picking as part of feedstock preparation. To manage pH levels in composting materials, the C:N ratio of the compost mix is adjusted, rather than directly making adjustments (e.g. by adding lime).[3]

Minimising odour emissions

Odour control throughout the composting process is a crucial aspect of environmental management for composting operations. Suitable methods and procedures required for odour control will depend on the proposed composting method, composition of feedstock received and the potential impact of the activity on surrounding land users and sensitive receptors.

Weather also has a significant impact on odour emissions and in Queensland’s warm climate, the feedstock receival area can be a major source of odours due to the decomposition of feedstock in the heat before it arrives on site. This is less of an issue in colder climates.[50] Therefore, onsite meteorological data will be useful when planning site operations to minimise odour impacts and in responding to complaints.[50]

The following meteorological parameters may have an influence on odour emissions: [51]

- wind speed

[49] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 122.
[50] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 13.
[51] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 82.

- wind direction
- air temperature
- temperature difference between 2m and 10m above the ground (used to calculate atmospheric stability at night)
- solar radiation (used to calculate atmospheric stability during the day)
- relative humidity.

Wind conditions greatly affect how odour emissions from composting activities are dispersed. During still or light wind conditions, particularly during the evening or early morning, odour emissions do not typically disperse effectively into the atmosphere. They travel with little dilution from the composting facility from receptor.[50] During moderate wind conditions, significant odour plumes may form which can be transported considerable distances.[50] Consequently, operators need to understand and consider wind conditions when undertaking activities onsite to minimise the potential for odour emissions at sensitive or commercial places. As much as operationally possible, activities that have the potential to generate odours such as feedstock mixing or turning, should be avoided during still or light wind conditions.[52]

Given the significant influence of weather conditions on the potential odour emissions from composting activities, it is recommended that an onsite weather station is installed at composting sites. An onsite weather station must be carefully sited, typically 10m above the ground to ensure that the collected observations are representative of the broader region rather than of the specific microclimatic controls on the composting site.[51] Weather stations should also be installed and operated in compliance with the Australian/New Zealand Standards:

- AS/NZS 3580.1.1:2016 (Methods for sampling and analysis of ambient air – Guide to siting air monitoring equipment) or the most recent or replaced version of that standard
- AS 3580.14:2014 (Methods for sampling and analysis of ambient air – Meteorological monitoring for ambient air) or the most recent or replaced version of that standard.

Odour Emissions Audits

In addition to the odour impact assessment undertaken during the planning and design stage, sites that have a higher risk of odour emissions should consider conducting an odour emissions audit to develop a representative odour emissions inventory of the site's operations.[53]

To conduct the audit, a representative number of samples from each emission source should be collected and analysed in accordance with the methods prescribed in:

- AS/NZS 4323.3:2001 (Stationary source emissions, Part 3: Determination of odour concentration by dynamic olfactometry) or the most recent or replaced version of that standard
- AS/NZS 4323.4:2009 (Stationary source emissions, Method 4: Area source sampling - Flux chamber technique) or the most recent or replaced version of that standard.[35]

In addition to the sampling method, other important matters to consider when measuring odour emissions from composting sites include:

- the weather conditions under which measurements are conducted with significantly higher emissions observed during the warmer seasons

[52] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 34.
[53] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 16.

- wind speeds and direction
- stockpile age
- feedstock used on site
- aeration and temperature of composting material.

Operational data collected as part of odour emissions audit can be fed into the odour dispersion model developed as part of the site's EA application to calibrate and refine the model.[53] The odour impact assessment can then be reviewed to evaluate whether the site is likely to comply with it EA conditions, or whether further measures may be required to prevent odour emissions at sensitive or commercial places.

Odour Treatment Options

Generally, it is necessary to capture odours to be able to treat them. Given the difficulty capturing odours from open windrow composting, odour management at sites using this method of composting should focus on avoiding the generation of odours.[54] However, there are treatment systems that can be applied to manage and reduce odours in open windrow and enclosed systems.

Odour treatment systems can broadly be categorised into three groups.

