GUIDELINES FOR ENVIRONMENTAL MANAGEMENT

BIOSOLIDS

LAND APPLICATION

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EPA VICTORIA

GUIDELINES FOR ENVIRONMENTAL MANAGEMENT

BIOSOLIDS LAND APPLICATION

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FOREWORD

EPA Victoria is continually looking for improved ways to ensure the environment is protected for the benefit of present and future generations of Victorians. Biosolids (appropriately treated sewage sludge) should be viewed as a potential resource that can be beneficially utilised in the agricultural, horticultural and municipal sectors, rather than as a waste-requiring disposal. This guideline describes minimum requirements for biosolids land application, thereby ensuring sustainable management, but enabling access to the potential benefits of biosolids – addition of organic matter, nutrients, trace elements and moisture with subsequent improvements in soil structure and fertility.

Although beneficial biosolids uses can include alternatives to land application, such as energy recovery, these alternative uses are not included in this document.

This guideline is based on an extensive review of scientific literature, legislation, codes and guidelines (in Australian and overseas) relating to biosolids use, disease risks, food safety, fertiliser and soil chemical contamination management. As a result, this guideline has integrated many of the best approaches in existing biosolids guidelines (interstate and overseas) including alignment with the draft National biosolids guideline under the National Water Quality Management Strategy.

This guideline provides a framework for sustainable biosolids land application and the exclusion of these schemes from EPA works approval and licensing provisions. As with all Guidelines for Environmental Management, the focus is on desired performance objectives and outcomes through quality management, allowing scope for innovation. By focusing on those elements that represent best practice and providing a systematic approach to achieving these, the guideline encourages suppliers and users of biosolids to strive for continuing improvement in environmental performance. Suppliers and users of biosolids have flexibility to consider and implement alternative measures to those suggested, provided an equivalent, or better, site-specific solution is achieved. At the same time, those seeking greater direction or certainty can simply apply the suggested measures.

MICK BOURKE

CHAIRMAN

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This guideline was prepared with input from a wide range of departmental and industry stakeholders. Central to the finalisation of the guidelines was the valuable contributions from members of the Victorian Biosolids Technical Working Group (2000). This was an informal group that comprised representatives from the Department of Natural Resources and Environment (now Department of Sustainability and Environment and the Department of Primary industries), EPA Victoria, Department of Human Services, the Water Industry (representatives from Melbourne Water, South East Water and Coliban Water) and Dairy Food Safety Victoria.

Input into these guidelines was also received from attendees at the 'Biosolids Management Forum' in Melbourne on 20 November 2000 and attendees at an EPA seminar series over August and September 2002. Comments were also received following the release of consultation drafts of the guideline in November 2000 and November 2002.

The willingness of international regulatory agencies to provide information to assist guideline finalisation, particularly the United States Environmental Protection Agency, the Department for Environment Food & Rural Affairs (UK) and the Environment Agency (UK), is acknowledged. During a best practice study tour in 2002, valuable information was also obtained from water businesses and organisations involved in biosolids management in the United Kingdom, France and the United States.

GLOSSARY OF TERMS

The following definitions apply to this guideline.

Term	Definition
Agricultural land	Land that is used for such uses as horticulture, turf growing, animal husbandry including the keeping or breeding of livestock, poultry and the growing of field crops or pastures. Includes land that is currently used for agriculture or could reasonably be expected to in the future.
Application site	The area of land with biosolids application.
Beneficial Uses	As defined in State Environment Protection Policies (SEPP) such as SEPP (*Waters of Victoria*).
Biosolids	In this guideline, biosolids are considered to be organic solids derived from sewage treatment processes that are in a state that they can be managed to sustainably utilise their nutrient, soil conditioning, energy, or other value (ie achieve minimum standards for classification as T3 and C2 biosolids). The solids that do not meet these criteria are defined as sewage sludge.
Bioavailability	Availability of a substance for uptake by biological system.
CLAR	Contaminant limited application rate. The maximum rate at which biosolids can be applied without exceeding the receiving soil contaminant limit (RSCL).
Commercially processed	Food that is subject to appropriate heat or chemical processes to reduce pathogens to levels that are safe for consumption.
Composting	The biological decomposition of the organic constituents of biosolids and other organic products under controlled conditions.
Controlled access	Where public or livestock access to biosolids application areas is restricted or controlled, such as via fences or signage, for a period of time stipulated by this guideline.
Contaminant grade	Grading category used to describe the quality of biosolids product based on the concentration of contaminants.
Dewatering	Dewatering processes reduce the water content of sludge to minimise the volumes for transport and improve handling characteristics. Typically,

	dewatered biosolids can be handled as a solid rather than as liquid matter.
Disinfection	A process that destroys, inactivates or reduces pathogenic microorganisms.
E.coli	A subset of coliforms found in the intestinal tract of humans and other warm-blooded animals. They can produce acid and gas from lactose at 44 to 44.5^{o}C; hence the test for them is more specific than for total coliforms and selects a narrower range of organisms. They are a more specific indicator of faecal contamination than total coliforms.
EIL	Ecological investigation level as described in the National Environment Protection Measure (*Assessment of Site Contamination*) 1999.
EIP	Environment Improvement Plan. A documented plan covering the use of biosolids to manage potential environmental or health risks.
HIL	Health Investigation Level, described in the National Environment Protection Measure (*Assessment of Site Contamination*) 1999.
Land disposal	Application of biosolids where beneficial use is not an objective. Disposal will normally result in application rates that exceed agronomic nutrient requirements or cause excessive contaminant accumulation in the soil.
ML	Maximum Level. The maximum level of an agricultural or veterinary chemical (normally associated with heavy metals and polychlorinated biphenyls (PCBs)) that is permitted to be present in food, expressed in milligrams of the chemical per kg of food (mg/kg). (ANZFA 'Food Standards Code', Section 1.4.1).
MRL	Maximum Residue Limit. The maximum level of an agricultural or veterinary chemical (normally associated with organochlorine pesticide residues such as DDT, dieldrin) that is permitted to be present in food, expressed in milligrams of the chemical per kilogram of food (mg/kg). (National Registration Authority 'MRL Standard', ANZFA 'Food Standards Code – Section 1.4.2.').
MPN	Most probable number (normally associated with bacterial testing).
NATA	National Association of Testing Authorities.
NLAR	Nutrient Limited Application Rate. The maximum rate at which biosolids can be applied without exceeding agronomic nutrient requirements.
PFU	Plaque-Forming Units (normally associated with virus testing).

Reprocessor	A person or organisation that reprocesses biosolids for use.
Stabilisation	The processing of biosolids to reduce volatile organic matter, vector attraction, and the potential for putrefaction and offensive odours.
Supplier	A person or organisation that produces and supplies biosolids for use. This includes a water business producing and treating biosolids and reprocessors involved in further treatment.
Sustainable use	The use of nutrients in biosolids at or below the agronomic loading rate and/or use of the soil conditioning properties of biosolids. Sustainable use involves protection of human health, the environment and soil functionality.
Treatment grade	Grading category used to describe the quality of biosolids product based on a combination of defined treatment processes, microbiological criteria and stabilisation to reduce vector attraction and odour generation.
VAR	Vector attraction reduction, includes measures such as stabilisation or management practices such as biosolids soil incorporation to avoid the biosolids attracting vectors such as flies or rodents.
Vectors	Any living organisms that are capable of transmitting pathogens from one organism to another, either: (i) mechanically (by transporting the pathogen); or (ii) biologically by playing a role in the lifecycle of the pathogen. 'Vectors' include flies, mosquitos or other insects, birds, rats and other vermin (source USEPA 1999)

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1. INTRODUCTION

1.1 Sustainable biosolids use

Biosolids, commonly known as treated or stabilised sewage sludge, are produced during the biological treatment of sewage. Biosolids contain significant quantities of organic matter, moisture, nutrients and trace elements, and as such are increasingly being viewed as a resource for agricultural and municipal sectors.

It is estimated that total annual production in Victoria is approximately 66,700 dry tonnes, with around 60 per cent of that production from the major metropolitan treatment plants. The biosolids are produced by a variety of treatment processes, including biological nutrient removal, trickling filter and lagoon based systems.

While biosolids can be a resource, potential risks associated with nutrients, microorganisms, chemical contaminants and unstabilised material need to be appropriately managed.

This guideline is focused on providing a framework for achieving safe and sustainable use of biosolids through land application. This guideline does not address in detail the use of biosolids in other programs such as energy recovery.

1.2 Guideline objectives

The overall objective of this guideline is to maximise the sustainable use of biosolids, by documenting good practice for matching biosolids quality with end use activities and minimising any associated risks.

To achieve this objective the guideline describes:

- the statutory framework relevant to end use schemes (Chapter 2);
- the roles and responsibilities of suppliers, reprocessors and users (Chapter 3);
- requirements for risk identification and end use scheme assessment (Chapter 3);
- biosolids contaminant, treatment and stabilisation grades (Chapter 4);
- permissible end uses of biosolids and site restrictions for protection of the public, agriculture and food safety (Chapter 5);
- site selection and management practices for end use schemes for environmental and public health protection (Chapter 6);
- requirements for record keeping and information transfer (Chapter 7);
- guidance for preparation of Environment Improvement Plans (EIP) (Chapter 8); and
- the process for review of these guidelines and research needs (Chapter 9).

Appendices contain more technical detail relating to the calculation of contaminant grades, application rates and requirements for monitoring biosolids quality and receiving soils. References and relevant departmental and industry contact lists are also appended.

The use of biosolids in accordance with this guideline will be considered as sustainable and therefore such schemes are excluded from EPA works approval and licensing requirements (Section 2.2). Schemes do, however, need to develop and follow a documented Environment Improvement Plan (EIP) (Chapter 8).

1.3 What are 'GEM's and the scope of this guideline?

The Guidelines for Environmental Management (GEM) series outlines key environmental objectives relevant to particular industries or activities, and provides suggested measures to achieve these objectives.

The *GEM: Biosolids Land Application* is written for the land application of biosolids generated from municipal sewage treatment plants treating domestic sewage and material accepted via trade waste agreements or otherwise introduced into the sewage treatment process (e.g. septage from septic tanks accepted at regional plants).

This guideline does not address material that is entirely comprised of:

- the use of solids generated from individual household systems (e.g. residential septic tanks) or trade waste treatment plants;
- grease trap wastes;
- screenings, grit and scum;
- sewer silt and stormwater waste;
- industrial waste; or
- drinking water treatment sludges.

While these materials are not directly addressed in this guideline, the principles described may nevertheless serve as a useful basis for management.