- **Biological systems** use microorganisms to breakdown odorous gases via systems such as biofilters. A biofilter is a bed of biologically active organic material which the odorous air from compost passes through in order to trap and treat odorous compounds.[54] A simple biofilter may be achieved by applying a thick layer or blanket of mature compost (unscreened or oversize fraction) and/or pure green waste mulch over the windrows once they are initially formed.[54] After the first turning, the mature compost gets mixed into the compost where it acts as an inoculum and continues to have a beneficial impact.[50] A compost cap should consist of 50 to 100-mm of screened compost, or 150 to 200-mm of unscreened compost or coarse material. [54] Compost caps should be carefully installed as a cap that is too finely screened or one that accumulates near the base of the windrow, can block air flow and starve the windrow of oxygen. [54] A biofilter can also be combined with a bioscrubber. Bioscrubbing is a process of biological waste gas treatment in which exhaust air is ‘‘washed’’ in an absorber with a scrubbing liquid.[55]
- **Physical systems** strip out odorous compounds through physical processes like condensation, adsorption and absorption. The simplest physical systems for odour control involve spraying water or fine mist over compost windrows, especially prior to or during turning events.[55] Another simple physical system is the use of covered compost systems which allow condensation to form on the underside of the cover. Odorous gases are trapped by this layer of condensation allowing them to be degraded there or after dripping back into the compost pile.[55]
- **Chemical systems** use a designated reaction to change the nature of an odour into a less offensive chemical form. Chemical scrubbing is a common odour control system in which exhaust-gas compounds are dissolved in a scrubbing liquid with chemicals added which react with the dissolved waste gas compounds to neutralise them.[56]

Best practice environmental management practices for odour management are listed in Table 6.

[54] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 103.
[55] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 107.
[56] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 108.

Table 6 Best practice environmental management practices to manage odours

Performance outcome	Best Practice Environmental Management Practices
The activity will be operated in a way that odour nuisance is prevented.	For high-risk sites, an odour audit or odour balance study is undertaken to identify and quantify odour emissions from each stage of the process, resulting in an odour emissions inventory for the site.[53] An Odour Management Plan and procedures for odour control are implemented on site. Adequate odour control and treatment equipment is installed and maintained on site. Operators understand the composition of their feedstocks and the odour risk potential of each feedstock. A site-specific aeration strategy is implemented on site that considers the composting process, feedstock in the composting mix and includes monitoring methods and a process for re-introducing oxygen as necessary. Composting material is monitored and kept within the parameter ranges / ratios outlined in Appendix A or other ranges / ratios demonstrated as ideal for the feedstock and processing techniques being used on site to minimise odours. Composting operations that process highly odorous materials and / or are located close to sensitive receptors use a form of forced aeration and / or enclosed composting processes for at least the initial phase of composting.[57] Where leachate is generated and storage is unavoidable, leachate drains freely from all operational areas and is stored in a containment facility where aerobic conditions can be maintained, or in enclosed tanks with adequate ventilation systems.[58] Leachate storages should be regularly desilted to prevent excessive accumulation of organic solids, which leads to anaerobic and odorous conditions.**Error! Bookmark not defined.**58 Waste from the composting process is appropriately stored and managed until it is removed and lawfully disposed of. Odour impact management practices implemented on site include the use of weather forecasts and monitoring of weather conditions (rainfall, temperature, wind direction and speed) to assist in reducing the risk of odour complaints and responding to complaints. For example: • Not turning windrows when the wind direction is blowing towards sensitive or commercial places • Reducing the time that feedstocks are stored on site during high temperature weather events.

[57] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 14.
[58] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 17.

Performance outcome	Best Practice Environmental Management Practices
	An onsite weather station that continuously measures and electronically logs the following parameters is installed, maintained and operated in compliance with the Australian/New Zealand Standards: • rainfall (mm/day) • wind speed (km/hour) • wind direction (cardinal direction, e.g. north-easterly) • air temperature (°C) • relative humidity (%).[59] Complaints about odours are correlated with recorded weather conditions and deliveries of feedstocks to identify the influence that weather may have had on the formation of odours. An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems - Requirements with guidance for use (or most recent versions).
	For turned open windrow composting Where appropriate to the feedstock being composted, windrows are managed by allowing an initial undisturbed phase for temperature build-up followed by appropriate blending and aeration, control of moisture and other measures to ensure microbial decomposition and stabilisation. Caps of mature composts (75-100mm or up to 150-200mm thick if unscreened) are applied to newly formed windrows where odorous feedstocks are used in compost.[50] The turning management strategy and equipment (e.g. specialised windrow turners or front-end loaders) for the site have been determined by an experienced operator through site trials and measurements. If operators experience persistent odour issues in spite of their turning management strategy, operators should review their other onsite practices such as feedstocks and compost mixes. Windrow heights are greater than 1m and less than 3.5m. Water is added as part of the turning strategy.[6] Adequate room is left around windrows for equipment access to implement best practice odour management practices.[6] During heavy and / or prolonged rain, windrows are covered with a breathable textile cover to prevent the generation of odorous leachate.[6]

[59] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 134.

	For enclosed or forced aeration systems Forced aeration strategies are optimised for a particular compost mix, so as not to have an adverse impact on odour emissions.[57] Odour emissions captured from an enclosed or forced aeration composting system are effectively treated through an engineered biofilter.[60] Wet scrubbing systems (which also can be used as a pre-treatment to a biofilter) are used to treat particularly strong odorous air streams·60

Turning open windrows

There is no best practice standard for the frequency and method of turning open windrows.[61] The turning management strategy for a site should be determined by an experienced operator through site trials and measurements and consider:[63]

- maintaining aerobic conditions versus releasing accumulated odours
- loosening of the compost and breaking up clumps versus reducing the porosity of the compost mix
- redistributing moisture.[61]

Process optimisation trials should demonstrate that different turning methods have been assessed and that the chosen method is appropriate.[19] This determination should be supported by site measurements to demonstrate that optimal conditions are being achieved (e.g. temperature profiles, moisture distribution, oxygen levels) as well as observations around particle size and porosity.[19] For some sites, a custom-designed windrow turner will deliver optimal results, while for other sites, the gentler turning action of a front-end loader may be more beneficial.[19]

Although there is no one optimal turned windrow strategy, there are some common practices that should be considered for all sites:

- Turning events should be minimised for open windrows containing odorous feedstocks, especially during the first 7-10 days of composting, with only the minimum turning required to support pasteurisation and moisture redistribution. This enables the odorous by-products generated during this initial phase to be oxidised to less odorous compounds before they are released to the atmosphere.[8]
- Care must be taken not to overwork or excessively turn a windrow. An aggressive turning schedule or method can reduce the porosity of a compost mix and lead to anaerobic conditions.[61][5] AS 4454:2012 (Compost, soil conditioners and mulches) recommends a minimum of three turns for pasteurisation of green wastes, or five turns for higher risk materials (e.g. manure, animal waste, food or grease trap wastes) over a minimum of 15 days.[6] It should be noted that this recommendation is the minimum requirement to achieve pasteurisation and does not consider other key parameters such as those listed in Appendix A.
- In general, specialised turners are more effective at turning and mechanical agitation than front-end loaders.[5]
- If a front end loader is used, care should be taken to ensure that the operators do not drive up on the compost when windrows are being formed, which can cause compaction and reduce airflow.[61]

[60] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 111.
[61] Arcadis Australia Pacific Pty Limited, 2019. Phase 1 Report, pg 129.

- Windrows should be turned during calm weather conditions where prevailing winds are not blowing in the direction of sensitive or commercial places.

Minimising dust emissions

Dust modelling should be undertaken to assess the dust emission risks on site and inform appropriate management measures. If dust modelling is conducted, it should consider meteorological aspects such as rainfall, relative humidity, wind direction and speed as this will help in assessing the likelihood of dust complaints. Best practice environmental management practices for dust management during composting are listed in Table 7.

Table 7 Best practice environmental management practices for dust management

Performance outcome	Best Practice Environmental Management Practices
The activity will be operated in a way that dust nuisance is prevented.	Site design, equipment, and operational procedures manage the risks of dust impact to other properties. Measures are implemented to mitigate the impact of activities that cause dust. For example: • Ensure dust sources are adequately enclosed and that equipment is accessible for maintenance and cleaning.[62] • Conduct dusty operations during weather conditions that minimise emissions (e.g. avoid windy dry weather days). [63] • Adding moisture during turning events. • Vehicles, equipment and machinery are sited away from sensitive and commercial places and their operation is limited to specified hours. • Dust suppression spraying occurs during heavy vehicle and equipment operation. • Vehicles leaving the site are sprayed down to remove dirt and compost materials. • Conveyor lines for intensive screening and mulching are covered. Dust monitoring includes the consideration of rainfall, relative humidity, wind direction and speed and the results are used to assist in responding to complaints. An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems - Requirements with guidance for use (or most recent versions).