2. STATUTORY FRAMEWORK

2.1 Legislation

Acts

Current Acts, policies and regulations administered by EPA and other Government agencies relevant to the use of biosolids are listed in Appendix A. Acts of particular significance to biosolids use are:

- *Environment Protection Act* 1970;
- *Health Act* 1958;
- *Livestock Disease Control Act* 1994;
- *Agricultural and Veterinary Chemicals (Control of Use) Act* 1992;
- *Food Act* 1984;
- *Australia New Zealand Food Authority Act* 1991.

Under the *Environment Protection Act* 1970 discharges to the environment must be managed so that they do not adversely affect the receiving environment (for example, land, surface water or groundwater). This Act includes works approval and licensing requirements administered by EPA Victoria, to ensure appropriate control of such discharges.

The *Environment Protection Act* also describes the key principles of environmental management and the waste hierarchy, with waste avoidance and recycling the preferred management option compared to disposal.

The *Health Act* 1958 makes provision for the prevention and abatement of conditions and activities, which are, or may be offensive or dangerous to public health.

The *Livestock Disease Control Act* 1994 outlines requirements for livestock grazing land irrigated with "sewage" or "nightsoil", in order to protect health of stock (specifically cattle and pigs grazing pasture or fed fodder from that land), and humans (consuming meat and milk products). *Taeniasis* (also known as "Beef Measles") is specifically addressed by this Act.

The *Agricultural and Veterinary Chemicals (Control of Use) Act 1992* contains a definition of "fertilisers" which includes the agricultural use of biosolids for fertilising the soil, supplying nutrients to plants or soil conditioning.

The *Food Act* 1984 legislates on food quality standards. Food is considered "adulterated" under the Act if it does not meet prescribed standards. Victoria complies with these national quality standards by enforcing the Australian New Zealand Food Authority (ANZFA) *Food Standards Code*. Developed under the *Australia New Zealand Food Authority Act* this code specifies "maximum residue limits" (MRLs) and "maximum levels" (MLs) permitted to be present in food. MRLs are normally associated with pesticide resides, whilst MLs are associated with metals, polychlorinated biphenyls (PCBs) and certain other organic chemical contaminants. It is an offence under the *Food Act* 1984 to sell food that is adulterated.

Refer to Appendix D for other important legislation, including the *Occupation Health and Safety Act* 1985 and the *Trade Practices Act* 1974.

Statutory policies

Government declares State Environment Protection Policies ("SEPP") and Waste Management Policies (previously referred to as Industrial Waste Management Policies ("IWMP")) under the *Environment Protection Act*. SEPPs provide ambient environmental quality objectives and general approaches to achieving the objectives. Compliance with the relevant SEPPs must be achieved for all activities that involve biosolids treatment and use.

SEPPs and IWMPs most relevant to biosolids use include:

- *SEPP (Waters of Victoria)* 2003 and its schedules;
- *SEPP (Groundwaters of Victoria)* 1997;
- *SEPP (Ambient Air Quality)* 1999;
- *SEPP (Air Quality Management)* 2001;
- *SEPP (Prevention and Management of Contamination of Land)* 2002; and
- *IWMP (Prescribed Industrial Waste)* 2000.

This guideline provides the framework to achieve the objectives of the above policies.

Regulations

The *Environment Protection (Scheduled Premises and Exemptions) Regulations 1996* outline the premises and activities that are scheduled and subject to works approval and licensing provisions of the *Environment Protection Act* 1970.

The regulations also provide exemptions from these works approval and licensing provisions for certain, otherwise scheduled, activities and premises.

The *Agricultural and Veterinary Chemicals (Fertilisers) Regulations* 1995 (and subsequent 1998 amendment) prescribes maximum heavy metal contamination levels and contaminant warning label requirements to accompany fertiliser products.

National documents

There are several requirements derived from a National level that are relevant to biosolids management and have influenced this guideline. These include:

- the National Environment Protection Measures (NEPM) *Assessment of site contamination* and *Movement of controlled wastes between States and Territories;* and the
- National Water Quality Management Strategy series of documents, including the 2002 draft *Guidelines for Sewerage Systems: Biosolids Management*.

Guidance documents

In addition to the previously mentioned legislation, there is a variety of guidance material of which biosolids managers should be aware. Examples of this documentation are referenced in the relevant sections of this guideline.

2.2 Exclusion from EPA works approval and licensing

Biosolids end use schemes that implement all the necessary measures to protect public health, stock health and the environment as specified in these guidelines are not regarded as a waste disposal activity. Therefore, such schemes will not be a scheduled activity under *Environment Protection (Scheduled Premises and Exemptions) Regulations 1996*, and do not require EPA works approval or licence.

Schemes that do not comply with the guideline will need to either obtain works approval and a discharge licence, or receive a site-specific exemption from EPA Victoria.

The proponent may propose alternative measures than those specified in the guidelines. These alternative measures must provide an equal or greater site-specific solution to manage the risks posed by the scheme. It is the responsibility of the proponent to demonstrate the adequacy of the alternative measures to the satisfaction of EPA Victoria and where relevant, other Government agencies. These will be considered on a case-by-case basis (e.g. specific approval from the Chief Veterinary Officer, Department of Primary Industries (DPI), may be needed where changes are being proposed for the management of livestock grazing schemes).

The need for implementation of measures beyond those specified in this guideline will depend upon the size of the scheme, classification of the biosolids and the sensitivity of the surrounding environment. The proponent should assess the need for these additional measures based upon identified risks.

It should be noted that the treatment of biosolids for end use schemes is not an exempt activity under the *Environment Protection (Scheduled Premises and Exemptions) Regulations 1996*. Sewage and biosolids treatment works will, therefore, require EPA works approval and may require an operating licence dependent on whether the treatment results in a waste discharge to the environment. Also note that composting and vermiculture facilities (greater than 10 tonnes per day production) also require a works approval (for more information refer to

Environmental Guidelines for Composting and Other Organic Recycling Facilities (EPA 1996).

3. ROLES, RESPONSIBILITIES AND RISK

3.1 Roles and responsibilities

Suppliers and users

It is important that suppliers and users of biosolids understand and meet their obligations under these guidelines.

Unrestricted grade biosolids

For schemes involving unrestricted grade biosolids, it is the supplier's responsibility to ensure the biosolids achieves the necessary contaminant and treatment grade requirements (C1/T1 grade – refer Chapter 4). The supplier must record quality and quantity information on the biosolids and submit the information annually to EPA.

End users of unrestricted grade biosolids do not have specific obligations under these guidelines. However, end users continue to have broad legislative responsibilities as per any product. As an example, EPA enforcement action could result from inappropriate use of any fertiliser, compost or soil ameliorant that led to surface water pollution.

Restricted grade biosolids

The supplier must ensure that any scheme supplied with restricted grade biosolids has either:

(i) an EIP (refer chapter 8) endorsed by EPA or an EPA appointed auditor as complying with these guidelines;

(ii) an EPA works approval or licence; or

(iii) a site-specific exemption from EPA.

The supplier should ensure that there are mechanisms (e.g. audits, contractual agreements) for ensuring end use schemes supplied with restricted grade biosolids comply with the relevant requirements. For the majority of schemes, this will mean complying with the endorsed EIP.

Suppliers of biosolids have a responsibility to ensure the product meets the biosolids classification required for the intended use.

Suppliers have a responsibility to keep a register of all schemes they supply with restricted grade biosolids. This register should include the end use site location, quality, quantity and use of the supplied biosolids. This information is to be submitted annually to EPA.

Users of the biosolids have a responsibility to ensure the site and scheme is managed in accordance with these guidelines, including adherence to the EIP, assessment of site suitability for biosolids application and recording of application details.

Local community liaison

Biosolids suppliers and users should establish pathways and procedures for continual and open liaison with the community. The extent of liaison should reflect the site circumstances (i.e. proximity to sensitive land uses, level of community interest, etc).

Key effective community liaison measures are:

- education of likely affected parties (i.e. neighbours, biosolids users);

- ready exchange of information; and
- a reliable complaint response system.

It is important that the user and/or supplier maintain records of all complaints and rectification actions. Complaint records should include the details of the incident (e.g. nature of complaint, time and date), the outcome of the investigation and actions taken. The names and contact details of complainants should be recorded, however, access to the complainant's personal details needs to be restricted.

Complaint records should be made available, on request, to EPA.

Agreements

A formal agreement should be developed between the supplier and user of biosolids. Suggested issues that may be addressed in the agreement include:

- definition of roles and responsibilities;
- cost of biosolids, contract duration and provisions for contract variations;
- biosolids characteristics (source, quality, quantity and supply reliability);
- when, where and for what purpose the biosolids are to be used;
- responsibility for the application site operation, maintenance, monitoring and auditing processes;
- the implementation of management controls in the EIP; and
- other issues relevant to the parties.

Details of the agreements will vary dependent upon the type of scheme.

EPA Victoria

EPA is responsible for publishing information on environmental protection, including guidelines for sustainable biosolids management. It is EPA's role to ensure that this guideline is effectively implemented throughout Victoria by undertaking audits of selected end use schemes (random or priority site basis) and maintaining a database of biosolids management in Victoria.

EPA is also responsible for auditing and reviewing the effectiveness of these guidelines. Reviews of these guidelines will occur from time to time to reflect additional information and research on biosolids management.

Other departments

While EPA is the primary regulator for biosolids, a number of Departments also have roles relevant to biosolids management. As examples, the Department of Human Services has responsibility for protection of public health and food safety and the Department of Primary Industries has responsibilities for livestock disease management and specialist advice on matters such as horticultural production and contaminant uptake.

3.2 Risk identification and management

It is important that biosolids suppliers and users work together to identify and assess the potential risks posed by their end use scheme.

The potential risks generally fall into the following categories:

- environmental;
- human and stock health;

- produce (food) safety; and
- legal liability.

The risks posed will vary dependent upon the end use of the biosolids (e.g. application for forestry versus application to land used for growing human food crops) and the location (e.g. relative to houses or watercourses), land capability (e.g. climate, soil types, slopes, etc) and scheme size.

For the use of restricted grade biosolids, details of risk identification and assessment should be provided in any EIP.

Environmental risk

Biosolids end use schemes must meet at least the following environmental performance objectives:

- protect the beneficial uses of soils, groundwater and surface waters as outlined in the relevant SEPPs (2.1);
- avoid soil contamination or structural change that reduces productivity; and
- avoid adverse impacts on the air environment as per SEPP (e.g. odour) (2.1).

To assess whether these objectives can be met for a particular scheme, the risks to beneficial uses of groundwater, soils and surface water need to be assessed for the organic and inorganic contaminants, nutrients and pathogens potentially present in biosolids.

The potential offsite impacts of disease transmission by way of 'vectors' such as insects, birds and other vermin need to be evaluated. The risk to air quality of odours from inadequately stabilised biosolids also needs to be assessed.