[62] Ministry for the Environment. 2016. Good Practice Guide for Assessing and Managing Dust. Wellington: Ministry for the Environment, pg 55.
[63] Ministry for the Environment. 2016. Good Practice Guide for Assessing and Managing Dust. Wellington: Ministry for the Environment, pg 56.

Water Contamination

Operators must implement measures to ensure that composting activities do not adversely impact on the environmental values of surface water or groundwater.

Stormwater

Well-designed and maintained surface water management controls are necessary to prevent pollution and flooding to surrounding land uses and water features. Runoff from composting activities is a potential source of environmental impacts due to high nutrient loads in the feedstock material.

A contaminant concentration limit(s) may be imposed as a condition of the development approval and/or EA for the authorised release of contaminated stormwater from the site to the receiving environment.

Operators will consequently have to monitor and record the quality of any stormwater or leachate which leaves the site that has been in contact with feedstock or contaminants used for, and / or resulting from, carrying out composting activities at the site. The water quality monitoring program should reflect the risk of potential environmental impacts associated with run-off from the site.

The order of preference for dealing with stormwater is indicated in Table 8. The preference in the first instance is to avoid stormwater contamination.

Table 8 Management hierarchy for stormwater management

<table>
<tr><td rowspan="4">Most preferred

Least preferred</td><td>1. Avoid the contamination of stormwater in the first instance. Measures may include:
• roofing areas where contaminants and or wastes are stored or handled
• diverting uncontaminated stormwater runoff away from areas where contaminants or wastes are stored or handled
• preventing incident rainfall on contaminants or wastes
• using alternate materials and or processes.</td></tr>
<tr><td>2. Minimise the quantity and or hazardous nature of the contaminated stormwater generated. For example, by minimising the size of areas where contaminants or wastes are stored or handled and by using alternate materials and or processes.</td></tr>
<tr><td>3. Recycling of contaminated stormwater produced, for example by incorporating reuse, reprocessing, and use of the stormwater.</td></tr>
<tr><td>4. Treatment of any contaminated stormwater to render it less or non-hazardous.</td></tr>
</table>

Groundwater

Adequate liners and leachate management systems are critical to prevent the contamination of groundwater systems. The leaching of nutrients to groundwater is a high risk where there is a significant degree of soil and / or rock permeability. Groundwater contamination risks also depend on the feedstock received at site and the extent to which these will contaminate leachate. Operators should implement procedures to avoid or minimise the formation of leachate through solid and liquid blending ratios and efficient methods of mixing the materials.[58]

Liners and leachate management systems will be required where composting operations are not conducted undercover or within an enclosed structure or where soil permeability creates a risk of ground water contamination.

Best practice environmental management practices for water quality are listed in Table 9.

Table 9 Best practice environmental management practices for water quality

Performance outcome	Best Practice Environmental Management Practices
The operation is managed so that the site does not adversely impact on the environmental values of surface water	Site selection and design should sufficiently address flood risk so that storm and flood waters do not enter the site. Where required, modelling has been undertaken to assess the flood risk to the proposed site. Adequate buffers exist between the composting activity and the local receiving environment. Where a buffer between a facility and surface waters is potentially necessary, the applicant has considered Table 1 in the CSIRO Guidelines for Riparian Strips for Queensland Irrigators[64] for agricultural operations in the six bio-geographical regions of Queensland. Stormwater is caught in on-site stormwater management drains and stored in adequately designed and maintained stormwater containment facilities. Contaminated water is directed to appropriate storage locations and kept separate from uncontaminated stormwater. An effective collection and recycling system for the reuse of stormwater onsite is implemented. Stormwater is reused where possible and stormwater run-off is prevented from entering locations where contaminated water is stored. Where reuse of the total expected volume of stormwater onsite is not practicable, opportunities for offsite reuse of appropriately treated stormwater are implemented. Stormwater that is to be released into the environment is tested and appropriately treated taking into account the receiving environment before release and meets all relevant EA conditions for the site and Environmental Protection (Water and Wetland Biodiversity) Policy 2019 Schedule 1 Environmental values and water quality objectives for waters. Erosion and sediment control measures are installed and maintained to: • allow stormwater to pass through the site in a controlled manner and at non-erosive flow velocities • minimise the duration that disturbed soils are exposed to the erosive forces of wind, rain, and flowing water

[64] Available at http://www.clw.csiro.au/publications/technical99/tr32-99.pdf

Performance outcome	Best Practice Environmental Management Practices
	• minimise soil erosion • minimise sedimentation of contour drains, drainage lines, channels and waterways • minimise negative impacts to land, waters or properties adjacent to the activities (including roads). Site topography is limited and uniform (i.e. relatively flat to gently sloped) to minimise sediment movement and to direct stormwater towards containment facilities. A water quality sampling regime, including appropriate monitoring and reporting that reflects the types and levels of risk associated with the operation is implemented onsite.[65] Leachate storages have adequate capacity to avoid overflows during times of heavy rainfall.[58] The leachate collection method ensures that all leachate is collected on site and achieves the following: • prevent ponding of leachate in any area other than the designated leachate collection and storage areas • prevent the reintroduction of leachate into composting material • drain leachate away from composting material • drain leachate to the collection drain. An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems - Requirements with guidance for use (or most recent versions).
The operation is managed so that the site does not adversely impact on the environmental values of groundwater quality.	Groundwater monitoring is undertaken unless it can be proven: • groundwater is at such a significant depth that it will not be impacted by leaching or percolation of contaminants or • the geotechnical composition of the composting pad surface and / or subsurface is sufficiently impermeable so that groundwater will not be impacted. An adequate hard stand area is used to prevent the leaching of contaminants to groundwater. Where soil permeability creates a risk of groundwater contamination, liners and leachate management systems are installed. Adequate erosion and sediment control measures are implemented and maintained to minimise contact of surface water with groundwater.

[65] For further information refer to the www.des using the search term ‘Water monitoring and sampling manual.’

Performance outcome	Best Practice Environmental Management Practices
	Adequate direction of stormwater management around contamination sources is achieved. An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems - Requirements with guidance for use (or most recent versions).

Minimising noise emissions

Noise impacts to sensitive and commercial places can be prevented through planning, design and management practices. Best practice environmental management for noise emissions are listed in Table 10.

Table 10 Best practice environmental management practices for controlling noise during composting

Performance outcome	Best Practice Environmental Management Practices
The activity will be operated in a way that noise nuisance is prevented.	Measures are implemented to mitigate the impact of activities associated with high noise levels. For example: • Avoid work involving noise at times when it is most likely to cause environmental nuisance, such as night-time, Sundays or public holidays. • Switch off equipment when not in use or limit the hours of operation. • Select the quietest machinery and equipment available and find quieter processes or ways of performing tasks (e.g. investigate whether there are suitable alternatives to reversing alarms on vehicles and select vehicles with low noise emissions). • Install appropriate acoustic screens or noise reduction barriers. • Ensure that roads have a suitable and well-maintained surface and limit the amount, type, times and speed of vehicle movements. • Start plant and vehicles sequentially rather than all at the same time. • Investigate whether it is possible to fit noise reduction features onto equipment (e.g. noise absorbent panelling or rubber lining). • Use existing screens or site features to their advantage to reduce noise. • If the noise is directional, point the source away from noise-sensitive locations). • Use enclosures around noisy equipment such as pumps or generators. • Ensure that equipment, vehicles and acoustic screens or other noise mitigation devices are properly maintained. • Ensure that each staff member is aware of their responsibilities to reduce noise emissions, and how this can be achieved. Noise at the sensitive and commercial places is periodically monitored to ensure that noise mitigation strategies are effective.

	Monitoring is undertaken at a sufficient frequency to demonstrate that the activity is not causing or likely to cause environmental harm. This may include background monitoring of a sufficient period to demonstrate a background level, taking into consideration natural and seasonal variations. An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems - Requirements with guidance for use (or most recent versions).

Fire Risk Management

Fire risk management practices should consider fire prevention as well as fire response. Best practice environmental management practices for fire risk management are listed in Table 11. Operators should also refer to the Guideline Prevention of fires in waste stockpiles (ESR/2020/5409)[1] for additional information.

Table 11 Best practice environmental management practices for fire risk management

Performance outcomes	Best Practice Environmental Management Practices
Fire risks are managed to prevent environmental harm	A fire risk management plan has been developed and implemented at the site that identifies: • the fire risks on site • measures to prevent and control fires if they were to occur. Measures to prevent fires in waste stockpiles have been implemented in accordance with the Guideline Prevention of fires in waste stockpiles (ESR/2020/5409).[1] Fire control equipment is maintained on the site and a staff training program has been developed. The site layout allows adequate space for emergency vehicles.