Chapters 4 to 7 of this guideline outline suggested treatment, biosolids quality, site control, monitoring and record keeping measures for managing and minimising risks to the environment. However, where risk assessment indicates additional measures are necessary, appropriate extra precautions should be implemented.

There is significant debate in the scientific literature regarding acceptable limits for contaminants in biosolids and soils. This guideline has adopted a conservative approach to ensure that environmental or public health problems associated with biosolids use are prevented. This approach is aimed at gaining public confidence and to help ensure agricultural markets or food safety are not compromised.

While the contaminant limits are considered to be conservative, risk management means that biosolids producers should implement waste management programs to reduce inputs of contaminants to sewer to the lowest practical levels. Risk management also means that suppliers should diversify land application programs, rather than focusing on a single site with long-term regular biosolids applications.

Biosolids may contain significant concentrations of phosphorus and nitrogen. While these nutrients are generally less available in biosolids compared to inorganic fertilisers, if applied to land in amounts exceeding agronomic demand, pollution of surface and/or ground waters may result.

To minimise this risk, biosolids application rates should be limited to the annual crop nutrient (agronomic rate) requirements. As an example the total annual nitrogen requirement (as mineral form)

for most crops and pastures ranges from 200-500kg/hectare, while phosphorus requirements range from 10-50kg/hectare. Chapters 5 and 6 provide more information on application rates and associated management practices.

Human and stock health risk

Biosolids end use schemes must not pose an unacceptable risk to the general public, on-site workers, stock health or food safety.

A preference of this guideline is the generation of high quality biosolids (i.e. containing low pathogen and chemical contamination) in the first instance. This maximises opportunities for biosolids use and minimises the reliance on management controls to address potential risks to the environment, human health, agriculture and food safety.

Pathogens that have been identified in raw sewage as necessitating health risk assessment for biosolids include:

- helminths (e.g. intestinal nematodes, *Ascaris*, and tapeworm, *Taenia*);
- bacteria (e.g. *Salmonella* and *Campylobacter*);
- protozoa (e.g. *Cryptosporidium* and *Giardia*); and
- viruses (e.g. adenoviruses, hepatitis).

The degree of risk from each of the above pathogen groups will depend upon the extent of biosolids treatment and the end use application. It will also depend on the population served by the treatment plant. As an example, some pathogen groups, e.g. *Ascaris*, typically have low incidence rates in Australia compared to overseas populations.

If not properly controlled, pathogens have potential to be transmitted to humans or stock by:

(i) direct routes (i.e. through skin contact, ingestion or inhalation); or

(ii) indirect contact (i.e. consumption of food or feed contaminated by biosolids).

Chapters 4 to 8 of the guidelines outline the biosolids treatment, quality, site control, monitoring and record keeping measures required for protection of the public and agriculture.

The receiving land (particularly agricultural land) should not be utilised as an extension to the treatment process. These circumstances would normally require site specific works approval and licensing.

Farm produce risks

Biosolids end use schemes must not result in unacceptable microbiological or chemical contamination in produce or food, or otherwise adversely affect farm produce quality.

Exposure routes need to be carefully managed to prevent contamination of produce. Victoria has a comprehensive food safety regulatory system based on the *Food Act* 1994*, Food (Amendment) Act* 1997 and the *Food Standards Code* (developed by the Australia New Zealand Food Authority or "ANZFA"). This framework is supported by Codes of Practice and other Acts specific to particular industries (e.g. the dairy industry).

A number of industries (e.g. dairy, meat, horticulture) have adopted quality assurance (QA) systems, such as Hazard Analysis and Critical Control Point (HACCP) to manage produce safety

risks. The use of biosolids should be addressed as part of these QA systems.

Further advice regarding produce (food safety) risk management associated with the use of biosolids, codes, regulations, approved QA systems can be obtained by contacting the appropriate Government agencies listed in Appendix F.

Market risks

Regardless of the scientific evidence to demonstrate the safety of biosolids use, some domestic and international markets for agricultural produce (e.g. salad vegetables) may perceive the use of biosolids negatively and may not wish to source produce that has been grown on biosolids amended land. Biosolids land application programs based on agricultural applications should investigate market acceptance of the practice.

Legal risks

Sewage treatment plant owners, operators and end users may be liable under common law and under the *Trade Practices Act 1974* for the use of biosolids products that cause harm.

Users of biosolids should make themselves aware of the documents (legislative Acts, policies, Codes of Practice, Australian Standards and guidelines) relevant to the use of biosolids.

To minimise the legal risks associated with biosolids end use schemes, suppliers in particular should ensure their potential legal risks and liabilities are addressed. This should include:

- putting in place "due diligence" procedures and systems such as an environmental management system; and
- demonstrating they are acting diligently regarding biosolids supply and use (i.e. adherence to these guidelines and other relevant documents).

ROLES, RESPONSIBILITIES AND RISK CHECKLIST

Objective

To ensure that suppliers and users of biosolids understand and meet their obligations in terms of compliance with this guideline.

Suggested measures

Supplier

- Where an unrestricted grade product is being produced, implement adequate sampling and analysis program to confirm biosolids quality (Chapter 4);
- Ensure any end use scheme it supplies with restricted grade biosolids, has either an EPA or EPA appointed auditor endorsed EIP; a works approval and/or licence; or a site specific exemption from EPA (3.1);
- Develop an agreement covering the respective interests and obligations of suppliers and users (3.1);
- Identify, assess and manage the risks posed by the supply of biosolids (3.2);
- Monitor, report and audit biosolids schemes it supplies in accordance with these guidelines;
- Maintain a register of biosolids users it supplies and submit this information in an approved form annually to EPA; and

- Ensure awareness of the relevant legislation, codes and guidelines relevant to the use of biosolids.

User (restricted grade)

- Enter into an agreement with the supplier (3.1);

- Identify and assess the risks posed by the use of biosolids (3.2);
- Develop and adhere to an EIP (EPA or EPA appointed auditor endorsed) in partnership with the supplier (3.1); and
- Ensure an EPA works approval and licence, or site-specific exemption is obtained if the end use scheme does not meet the guideline requirements.

4. BIOSOLIDS CLASSIFICATION

Classification of biosolids is based on two independent factors, namely the contaminant concentrations in the biosolids and the microbiological quality post treatment. The classifications within these factors are:

(i) Contaminant Grade (C1 or C2) based on biosolids contaminant concentrations (4.1); and

(ii) Treatment Grade (T1, T2, T3) based on the treatment technology utilised, microbiological criteria and measures used to inhibit bacterial regrowth, vector attraction (such as insects or vermin) and odour (4.2).

Biosolids can be generalised as 'unrestricted' or 'restricted' quality, with unrestricted grade material achieving both the C1 and T1 classifications.

Restricted grade material (e.g. C2/T1, C1/T2,…) requires land application management controls (Chapters 5 and 6) to ensure protection of the environment, public health and agriculture (e.g. food safety).

Material that falls outside these grades for either contaminants (considered as C3) or treatment (considered as T4) is not covered under this guideline. Land application of such material may require an EPA works approval and potentially licensing.

This guideline describes the minimum requirements for sustainable biosolids management.

4.1 Contaminant grades

4.1.1 Biosolids contaminant grades

The highest quality biosolids contaminant grade is termed C1. C1 biosolids have sufficiently low contaminant levels that specific management controls on end use are not needed. The C1 limit has been derived for individual contaminants based on a conservative scenario – protecting the most sensitive land use from the application of biosolids as a complete topsoil replacement. Therefore, the C1 limit is adopted from the most stringent soil investigation values for protection of:

- human health in residential scenarios (e.g. protecting children that ingest soil) as per the Health Investigation Level (HIL) in the (NEPM) (*Assessment of Site Contamination*) 1999;
- the environment as defined by the Ecological Investigation Level (EIL) in the above NEPM; and

- food safety by ensuring food standards (MLs and MRLs) are not exceeded. While this issue is addressed in the NEPM framework, the numerical criteria described in the NEPM do not consider food standards. Therefore, the relevant limits in this guideline were developed from reviews of scientific data.

The C2 limit provides a ceiling concentration above which contaminant levels are considered excessive and this guideline does not permit land application. The C2 limit is based on a combination of:

- protecting soil investigation levels (discussed above) from repeat application scenarios;
- the biosolids quality that should be readily achievable from sewage treatment plants with effective sewer input controls; and
- regulatory requirements such as contaminant limits for fertilisers.

Contaminant grading process

Contaminant grading of biosolids involves the following steps:

(i) establishing a sampling program considering biosolids generation processes and volumes of production (Appendix B);

(ii) testing contaminant levels using accredited laboratories (for example NATA);

(iii) statistical examination of the results, with determination of biosolids contaminant concentrations (BCC) and classification against the contaminant grades (Table 2); and

(iv) refinement of the monitoring program and ongoing classification.

Deriving the BCC

To ensure safe and sustainable biosolids use, the fundamental objective in analysing biosolids and calculating a BCC value is to ensure that no more than 5 per cent of biosolids are incorrectly classified as belonging to a higher quality grade i.e. classifying a biosolids product as C1 when the product is actually C2, or classifying as C2 when the product is actually C3.

Biosolids producers are able to propose a process for statistical analysis of their data to achieve the above objective. However, before use, the process will need to be endorsed by EPA or an EPA appointed auditor. Alternatively, the producers can adopt the generic approach described below (formula 1) and further detailed in Appendix B. Although this generic approach does not fully adopt strict statistical principles (for example the need for transformation of skewed data), the conservatism inherent in the C1 and C2 limits means that it is a pragmatic and practical method for classification, particularly by small producers.

Guidance on issues including minimum sampling frequency and composite analysis is described in Appendix B.

Calculated BCC values for each contaminant are compared with the corresponding grade limits in Table 2. The biosolids contaminant grading is the most stringent grading for any contaminant. For example, if zinc was the only contaminant with a C2 grading and all other contaminants were C1, the biosolids classification would be C2.

Formula 1 Generic method for calculating BCC (sourced from Gilbert (1987)):

$$BCC_n = m + (y * s)$$

Where

m = arithmetic mean of n samples;

s = standard deviation of n samples;

y = coefficient derived from Table 1.

Table 1. Coefficient based on sample number for calculating BCC

Sample size (n)	Coefficient (a)
5	0.95
6	0.82
7	0.73
8	0.67
10	0.58
11-14	0.52
15-20	0.44

Improving contaminant grading

Processes such as composting, lime stabilisation or soil blending may result in a final product that meets the C1 provisions despite the initial biosolids material being C2. In this instance, provided the final product is re-sampled and conforms to the C1 criteria, the final product can be classified as C1.