Pests and Vectors

Proper pasteurisation of compost is essential to eliminate most of the pathogens and weed seeds that may have been present in the feedstock material. Pasteurisation is the process whereby organic materials are treated to significantly reduce the numbers of plant and animal pathogens and plant propagules. Some weed seeds may survive the composting process if the pasteurisation was not uniform or the temperature / time relationship was not suitable. To prevent the environmental and community issues that may result from pests and vectors, operators must implement measures to keep the population of pests and vectors on site as low as possible. Operators must also ensure that measures are in place to prevent contaminants, such as weed seeds, that may be present in incoming feedstock and unfinished compost from being reintroduced into mature compost.

Best practice environmental management practices for pest and vector management are listed in Table 12.

Table 12 Best practice environmental management practices for pest and vector management

<table>
<tr><th>Performance outcomes</th><th>Best Practice Environmental Management Practices</th></tr>
<tr><td>The presence of vectors and pests on site is as low as possible</td><td>A pest and vector management and monitoring program is implemented on site.

Operators understand and comply with requirements under the Biosecurity Act 2014 to control the spread of weeds and pests.

There is minimal time between when feedstock is delivered to the site and when it is introduced into the composting process.

There are no, or only very limited, exposed storages of rapidly biodegradable organics (including grass clippings, food and animal wastes) on site.

Rapidly biodegradable organics are stored in moisture, pest and vector proof containers.

Procedures are in place to identify and manage any declared pests on site.

Outbreaks of pests or vectors are controlled by established deterrence and eradication measures.

An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems - Requirements with guidance for use (or most recent versions).</td></tr>
<tr><td>The risk of pathogen transmission is as low as possible</td><td>All feedstock is subjected to a pasteurising process as per Table 13 – Pasteurisation requirements as relevant to the compost process and feedstock type.

Table 13 – Pasteurisation Requirements
<table>
<tr><th>Type of feedstock</th><th>Pasteurisation requirements</th></tr>
<tr><td>Lower-risk feedstock
(including plant materials or vegetation)</td><td>Appropriate turning of the windrow so that the whole mass is subjected to a minimum of three turns with the internal temperature reaching a minimum of 55°C for three consecutive days before each turn.</td></tr>
<tr><td>Higher-risk feedstock
(including manure, animal waste, food or grease trap wastes)</td><td>The core of the compost mass must be maintained at 55°C or higher for 15 days or longer, during which the windrow must be turned a minimum of five times.</td></tr>
<tr><td>All feedstock</td><td>An alternative process that guarantees the elimination of plant propagules and a reduction of human and animal pathogen numbers that meets the same level as the other methods listed. The process must be confirmed by:</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Performance outcomes</th><th>Best Practice Environmental Management Practices</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td>

pathogen testing in accordance with Appendix D, Paragraph D5.4 of AS Composts, soil conditioners and mulches:2012 (Composts, soil conditioners and mulches) and
the elimination of viable plant propagules in accordance with Appendix M of AS 4454:2012 (Composts, soil conditioners and mulches).

</td></tr>
</table>
Measures are in place to ensure:

compost is uniformly and effectively pasteurised
quality assurance for finished compost including routine testing.

Contaminants from feedstock or unfinished compost are not reintroduced to finished compost through measures including:

the separation of areas for keeping feedstock, composting material and finished compost
cleaning vehicles and machinery used for feedstock and unfinished compost before they are used for finished compost.

Where possible, finished compost is kept covered.
An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems - Requirements with guidance for use (or most recent versions).
</td></tr>
</table>

Litter

Physical barriers (e.g. fences and screens) and onsite management practices (e.g. regularly scheduled clean-ups of the site) must be implemented to ensure that litter from the activity is not spread beyond the site boundary. Best practice environmental management practices for preventing litter are listed in Table 14.

Table 14 Best practice environmental management practices for preventing litter

Performance outcome	Best Practice Environmental Management Practices
Litter from the activity is not present beyond the site boundary.	Physical barriers including fences or movable litter screens are implemented at the site and effective in preventing windblow litter leaving the site. Staff at the site undertake regular clean-ups to remove litter from the site. Vehicles entering the site have covered loads if their contents may become windborne and generate litter. Vehicles are checked for visible litter (e.g. tracking litter in the wheels of the vehicle) before leaving the site and any litter that is identified is removed.