Treatment processes that produce a C2 product from C3 material will not typically be accepted if the process involves dilution. Case by case assessment and endorsement will be required in these circumstances.

Table 2. Contaminant upper limits for classifying biosolids as grade C1 or C2 (values are mg/kg dry weight).

Contaminant	Grade C1 and RSCL[1]	Grade C2
Arsenic	20	60
Cadmium	1	10
Chromium[2]	400	3000
Copper	100 (150)[3]	2000
Lead	300	500
Mercury	1	5
Nickel	60	270
Selenium	3	50
Zinc	200 (300)[4]	2500
DDT & derivatives	0.5	1
Organochlorine pesticides[5]	0.05	0.5
PCBs	0.2	1

Table notes

1. Refer 4.1.3 for varying the RSCL.
2. Chromium (III) limit due to expectation that this will be the dominant form.
3. 150 mg/kg copper limit for biosolids products composted to AS 4454.
4. 300 mg/kg zinc limit for biosolids products composted to AS 4454.
5. Organochlorine pesticide limit applies individually to: dieldrin, aldrin, chlordane, heptachlor (and the epoxide), hexachlorobenzene and lindane.

4.1.2 Receiving soil contaminant limits (RSCL)

Application of biosolids (either as once off applications or repeated applications) must not cause chemical contamination of receiving soils. This guideline describes default contaminant limits for receiving soils that are identical to the limits for Contaminant Grade 1: for example, the copper soil limit for sites receiving biosolids is set at 100mg copper/kg dry weight.

The methodology for determining biosolids application rates to protect soil limits is discussed in Section 6.4 and illustrated by example in Appendix C.

4.1.3 'Varying' RSCL limits

Since the RSCL limits (Table 2) are established based on the most conservative assessment endpoint (from human health, environment and food safety), the limits may be overly conservative under defined scenarios. As an example, the cadmium RSCL limit of 1mg/kg is based on protection of food standards, while ecological and human health investigation levels of 3 and 20mg/kg respectively, are described in the NEPM (*Assessment of Site Contamination*) 1999. As such, it could be envisaged that there are circumstances where use on agricultural land can be excluded (e.g. residential or site rehabilitation) and a RSCL higher than 1 mg/kg may provide an appropriate level of protection.

Likewise, in some circumstances the RSCL may be lower than background soil levels. This becomes problematic, since under a strict interpretation of the controls in 4.1.2, biosolids application would be prohibited if the relevant contaminant in biosolids exceeded the C1 limit. However, it is acknowledged that elevated background concentrations may have a low bioavailable fraction and therefore biosolids application poses a low risk. As an example, despite having total nickel levels as high as 300mg/kg (C1 limit is 60mg/kg), ferrosols may be highly productive soils due to low nickel bioavailability. Therefore, EPA will consider, on a case-by-case basis, endorsing the use of biosolids in these situations. Justification for the endorsement will need to be provided by the proponent.

While the above discussion is focused on 'increasing' the RSCL, in some situations, a RSCL less than the limit in Table 2 may be necessary. This should be considered as part of the application site's overall land capability assessment site, with highly acid or sandy soils potential triggers for reduced limits.

Assessment of the above considerations should be based on the principles in the NEPM (*Assessment of site contamination*) 1999.

4.1.4 Other contaminants

Where a sewage treatment plant receives trade waste discharges, the potential significance of these discharges and the implications for biosolids quality needs to be investigated. This investigation should particularly focus on contaminants that may be discharged in large quantities but which are not listed in Table 2.

Early redrafts of the biosolids directive in the European Commission (EC) have proposed limits for a range of organic compounds that are not included in Table 2. These compounds include linear alkylbenzyl sulphonates and polycyclic aromatic

hydrocarbons, compounds that are released from both domestic and industrial/commercial sources. Recently published reviews have indicated that these compounds are not typically present in sufficient concentrations in biosolids to necessitate inclusion in the current guideline.

Dioxin-like compounds

An investigation level of 50ng TEQ/kg, considering polychlorinated dibenzo-*p*-dioxins (PCDDs) polychlorinated dibenzofurans (PCDFs) and coplanar polychlorinated biphenyls (PCBs), is included for biosolids. The levels should be calculated based on World Health Organisation recommendations (den Berg et al., 1998). Where dioxin levels exceed 50 ng TEQ/kg, restrictions on sensitive end uses such as cattle grazing or dairy uses should be implemented. The need for management controls on other end uses should also be considered. For comparison, the US EPA is proposing a biosolids dioxin limit of 300 ng TEQ/kg, while the EC is proposing 100 ng TEQ/kg.

Testing for dioxin-like compounds is not automatically required. Sewage treatment plants receiving significant quantities of chlorinated trade wastes or other potential sources of dioxins should consider the need for a dioxin screen based on a composite sample(s).

Aluminium

Guidance for aluminium is being considered and will be included as a technical addendum.

4.2 Treatment grading

Three treatment grades are described in this guideline: T1, T2 and T3. These grades are primarily based on satisfying three main criteria (see Table 3):

- the adoption of a prescribed treatment process with minimum performance criteria (for example temperature/time);
- microbiological limits to demonstrate that the defined treatment processes are operating effectively; and
- measures for controlling bacterial regrowth, vector attraction (for example insects, birds, vermin) and generation of nuisance odours.

In situations where a proponent wishes to use a treatment process that is not prescribed within Table 3, classification is based on either:

(i) the process undertaking a verification program to enable inclusion as a 'prescribed' treatment for the relevant grade; or

(ii) a relatively intensive batch testing program on the produced biosolids to demonstrate pathogen removal.

A flow diagram of the treatment classification process using T1 biosolids as an example is provided in Figure 1.

4.2.1 Producing T1 from recognised treatment processes

Grade T1 represents the highest quality grade and from a microbiological perspective is suitable for unrestricted use. Since this guideline does not include regulatory controls on the end use of T1 products, there is a particular emphasis on ensuring adoption of treatment processes that can reliably

achieve significant log reductions across a wide range of pathogens.

However, there are a restricted number of treatment processes that have been demonstrated as being capable of reliably reducing a wide range of pathogens to low levels. These treatment processes are described in Table 3 and are principally derived from the US EPA 503 requirements including Processes to Further Reduce Pathogens (PFRP) (US EPA, 1999).

This guideline provides generic minimum quality assurance criteria, rather than prescriptive detail for each treatment processes. Therefore, as part of process verification, producers must provide documentation to support the equivalency of their process to established processes. The information must also include details of QA/QC procedures to ensure effective process control. As examples, for thermophilic digestion processes, this could include data describing batch retention times. For composting, the process would be based on established QA/QC procedures in the Australian Standard (AS) 4454 *Composts, soil conditioners and mulches,* including such information as feedstock ratios, temperature monitoring frequencies and the depths of monitoring.

Microbiological standards, sampling and analysis

Verification phase

Prior to commencing supply of T1 biosolids products, treatment processes are required to undertake an initial verification phase. During this phase, T1 biosolids are required to be analysed for *E.coli*, at a frequency of 1 sample per 50 tonnes, with a 90^{thile} limit of ‹100 *E.coli*/gram dw. *E.coli* sampling is to continue until 10 sequential samples have been verified as achieving the T1 grade.

During the verification period, the biosolids are also required to have direct analysis for Salmonella and enteric viruses (adenovirus, reovirus, enterovirus). At a minimum, analysis is to be undertaken on 4 individual samples until 100 grams of material has been analysed (as examples, a minimum of 4 samples each of 25 grams or 10 samples each of 10 grams).

The limit for the Salmonella analysis is ‹ 1 Salmonella/5g dw or non detect Salmonella/5g in a presence/absence test (repeated testing at this sample size is considered to demonstrate the Table 3 criteria of ‹ 1 Salmonella/50g). The enteric virus analysis has a limit of ‹ 1 PFU/10g dw (repeated testing at this sample size is considered to demonstrate the Table 3 criteria of ≤ 1 enteric virus/100g).

For batch processes, for example some compost processes, verification sampling should be spread across different batches of product. For continuous treatment processes, sampling frequency should be spaced across 500 to 1000 tonnes of production.

During verification phase, monitoring of process criteria (such as temperature) is required to be undertaken and the minimum standards described in Table 3 achieved.

Exceedences

No greater than 10 per cent of samples are permitted to exceed the *E.coli* limit of 100 *E.coli*/g dw and no single value is to exceed 500 *E.coli*/g dw. In the event of an exceedence of the 100 *E.coli*/g dw

criteria, sampling should be immediately repeated and the process operation investigated.

No exceedence of the Salmonella or enteric virus limit is accepted. Affected biosolids must be subject to additional treatment or classified as a lower grade product, until the cause of the non-compliance is rectified.

Routine monitoring

Post process verification, monitoring is primarily focused on achieving the prescribed process criteria (for example temperature). This is coupled with each 100 dry tonnes of product being analysed for *E.coli*, with a 90^{thile} limit of ≤100 *E.coli*/g dw and a maximum value of 500 *E.coli*/g dw.

A lower frequency may be endorsed if:

i) for continuous processes there is historical data over 10 samples and at least one year to demonstrate reliable compliance; or

ii) for batch processes, initial testing indicates that the batches are relatively homogenous.

Sample timing and regrowth testing

The *E.coli* criteria applies immediately after the defined treatment process, to avoid the use of 'bolt-on' processes such as short-term storage to achieve the bacteriological criteria. Although the use of such 'bolt-on' processes may significantly reduce indicator organisms such as *E.coli*, they may have minimal effect on key pathogen groups and therefore undermine the reliability of the indicators.

To ensure that pathogenic bacterial regrowth has not occurred post treatment (with associated risks to end users), the *E.coli* and Salmonella criteria also applies to the product post storage. During the verification phase, four separate samples of the biosolids product are required to be stored for two weeks under conditions that are representative, but favourable for regrowth. For example a bagged product can be stored in its original state, while a product likely to be stored outdoors should be wetted to simulate rainfall. Periodic storage and regrowth testing should be undertaken as part of ongoing monitoring,that is six monthly or annually.

Note. An alternative approach to the direct assessment of regrowth is providing literature evidence that the properties of the specific product are sufficient to avoid regrowth of pathogenic microorganisms.

Ensuring inhibition of pathogenic bacterial regrowth is a particularly significant issue for T1 biosolids. Due to the high temperatures characteristic of T1 processes, both pathogenic and non-pathogenic microorganisms are reduced to very low levels. If the biosolids are not 'stabilised' post treatment, the presence of food sources coupled with the absence of competing microorganisms, provides an opportunity for pathogenic bacteria such as *Salmonella* sp. to repopulate the biosolids. Note. Regrowth is an issue limited to bacteria, rather than viruses or protozoa.

Minimising bacterial regrowth, therefore relies on biosolids stabilisation or other treatments to reduce the bacterial food sources, avoid moisture entering dried biosolids and/or ensure competing 'beneficial' microorganisms are retained at high

levels. The optimal solution for inhibiting regrowth depends on the treatment process used for pathogen removal. Table 4 provides suggested measures for different treatment processes to inhibit bacterial regrowth.

4.2.2 Producing T1 products from alternative treatment processes

Verification of alternatives

Treatment processes that are not described in Table 3 may be included as prescribed T1 processes if they undergo a verification process to demonstrate significant log reductions for a range of potential pathogens. This guideline nominates default performance objectives under realistic worst case process conditions of:

- ›three log reductions in enteric viruses;
- ›two log reduction in Ascaris ova; and
- achieving the *E.coli* and *Salmonella* criteria in 4.2.1.

Ascaris ova are widely used as an indicator organism, since they are relatively resistant to treatment. Therefore, a two log reduction in Ascaris ova would be associated with significantly larger reductions in other pathogen groups for example Taenia or protozoa. However, the organism is problematic as an indicator in Victoria, since low levels in raw sludge mean that demonstrating the required low reductions is difficult.

There is significant research being undertaken in Australia and internationally into the development of indicator organisms for verifying pathogen removal by 'novel' technologies. Proponents of novel technologies should contact EPA Victoria and other relevant Government departments to confirm microbiological indicators relevant to their process and an appropriate program for verification of process efficiency.

Once the efficacy of the novel treatment process has been confirmed, routine monitoring based on treatment indicators (such as temperature and duration) and microbiological indicators will be required. It is likely that *E.coli* and/or *Salmonella* will be used as the microbiological indicator, however, this may vary depending on the proposed treatment process.

Figure 1. Flow diagram of classification sequence for Grade T1 biosolids

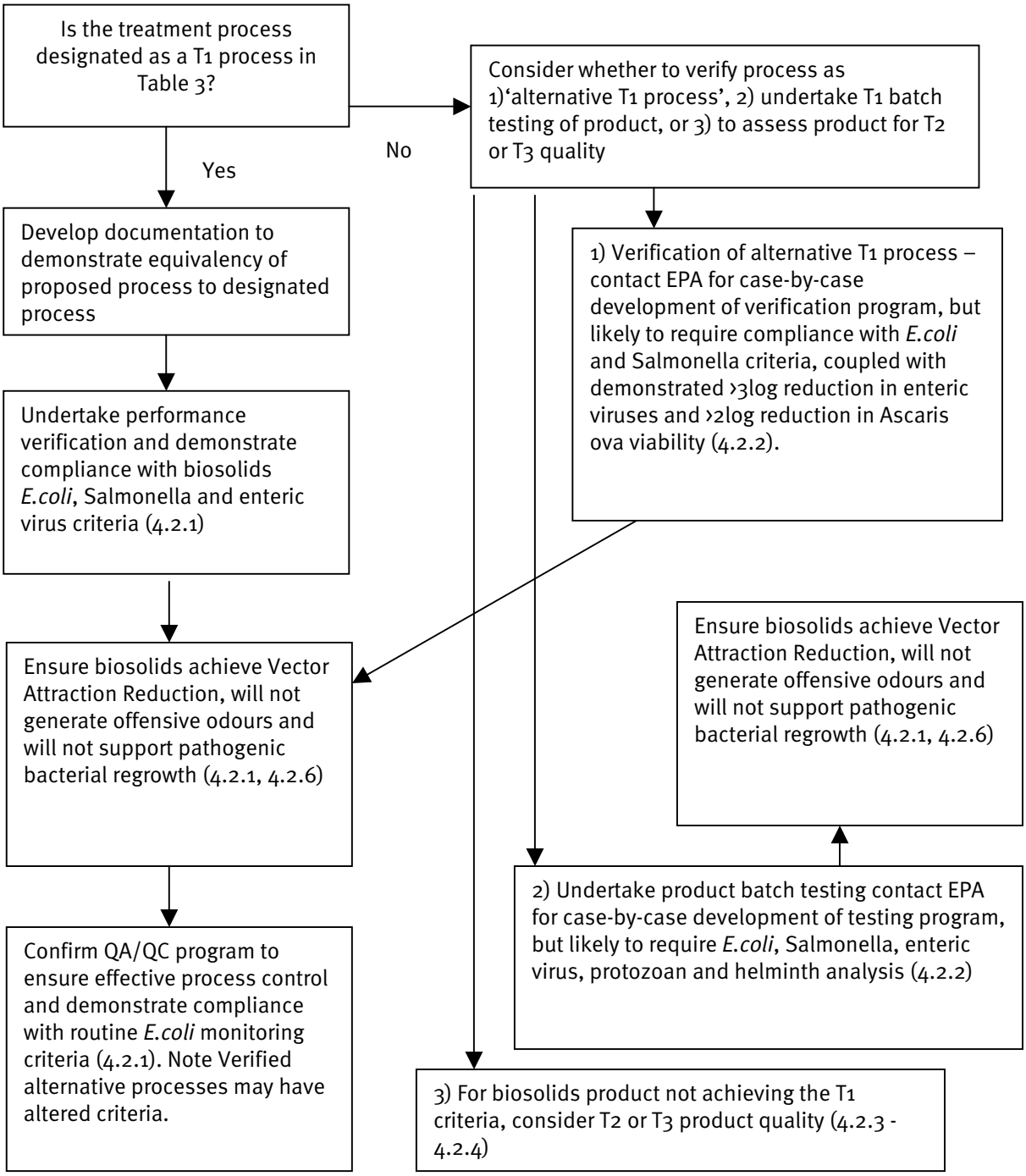

Table 3. Treatment grades based on treatment process, microbiological criteria and other suggested controls

Treatment process	Associated controls
Treatment Grade T1 Microbiological criteria ***Verification*** (of prescribed processes listed below) ‹ 1 Salmonella/50g (dw), ‹100 *E.coli* MPN/g (dw) and ≤1 enteric virus PFU/100g with analysis detailed in 4.2.1. Verification of inhibition of pathogen regrowth is also required (4.2.1). ***Routine monitoring*** (of prescribed processes listed below) is based on ‹100 *E.coli* MPN/g (dw) (4.2.1). ***Alternative process*** microbiological verification described on case-by-case basis (detailed 4.2.2) Vector attraction reduction controls also required (see Table 4).	
Composting processes that simultaneously heat all material (e.g. in-vessel) Temperature of all compost material to be maintained at ≥55°C for ≥3 continuous days with process control as per AS-4454.	Relevant vector attraction reduction controls (refer Table 4) and production of product that does not generate offensive odours. Weed seed controls may be needed in landscaping or agricultural applications.
Composting windrow method Temperature of compost material maintained at ≥55°C for ≥15 days, including 5 turnings of the windrow. Process control as per AS-4454.	Relevant vector attraction reduction controls (refer Table 4) and production of product that does not generate offensive odours. Weed seed controls may be needed in landscaping or agricultural applications.
High pH and high temperatures Biosolids pH raised to ≥12 for ≥72 continuous hours and during this period, maintained at ≥52°C for ≥12 continuous hours. Final biosolids product to be air-dried to a solids content of ≥50%.	Relevant vector attraction reduction controls (refer Table 4) and production of product that does not generate offensive odours.
Heating and drying Biosolids dried by heating particles to ≥80°C to a final solids content of ≥90%.	Relevant vector attraction reduction controls (refer Table 4) and production of product that does not generate offensive odours.
Long-term storage Sludge is digested, dewatered to ›10% w/w solids and stored for › 3 years.	Product must be stored in manner that ensures no recontamination and not generate offensive odours.
Thermophilic digestion processes EPA endorsement of processes operating at greater than 55°C will be considered on a case-by-case basis depending on retention time, process stages and batch versus continuous feed/draw.	Relevant vector attraction reduction controls (refer Table 4) and production of product that does not generate offensive odours.

Table 3 ctd. Treatment Grades based on treatment process, microbiological criteria and other suggested controls

Suggested Treatment Process	Other suggested controls
Treatment Grade T2 Microbiological criteria ***Routine monitoring*** (of prescribed processes listed below) ‹10 Salmonella/ 50g dw, ‹1000 *E.coli* MPN/g dw (described in 4.2.3). ***Alternative process*** Based on achieving Salmonella and *E.coli* criteria and demonstration of 2 log *Taenia saginata* and enteric virus removal or batch testing to demonstrate ‹ 1 *Taenia* ova per 10g and ‹ 2 enteric virus PFU per 10g. Vector attraction reduction controls also required (see Table 4).	
Composting method The temperature of all compost material to be ≥53°C for ≥5 continuous days or ≥55°C for ≥3 continuous days. (NB. Although this criteria is comparable to T1, it is also included as a T2 process in reflection that achieving the stringent T1 *E.coli* limits may require specialised techniques.	Relevant vector attraction reduction controls (see Table 4) and product that, coupled with management controls, does not generate offensive odours. Weed seed controls may be needed in landscaping or agricultural applications.
Heating and drying Biosolids are heated to ≥70°C and dried to a solids content of at least 75% w/w.	Relevant vector attraction reduction controls (see Table 4) and product that, coupled with management controls, does not generate offensive odours.
Aerobic thermophilic digestion Aerobic conditions at 55-60°C for ≥10 continuous days. Final product dried to ≥50% solids. (NB. Could also achieve T1 process).	Relevant vector attraction reduction controls (see Table 4) and product that, coupled with management controls, does not generate offensive odours.
Treatment Grade T3 ***Routine monitoring*** (of prescribed processes listed below) ‹2,000,000 *E.coli* MPN/g (dw). ***Alternative process*** Based on *E.coli* criteria and 1 log reductions in Salmonella and enteric viruses. Vector attraction reduction controls also required (Table 4).	
Anaerobic digestion ≥15 days at ≥35°C or ≥60 days at ≥15°C.	For all Grade T3 treatment processes: Relevant vector attraction reduction controls (see Table 4) and product that, coupled with management controls, does not generate offensive odours. Weed seed controls may be needed in landscaping or agricultural applications.
Aerobic digestion ≥40 days at ≥20°C or ≥60 days at ≥15°C.	
Composting Aerobic conditions maintained ≥5 days at ≥40°C including ≥4 hours at ≥55°C.	

Batch testing of alternatives

In some circumstances, difficulties with demonstrating enteric virus or Ascaris ova removal may make batch testing an attractive method for confirming the produced biosolids is of T1 treatment grade. This guideline does not include prescriptive criteria for batch testing and proponents should therefore contact EPA Victoria to discuss criteria applicable to their process. It is likely that batch testing would include analysis for *E.coli* and *Salmonella* as per 4.2.1, enteric viruses, helminth ova and potentially protozoa such as *Giardia*.