Performance outcome	Best Practice Environmental Management Practices
	Any rejected feedstock or residual wastes is stored appropriately to prevent litter before being removed for lawful disposal. After becoming aware of any litter that has left the site, the litter is cleaned up immediately. An environmental management system is implemented per AS/NZS ISO 14001:2016 Environmental management systems - Requirements with guidance for use (or most recent versions).

6. Appendix A - Key process parameters

Parameter	**Range or ratio**
Carbon to Nitrogen ratio (C:N ratio)	Between 25:1 and 40:1
Porosity or bulk density	Porosity - Between 45% and 65% total volume Bulk density at the start of composting – Less than 650 kg/m^3
Moisture Content	Between 45% and 60% moisture content
pH	Between 6.5 and 8.0
Oxygen content	Greater than 10%
Temperature	Between 55°C and 75°C

7. Appendix B – Feedstock unsuitable for composting

Feedstock Material	Description
Asbestos and asbestos containing materials	
Bilge waters	Sea and fresh water from vessel pump outs.
Biosecurity waste	(a) waste that is goods subject to biosecurity control under the *Biosecurity Act 2015* (Cwlth); or (b) goods under the *Biosecurity Act 2015* (Cwlth) that are or were in contact with waste mentioned in paragraph (a).
Dye waste (water based)	By-product from industrial dying processes.
Effluent waste and wastewater	Liquid industrial or domestic effluents and waste streams, including contaminated groundwater and stormwater, except those of known origin and composition solely containing organic material as defined in the definition of environmentally relevant activity organic material processing ERA 53.
Filter cake and presses	Any concentrated solid and semi-solid waste streams from water treatment process (e.g. centrifuge, filter press), excluding material that complies with the requirements of End of Waste Code ENEW07503318.[66]
Filter and ion exchange resin backwash waters	Any backwash and reject water from a filtration (e.g. sand or membrane filter) or ion exchange process, excluding material that complies with the requirements of End of Waste Code ENEW07503318.[66]
Forecourt water	Run off from service station forecourts.
Hide curing effluent	Effluent and wastes from tanneries including, but not limited to, the various steps involved in preparing animal hide e.g. washing for removal of hair, fat removal, chemical treatment.
Leachate waste	A liquid that has passed through, or emerged from, or is likely to have passed through or emerged from, a landfill or from a non-organic waste or contaminated soil deposit.
Materials containing persistent organic pollutants including polybrominated diphenyl ethers (PDBEs), polychlorinated biphenyls (PBCs), polyfluorinated organic compounds[67] and polyaromatic Hydrocarbons (PAHs).	
Materials originating from activities or sites associated with PFAS contamination,[68] except where representative analysis results for the load using lowest practicable limits of reporting, including paired standard and total oxidisable precursor assay and for solids, Australian Standard Leaching Procedure (ASLP) leachability with an unbuffered leach solution, indicate absence of PFAS.	

[66] Available online at https://environment.des.qld.gov.au/
[67] Materials containing per and poly-fluoroalkyl substances (PFAS) are considered separately
[68] Operators should refer to Appendix B of the PFAS NEMP for details of activities associated with PFAS contamination. The PFAS NEMP is available online on the Australian Government Department of Agriculture, Water and Environment website at https://www.environment.gov.au/

Feedstock Material	Description
Municipal solid waste (excluding segregated compostable organic waste that does not include another unsuitable material).	
Paint and industrial coatings products and wash	Paint and industrial coatings products and water and solvent wash down water containing paint and industrial coatings residues.
Particle board	Any part of an engineered wood panel product, manufactured from wood particles, coated in adhesive resin and pressed together into a finished panel.
Sullage waste (greywater)	Greywater / wastewater from domestic or commercial buildings excluding sewage but including waters drained from showers, sinks and laundries.
Treatment tank sludges and residues	Any treatment tank sludge or residue, excluding sludges and residues containing only plant or animal based organic matter or material that complies with the requirements of End of Waste Code ENEW07503318.[66]
Treated timber waste	Any treated timber waste that does not meet the requirements of End of Waste Code ENEW07607119.[66]
Waste containing restricted stimulation fluids	
Waste known to be contaminated with glass, metal, rubber and coatings that cannot be eliminated though processing	
Waste treated by immobilisation or fixation	
Water based inks	Liquid wastes from ink use or manufacture.
Water and solvent based paints and industrial coatings	Liquid waste paint, including where undiluted.