Note. Regrowth management and controls to reduce vector attraction and ensure offensive odours are avoided will be required for all alternative processes as per 4.2.1 and 4.2.6.

4.2.3 Treatment grade T2

The default mechanism for producing treatment grade T2 biosolids is by adopting the prescribed treatment processes, coupled with achieving the microbiological standards (‹10 *Salmonella*/50g of final product (dry wt), ‹1000 *E.Coli* MPN/g (dry wt)) and vector attraction reduction measures set out in Table 3. The *E.coli* limit is expressed as the 90th percentile, while the Salmonella limit is based on either MPN analysis or via not more than one of five Salmonella presence/absence tests (using 5 g samples) having a positive result.

For the prescribed processes, process verification is required, with *E.coli* and *Salmonella* monitoring undertaken immediately post treatment and as a 'ready for sale' product. The initial sample frequency is one sample per 50 dry tonnes of continuous production. After 250 dry tonnes have been processed, a sampling frequency for *E.coli* of between 100-200 dry tonnes can be adopted. Salmonella testing is not required for routine monitoring, however, periodic sampling should be undertaken.

For treatment processes that are not prescribed in table 3, demonstration of T2 microbiological quality biosolids can be achieved by either:

- batch testing to demonstrate individual batches of biosolids achieve the microbiological standards of ‹10 *Salmonella*/50 grams dw, ‹1000 *E.coli* MPN/g dw (interpreted as above) ‹ 1 Taenia ova/10 grams dw and ‹ 2 enteric virus PFU/10 grams dw as 90th percentile limits; or
- process verification to demonstrate the treatment process can achieve under realistic worst-case process conditions objectives of 2 log *Taenia saginata* and 2 log enteric virus removal, plus the bacteriological limits.

For both these options, EPA will confirm the acceptability of proposals with the Chief Veterinary Officer (DPI). The sampling frequency for batch testing should be one sample per 100 dry tonnes, but a minimum of five samples are required to have been taken before T2 grade biosolids can be confirmed. Biosolids that can be shown to be relatively homogenous may be considered for reduced sampling frequency.

As with all biosolids products, T2 biosolids must not generate offensive odours that can be detected off-site during either storage or land application. T2 biosolids are required to undertake vector attraction reduction controls, as described in 4.2.6 and Table 4.

4.2.4 *Treatment grade T3*

The default mechanism for producing treatment grade T3 biosolids is by adopting the prescribed treatment processes, coupled with achieving the microbiological limit (<2,000,000 *E.coli* MPN/g (dw) as a 90th percentile) and vector attraction reduction measures set out in Table 3.

For treatment processes that are not prescribed in table 3, process verification is required to demonstrate that the treatment process can achieve, under realistic worst-case process conditions, objectives of a one log reduction in Salmonella and a one log reduction in enteric viruses.

As with all biosolids products, T3 biosolids must not generate offensive odours that can be detected off site during either storage or land application. T3 biosolids are required to undertake vector attraction reduction controls, as described in 4.2.6 and Table 4.

T3 biosolids have a specific restriction on use with cattle grazing, primarily due to concerns with reliability of *T. saginata* removal. However, selected T3 processes are capable of producing significant reductions in *T.saginata*. Biosolids producers considering using T3 biosolids in association with cattle grazing will need to be able to demonstrate, to the satisfaction of the Chief Veterinary Officer, that the process train can be expected to reliably remove *T.saginata*.

For T3 biosolids, *E.coli* samples should initially be taken every 100 dry tonnes, but can be reduced to periodic samples for example 200-500 tonnes once a stable process has been demonstrated.

4.2.5 *Treatment grade T4*

Grade T4 biosolids are those which do not meet any of the treatment processes outlined in Table 2 and are likely to require site specific risk assessment, EPA works approval and licensing.

4.2.6 *Reducing vector attraction and odour*

The US EPA defines 'Vectors' as any living organisms that are capable of transmitting pathogens from one organism to another, either:

(i) mechanically (by transporting the pathogen); or

(ii) biologically by playing a role in the lifecycle of the pathogen. Vectors include flies, mosquitos or other insects, birds, rats, and other vermin. The transport of pathogens by vectors can be controlled by any of the following:

- biological processes which breakdown volatile solids, reducing the available food nutrients for microbial activities and odour producing potential;
- chemical or physical conditions which stop microbial activity; and
- physical barriers between vectors and volatile solids in biosolids.

Vector attraction reduction ('VAR') options are summarised in Table 4.

Biosolids need to satisfy both the relevant VAR process and the treatment (pathogen reduction) process to determine the specific Treatment Grade of the product. In some cases, achieving the defined treatment process for pathogen reduction will also provide compliance with the appropriate VAR measure. VAR (particularly for grade T1 and T2

biosolids) should be met after or concurrent with pathogen reduction to inhibit pathogenic regrowth.

Some VAR methods are only conducive to biosolids produced from certain treatment/stabilisation processes (see third column of Table 4). Adopting VAR and pathogen treatment measures that are not described in tables 3 and 4 should be carefully considered for efficacy.

Processes other than those listed can be utilised, however these processes require case by case verification and subsequent EPA approval.

An important issue with the VAR measures listed in Table 4 are that they are not developed specifically for the control of offensive odours. While these processes may be effective odour management techniques, they may not be applicable to all circumstances. A generic requirement to avoid generation of offensive odours applies to all biosolids application schemes and at times this requirement may necessitate additional stabilisation than suggested in Table 4.

Table 4. Suggested vector attraction reduction requirements (derived from USEPA 1999).

#	Suggested VAR requirements	Biosolids most suited:
1	Biosolids treatment process reduces volatile solids by ≥38%	all biological anaerobic or aerobic processes
2	Biosolids containing stabilised solids only, dried to ≥75% solids content	Fully stabilised by anaerobic or aerobic process
3	Biosolids containing unstabilised solids, dried to ≥90% solids content	Heat dried biosolids
4	Aerobic treatment for ≥14 days at minimum 40°C and average ›45°C	Composted
5	Biosolids pH raised to ≥12, and without addition of further alkali pH maintained at ≥12 for 2 hours and then at pH ≥11.5 for an additional 22 hours	PH (alkali/lime addition) and temperature
6	Injection or incorporation of biosolids into soil within 6 hours of surface application	Partially stabilised or unstabilised biosolids, liquid sludges.

4.2.7. Sampling and analytical QA/QC

Sampling and analysis should be done under the direction of suitably qualified persons in accordance with EPA Publication 441 *A Guide to the Sampling and Analysis of Water, Wastewater, Wastes and Soils*, and *AS 1766 Food Microbiology* series.

Where NATA accredited tests are available for analysis, testing must be undertaken by a NATA accredited laboratory for the relevant test. Testing for organisms such as helminths and enteric viruses at the low detection levels expected in biosolids is inherently complex. NATA accreditation may not be available and therefore specialist advice regarding sampling and analyses protocols will need to be sought from EPA, microbiological diagnostic units and/or infectious diseases.

4.3 Classification summary

The steps involved in the classification process are summarised below:

1. Test biosolids for chemical contaminants (Table 2) and use the method described in Section 4.1 and Appendix B for calculating the biosolids grade for each contaminant;
2. Assign contaminant Grade C1 or C2 based on the lowest quality grade identified in Step 1. If assigned worse than Grade C2, then biosolids are not considered further in these guidelines for sustainable use;
3. Verify biosolids treatment processes, microbiological criteria and stabilisation/vector attraction reduction against the measures with Table 3 and Section 4.2.1-4.2.6;
4. Assign Treatment Grade T1, T2, T3 based on the comparison at Step 3. If assigned worse than Grade T3 then biosolids are not considered further in these guidelines for sustainable use; and
5. Conduct ongoing contaminant, treatment process and microbiological monitoring to ensure desired biosolids quality is maintained.

After contaminant and treatment grading, the permitted end uses can be determined. These end uses and the necessary supplier and user site management requirements for biosolids end uses are described in Chapters 5 and 6.

Biosolids quality

Objective

To ensure that biosolids quality is appropriate for the intended use.

Suggested measures to meet the performance objective

- Ensure that the biosolids are appropriately classified as C1 or C2 grade (Section 4.1, Table 2)
- Ensure that the biosolids are appropriately classified as T1, T2 or T3 based on the treatment process requirements, microbiological standards, vector attraction reduction requirements and odour management (Section 4.2, Table 3);
- Ensure that the grading is appropriate to the intended use (Table 5); and
- Undertake ongoing chemical and pathogen monitoring of biosolids quality (4.1-4.2).

5. PERMITTED END-USES & SITE SPECIFIC RESTRICTIONS

This chapter should be read in conjunction with Chapter 6 'Site Selection and Environmental Management'.

5.1 Background principles

This guideline aims to facilitate sustainable biosolids use. To qualify as 'sustainable use' the soil enhancement qualities (such as organic matter) and plant macro and micro nutrient benefits of biosolids need to be utilised. Biosolids application rate should match nutrient needs for optimum plant growth, but without causing excessive accumulation of contaminants (that is, not exceeding the receiving soil ceiling limits).

Biosolids use must be undertaken in a manner that is protective of soil ecosystems, soil productivity, surface and groundwater resources, farm produce quality, stock and human health, public confidence and agricultural produce/food market acceptance.

Application of biosolids must also be planned and managed so that the current or future beneficial uses of the soil/land are not sacrificed, regardless of the land's current land use zoning. Future (or potential) land uses need to be protected by ensuring that all the suitable uses of the land prior to the application of biosolids, are still available post biosolids application. This does not include temporary restrictions on land use such as withholding periods.

5.2 Permitted end uses

When assessing biosolids treatment and possible end uses, it is recommended that cost/benefit analyses be undertaken to compare the net environmental gains, sustainability and economics associated with the following two alternatives:

(i) production of high grade (T1, T2 and C1) biosolids in the first instance (i.e. implying higher treatment costs) that open up a wide range of end use opportunities; or

(ii) production of lower grade (T3 and C2) biosolids (i.e. lower treatment costs) that have a more limited range of accepted uses and additional management controls.

Once the contaminant and treatment grades are known (Chapter 4), the range of permitted end uses can be identified.

The highest-grade biosolids (a combination of Treatment and Contaminant Grades T1 and C1) are suitable for unrestricted use including use in residential areas and growing of human food crops consumed raw.

Lesser grade biosolids (i.e. Grades C2, T2 and T3) have restricted uses and require controls on public access to application sites, withholding periods for stock or human food crops, forestry, land rehabilitation, etc. Restricted uses require Environment Improvement Plans to document the end use management controls for protection of the environment, public health and agriculture.

Table 5 lists a range of allowable end uses according to the biosolids grade (C1-C2 and T1-T3). The stringency of the specific controls depends on

the biosolids quality and also the potential for direct human or stock exposure.

Guidance on accepted end uses corresponding to biosolids grades and the site restrictions for food safety, public and animal access control are provided in Table 6 (Agricultural uses) and Table 7 (Non-Agricultural uses). There are also "Generic Site Restrictions" that are common to all biosolids end uses such as agronomic application rates, buffer distances and land capability assessment (Chapter 6).

Materials that are classified as being of lower quality than either C2 or T3, are not covered by these guidelines. However, T4 and C3 quality may be suited to such processes as energy recovery and therefore these uses are briefly listed in Table 7.

5.2.1 Agricultural uses

Biosolids applied to land used to grow produce for human and stock consumption must not result in unacceptable microbiological or chemical contamination of produce nor adversely impact upon produce quality.

Table 6 illustrates a range of allowable agricultural end use schemes, corresponding to the minimum treatment and contaminant grade of biosolids and the associated public/animal access and food safety restrictions (for example livestock withholding periods).

A key philosophy of agricultural use is the promotion of biosolids grades that are suitable for specified use without a reliance on significant restrictions on management of the application site. For example, a significant restriction would be relying on a three year withholding period to provide protection for human crops that are potentially consumed raw.

Human food crops

Only treatment grade T1 biosolids may be used in circumstances where planned cropping strategies will result in direct contact between the soil and human food crops that are potential consumed raw. This includes produce such as carrots, lettuces, strawberries and mushrooms.

Where human food crops that are potentially consumed raw will be protected from direct contact with the soil (e.g. harvested produce ≥1 metre above soil surface) treatment grade T2 biosolids may be used. However, the biosolids application should not occur within a period of three summer months before expected harvest and during this time windfall should not be collected.

Treatment grade T2 biosolids have been through a relatively intensive pathogen reduction process and therefore the combination of treatment with a withholding period and produce separation is considered to provide an appropriate and practical level of control.

Grade T3 biosolids are not permitted as part of a planned cropping strategy that involves food crops that could potentially be consumed raw. Although this practice is allowed in key jurisdictions such as the US and UK, the practice requires significant withholding periods of one to three years. Since these lengthy time periods are considered impractical to enforce and monitor, the practice has not been accepted in this guideline. However, where land amended with T3 biosolids is subsequently considered for growing food crops that are

potentially consumed raw, a default withholding period of three years will be required.

Grade T3 or better biosolids may be used on crops or produce that will be either cooked at greater than 70°C for two minutes or processed (such as cereals, wheat and grapes for wine production) prior to sale to the domestic market. Use of T3 biosolids on crops that will be cooked after sale to the domestic market may be accepted, however, the safety of the practice needs to satisfy the relevant government agencies, such as EPA and the Department of Human Services (DHS).

Grazing

The presence of helminths in untreated sewage is a key risk to be managed with the use of biosolids for livestock grazing. Without adequate treatment and management, helminths in biosolids applied to grazing land have potential to establish cycles of infection between humans and animals (such as *Taenia solium,* which is relevant for pigs and *T. saginata*, which is relevant for cattle). Human consumption of contaminated, uncooked meat can complete infection cycles from animals back to humans.

As with a range of organic materials such as manures and dairy shed effluent, the use of biosolids on grazing land also requires management of potentially pathogenic organisms such as Salmonella and protozoa.

Due to the need to manage helminth transmission, all biosolids used in association with cattle grazing are required to have undergone treatment for *T.saginata*. The T2 processes described in Table 2 are known to reliably inactivate *T.saginata* and therefore T2 processes are permitted in association with cattle grazing. The performance of the T3 processes is less reliable and therefore T3 biosolids in association with cattle grazing will need case by case assessment and endorsement by EPA and the Chief Veterinary Officer (DPI). It is likely that any endorsement would require a combination of T3 process trains, thereby ensuring reliable *T.saginata* removal.

Where a sewage treatment plant receives significant quantities of abattoir effluent, use of biosolids from T3 processes or a non-prescribed T2 process requires EIPs for cattle grazing schemes to be endorsed by the Chief Veterinary Officer. Likewise, the EIP requires endorsement if the biosolids is produced from a T2 alkaline stabilisation process.

For T3 biosolids, a cattle grazing withholding period of 2 years is applied (unless the T3 process has been shown to be effective at Taenia removal). A three summer month withholding period post incorporation is applied for harvesting of forage for cattle consumption.

For T2 biosolids, a cattle and poultry withholding period of 30 days, or until the pasture is re-established, is required for grazing or forage harvest after surface incorporation. If biosolids are surface applied rather than incorporated, a 30 day withholding period is required in association with 'watering in' or rainfall. Otherwise, a 60 day withholding period for surface application applies.

Although demonstration of *T.saginata* removal may enable use of T3 biosolids in association with cattle, grazing of lactating dairy cattle on T3 amended land will not typically be permitted.

Forage crops for poultry are permitted to be used in conjunction with T3 biosolids, based on soil incorporation and a 30 day withholding period.

For livestock such as sheep, goatsand horses (but not cattle, pigs, poultry), helminth transmission is less relevant and therefore T3 biosolids are permitted. The management controls are differentiated based on soil incorporation or surface application and whether the animal is reared for the human food chain. Surface application is not permitted for animals that are part of the human food chain for example sheep, while other animals (for example horsesand alpacas) require a three summer month withholding period. If the biosolids are soil incorporated, a withholding period of 30 days, or until the pasture is reestablished, is required for both groups of animals.

It is not considered best practice to enable pigs to come into contact with biosolids. This is a risk management step, reflecting the significance of *T.solium* and the current lack of a *T.solium* cycle in Australia.

Surface application

Where biosolids are intended to be surface applied (that is not incorporated) in association with grazing animals for meat or dairy produce, the potential risks to food standards and animal welfare require careful consideration. For chemicals that are of concern for meat and dairy produce (such as persistent organics), surface applied biosolids would be required to be below the C1 limits. Risk management entails that repeat applications of biosolids (that is › two applications) should trigger soil incorporation. This is further discussed in section 6.4.2.

QA Systems for food/produce safety

Agricultural uses of biosolids should implement the required management controls through the use of QA systems. Several agricultural industries (such as dairy, meatand horticulture) have adopted QA systems to address produce safety. Implementing a HACCP plan approved by a HACCP consultant may be one way of demonstrating an appropriate QA system.

There may be industry specific issues not fully addressed by this guideline. Advice in relation to produce safety regulations, codes, issues, risks and quality systems associated with the use of biosolids can be obtained from various sources including:

- food safety regulators;
- industry associations;
- accredited QA consultants; and
- produce buyers (for example supermarket chains).

Further advice can be obtained from the relevant Authority or industry association. Some relevant government agency and industry contacts include:

- *food crops*: DHS, Institute for Horticultural Development (DPI) the Vegetable Growers Association; and
- *cattle and dairy animals*: Chief Veterinary Officer, DPI; Dairy Food Safety Victoria (DFSV).

Off-site packaging and sales control

Labelling of food products grown on land receiving restricted grade biosolids may be necessary for offsite produce sales. For example, fodder grown on T3 biosolids and then sold on the open market

should have controls to restrict its use by pigs and cattle (if within harvest withholding period). Labels should advise that the product was grown from land receiving restricted grade biosolids and provide relevant warnings (for example 'not suitable for use by pigs or cattle').

5.2.2 Non-agricultural uses

Table 7 contains the recommended biosolids grades and public/animal access site restrictions for non-agricultural use schemes.

Unrestricted public access

Unrestricted public access refers to biosolids use on public land primarily used for recreational activities (for example sporting fields) or private residential land.

T2 biosolids is the minimum biosolids quality that may be used, subject to soil incorporation with a three summer month public access withholding period. Where restrictions on public access cannot be ensured, T1 biosolids must be used.

Restricted public access

Restricted public access refers to biosolids use on non-residential private land or public land not primarily used for recreational activities.

T3 biosolids may be used, subject to soil incorporation with a 30 day (and revegetation) public access withholding period, or surface application with a twelve-month public access withholding period. Where restrictions on public access cannot be ensured, T1 or T2 biosolids must be used.

Note that any landscaping schemes that may result in agricultural use will need to comply with the relevant agricultural use site restrictions as described in Table 6.

Energy recovery or landfill disposal are not be considered as 'use' options under these guidelines but are included in Table 7 for completeness. Management approaches such as energy recovery or incineration do not typically require pathogen reduction or high quality biosolids from a contaminant perspective. As a result, they may enable use of 'T4/C3' sewage sludge. These approaches require site specific approval from EPA (that is works approval and licensing). Landfilling of biosolids will not typically be permitted for biosolids that are of sufficiently high quality and can be sustainably reused.

5.3 Sensitive uses

There are some areas of land that may need careful consideration, before the use of biosolids. This is not due to inherent properties of biosolids, but is a control that should be relevant to any organic or inorganic fertiliser or soil additive. The potential sensitive uses include areas having highly sensitive ecological, natural, conservation, cultural or heritage values worthy of highest levels of protection. As examples:

- gazetted National or State parks;
- Crown nature reserves for flora and fauna;
- groundwater recharge areas;
- potable water supply catchments; or
- aboriginal land of cultural importance.

Early advice should be sought from the relevant controlling authority (such as DSE, Parks Victoria, Melbourne Water) as to whether biosolids use

would be allowed or restricted in such sensitive areas.

Permissible end uses

Objectives

To ensure appropriate site control measures are implemented for specific end uses to minimise the risk to food safety, public and stock health.

Suggested measures to meet the performance objective

Agricultural uses

- Ensure biosolids quality meets the contaminant and treatment grade specified for corresponding agricultural end uses (Tables, 2, 3 and 6);
- Implement the relevant "Site Restrictions – Public/Animal Access, Food Safety" as described in Table 6;
- Encourage schemes with moderate to high exposure potential (for example vegetable growing, dairy cattle) to adopt a quality assurance system, such as HACCP, to manage produce safety;
- Ensure T3 biosolids are not used in association with cattle grazing unless the required withholding periods have been achieved or the practice is endorsed by the Chief Veterinary Officer (DPI);
- Ensure T3 biosolids are not planned to be used in association with growing of food crops potentially consumed raw;
- Ensure labelling or other effective measures are implemented for farm produce grown on biosolids that may have sales product restrictions, for example fodder for cattle, pigs and poultry, and food crops grown on T3 Grade biosolids that require commercial processing.