8. Appendix C - Odour rating of composting feedstock

Note: If a **feedstock** can fit within multiple listings, the most specific listing applies. For example, 'vegetable waste' could be considered 'Food organics' with a high odour rating. However, as 'vegetable waste' is listed as a specific example under 'Food and food processing waste' the applicable odour rating for 'vegetable waste' is medium.

Feedstock	Examples	Odour Rating
Abattoir waste	Meat processing leftovers, bone material, blood, tallow waste, abattoir waste including animal effluent and residues from meat processing, including abattoir effluent, liquid animal wastes (blood) and sludge	Very high
	Paunch material	High
Animal manure	Horse manure, chicken manure, cow manure, livestock manure, or any manure produced by animals, wastewater from holding yards	High
Animal waste and animal processing waste	Any dead animals or part/s of dead animals, remains of animals or part/s of remains of animals (e.g. chickens from poultry farms), egg waste, milk waste, mixtures of animal manure and animal bedding organics	Very High
Bark, lawn clippings, leaves, mulch, pruning waste, sawdust, shavings, woodchip and other waste from forest products	Cane and sorghum residues including bagasse, forest mulches, cypress chip, green waste, mill mud[69], pine bark, sawmill residues non-treated (including sawdust, bark, wood chip, shavings etc.), tub ground mulch (from land clearing and forestry waste), peat, seed hulls/husks, straw, and other natural fibrous organics, wood chips (forestry waste and land clearing, household maintenance), wood waste (including untreated pallets, offcuts, boards, stumps and logs); worm castings suitable for unrestricted use	Low
Biosolids	Biosolids that are not stabilised biosolids	Very high
	Stabilised biosolids	Medium
Cardboard and paper waste	Paper mulch	Low
	Paper pulp effluent, paper sludge dewatered	Medium
Compostable polylactic acid (PLA) plastics	Compostable plastics produced in accordance with: (a) AS 4736:2006 (Biodegradable plastics) or the most recent or replaced version of that standard or (b) AS 5810:2010 (Biodegradable plastics - Biodegradable plastics suitable for home composting) or the most recent or replaced version of that standard.	Low
	Ammonium Nitrate, dewatered fertiliser sludge	High

[69] That meets the Resource quality criteria for the approved use in the Sugar Mill By-Products End of Waste Code (ENEW07359817)

Feedstock	Examples	Odour Rating
A substance used for manufacturing fertiliser for agricultural, horticultural or garden use	Fertiliser water and fertiliser washings, stormwater from fertiliser manufacturing plants containing fertiliser washwater	Medium
Fish processing waste	Fish bones and other fish remains/leftovers, wastewater from fish processing	Very high
Food and food processing waste	Expired/past used by date non-protein based food from supermarkets, expired beer, vegetable oil wastes and starches, vegetable waste, yeast waste, food processing effluent (wastewater) and solids (including sludges) from non-protein based food	Medium
	Food processing effluent (wastewater) and solids (including sludges) from protein based food	Very high
	Food organics, expired/past used by date protein based food from supermarkets, brewery and distillery effluent and waste	High
	Expired soft drinks, molasses waste, grain waste (hulls / waste grains), starch water waste, sugar and sugar solutions	Low
Grease trap waste	Oil and grease waste recovered from grease traps	Very high
Green waste	Leaves, grass clippings, prunings, tree branches from household maintenance	Low
Inorganic additives with beneficial properties	Bentonite	None
	Crusher dust	None
	Drilling muds (non-CSG and no additives)	None
	Gypsum	Medium
	Lime and lime slurry (inert)	None
Mushroom compost and mushroom growing substrate		Medium
Poultry processing waste	Feathers, meal and bone leftovers, egg waste including poultry processing poultry abattoir effluent and sludges	Very high
Soils	Acid sulfate soils and sludge	High
	Clean soil, clean mud, sand	None

Feedstock	Examples	Odour Rating
Stormwater	Low level organically contaminated stormwaters or **groundwaters** (tested)	Low
Wood waste from untreated timber	Untreated pallets, offcuts, boards, stumps and logs, sawdust, shavings, timber offcuts, crates, wood packaging	Low