Non-agricultural uses

- Ensure biosolids quality meets the Contaminant and Treatment Grade specified for corresponding non-agricultural end uses listed in Tables 2, 3 and 7;
- Implement the relevant "Site Restrictions – Public/Animal Access" as described in Table 7;

Sensitive land uses

- Prior to any biosolids use commencing on identified sensitive land uses, proponents should seek advice from the relevant controlling authority (such as DSE, Parks Victoria, Melbourne Water) as to whether biosolids use would be allowed.

Table 5. Biosolids classification and permissible end uses

Treatment Grade	Chemical grade	"Unrestricted"[1]	"Restricted Uses"					
			Agricultural Uses				Non-Agricultural Uses	
			Human food crops consumed raw in direct contact with biosolids[2],	Dairy and cattle grazing/fodder (also poultry), human food crops consumed raw but not in direct contact[3]	Processed food crops[4]	Sheep grazing and fodder (also horses, goats), on food crops, woodlots[5]	Landscaping (unrestricted public access)[6]	Landscaping, (restricted public access), forestry, land rehabilitation[7]
T1	C1	✓	✓	✓	✓	✓	✓	✓
T2	C1	**X**	**X**	✓	✓	✓	✓	✓
T3	C1	**X**	**X**	**X**	✓	✓	**X**	✓
T1	C2	**X**	✓	✓	✓	✓	✓	✓
T2	C2	**X**	**X**	✓	✓	✓	✓	✓
T3	C2	**X**	**X**	**X**	✓	✓	**X**	✓

Legend to symbols in Table 4:

✓ the biosolids grade will generally be acceptable for the enduse. Biosolids grades less than T1C1 will be subject to management controls.

X biosolids of this quality are not acceptable for the end use (would require a risk assessment and site specific EPA approval/licensing).

Notes to Table 5:

1. Unrestricted uses - biosolids are suitable for distribution, marketing and appropriate use with only minimal controls (e.g. recommended handling/safety directions). Includes sale as a bagged product for residential use.
2. Human food crops potentially consumed raw and in direct contact with biosolids include lettuces, strawberries and carrots.
3. Human food crops potentially consumed raw but not in direct contact with biosolids include those grown on trees for example fruit.
4. Processed food crops refer to crops that are either cooked at greater than 70°C for two minutes or processed (such as cereals, wheat and grapes for wine production) prior to sale to the domestic market.
5. Non-human food crops include turf, woodlots, flowers and ornamental plants(that is, not for human consumption).
6. Landscaping with unrestricted public access - includes public parks and sports grounds, with controls on access during soil renovation and until fully revegetated.
7. Landscaping with restricted public access, land restoration - includes non-recreational land, road development, rehabilitation of quarries, mines and landfills, sewage treatment plants and other landscaping where there is controlled or limited public and stock access. Forestry also involves restricted public and stock access.

Table 6: Permitted agricultural uses depending on biosolids grade and associated management controls

Category	*Minimum grade*	*Management controls – animal withholding periods and food safety*[1]
All uses	T1 / C1	Application in accordance with supplier's labelling or other written instructions. Labelling should specify recommended practices such as directions for safe use and handling by users and suitable application rates.
All uses including human food crops consumed raw in direct contact with biosolids (for example lettuces, strawberries and carrots)	T1 / C2	Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix.
Human food crops consumed raw but with harvested produce ≥1 metre above soil surface (for example fruit trees)	T2 / C2	Biosolids application should not occur within three summer months of harvest and during this timeframe, windfall should not be harvested. Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix.
Human food crops cooked or processed prior to sale to consumers[2] (for example wheat, oats, wine grapes)	T3 / C2	Crops should not be harvested for at least 30 days after biosolids application; Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix.
Pasture/Fodder for cattle (dairy and beef) and poultry (but not pigs)	T2 / C2	30 day or until pasture re-established for grazing (and forage) withholding period post soil incorporation or post surface spreading with 'watering in' / rainfall. Otherwise, a 60-day withholding period for surface application applies. Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix. Surface application requires assessment of risks to food standards.

Category	*Minimum grade*	*Management controls – animal withholding periods and food safety*[1]
Pasture/Fodder for cattle (dairy and beef) and poultry (but not pigs)	T3 / C2	Grazing of cattle on T3 amended land requires a two year withholding period post application. Cattle can be fed fodder from T3 amended land following soil incorporation and a three summer month withholding period prior to harvest. Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix. Surface application requires assessment of risks to food standards.
Pasture/fodder for sheep, goats, horses, etc (but not cattle, pigs, poultry)	T3 / C2	Animals have withholding period post soil incorporation of 30 days or until pasture re-established. Surface application is allowed for animals that are not part of the human food chain, but requires a three summer month withholding period. Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix. Surface application requires assessment of risks to food standards.
Non Food Crops (for example turf, woodlots, flowers)	T3 / C2	Turf should not be harvested for at least 12 months after biosolids application. Other crops harvested without attached soil material should not be harvested for at least 30 days after biosolids application. Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix.

Notes to Table 6:

1. There are also a range of "Site Selection and Environmental Management" constraints (refer Chapter 6) corresponding to biosolids grades and enduse schemes (that is, environmental, buffer distances, land capability factors).
2. Processed food crops refer to crops that are either cooked at greater than 70°C for two minutes or processed (such as cereals, wheat and grapes for wine production) prior to sale to the domestic market. Crops that are cooked prior to consumption can be sold uncooked to consumers provided the safety of the practice can be demonstrated to relevant Government agencies, DHS and EPA for example.

Table 7: Permitted non-agricultural uses depending on biosolids grade and associated management controls

Category	*Minimum grade*	*Management controls – public access withholding periods and related controls* [1]
All uses	T1 / C1	Application in accordance with supplier's labelling or other written instructions. Labelling should specify recommended practices such as directions for safe use and handling by users and suitable application rates.
All uses	T1 / C2	Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix.
Landscaping of public use land (public parks, sportsgrounds)	T2 / (C1/C2)	Soil incorporation and three summer month public access withholding period Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded and preferably incorporation of biosolids into soil matrix
Landscaping of land with limited public use (private, non-recreation land)	T3 / C2	Soil incorporation with 30 day (and until vegetation re-established) public access withholding period, or surface application with 12 month public access withholding period and vegetation re-established. Application site EIP focused on any contaminant risks, including ensuring soil limits are not exceeded.
Forestry and site rehabilitation eg landfills	T3 / C2	As per landscaping with restricted access Use for landfill rehabilitation should be in accordance with an approved Landfill Rehabilitation Plan. Biosolids are not to be used for landfill capping or routine covering of wastes.
Oil from sludge ("OFS") (thermochemical treatment) process	N/A	Biosolids recycling by thermochemical (for example OFS) processes is subject to: case by case assessment of contaminants in by products (oil, char/ash) and air emissions, with EPA works approval and potentially licensing of facility.
Energy recovery or incineration	N/A	Biosolids utilisation for energy recovery (incineration) is subject to: case by case assessment of contaminants in by products (ash) and air emissions, with EPA works approval and potentially licensing of facility.
Landfill disposal	N/A	Biosolids disposal at landfills is subject to case by case assessment of contaminants in biosolids and leachate, with EPA works approval and potentially licensing of facility. Landfill disposal of biosolids that are of a quality suitable for beneficial use for example energy recovery or land application will not be permitted.

Note to Table 7: 1 There are also a range of "Site Selection and Environmental Management" constraints (refer Chapter 6) corresponding to biosolids grades and end use schemes (that is, environmental, buffer distances, land capability factors).

6. SITE SELECTION & MANAGEMENT

Once the biosolids grade and feasible end uses have been determined (covered in Chapters 4 and 5 respectively), the suitability of potential end use sites needs to be evaluated and appropriate management practices adopted.

This chapter is focused on restricted grade biosolids since the unrestricted grade (T1C1) biosolids do not have specific management controls on end use. However, the principles of this section can be considered for best practice management of T1C1 biosolids and other organic and inorganic fertilisers and soil additives.

Although end users do not have specific obligations under these guidelines for T1C1 products, end users continue to have the broad legislative responsibilities as per any product. As an example, EPA enforcement action could result from inappropriate use of any fertiliser that resulted in surface water pollution.

6.1 Site selection

The initial phase of site selection and assessment should begin with a screening process. This activity should identify characteristics that will typically make a site unsuitable for biosolids application, unless the characteristics can be addressed through detailed management controls. For example, biosolids application would not typically be permitted on land that:

- is classified in a sensitive land category (Section 5.3);
- is regularly subject to waterlogging or flooding;
- would be covered with snow at the time of application;
- has surface rock outcrops over greater than 10 per cent of the area (except for forestry and rehabilitation uses); or
- has limited buffer distances. Recommended buffer distances are described in Table 8, however, these distances can potentially be decreased with management controls.

Following these initial site considerations, characteristics such as soil structure, pH, land slope and watertable depth need to be evaluated (see criteria tabulated in Table 9) as part of a land capability assessment.

Table 9 also contains indicative rankings (that is, 'slight', 'moderate' or 'severe') relating to potential limitations on use. Sites with only slight limitations should be able to receive regular biosolids applications without adverse effects linked to those characteristics.

Site characteristics with more severe rankings should receive greater attention in the risk assessment and the scheme may need to be limited in terms of biosolids quality, application rate and frequency. The table does not provide prescriptive controls, since a range of management approaches are possible (depending on the site characteristics) and therefore are best considered on a case by case basis.

The interaction of parameters should be considered. As an example, moderate risks for soil acidity, soil permeability and depth to groundwater could indicate a severe risk to groundwater from mobile metals.

The site selection characteristics in Tables 8 and 9 are not intended to represent a comprehensive list of all site suitability factors. If an assessment indicates unique site features not covered by these guidelines and that poses a significant environmental or human health risk, the biosolids should either not be used, or used subject to site specificrestrictions.

6.2 Site management practices

Following selection of potentially suitable end use sites, proponents will need to adopt effective site management controls to protect the environment, public health and agriculture. Appropriate management measures are required at all stages (i.e. 'cradle to grave') of biosolids use, including:

- site preparation (6.2.1);
- biosolids transport and storage (6.2.2);
- determining management controls, for example application methods, signage and fences around application sites (6.2.3);
- determining application rates (6.4); and
- monitoring post-application (6.5).

Table 8. Recommended buffer distances (metres) from biosolids application site using T2 or T3 biosolids

Land uses[1]	Treatment grade	
	T2 or C2	T3
Residential zone, urban areas	50	250
Occupied dwelling	25	50
Surface waters	50	50
Drinking water bores	100	250
Other bores	25	50
Farm dams	25	25
Animal enclosures	10	50
Farm driveways, access roads and fence lines	5	5
Significant native flora or fauna	25	50
Sensitive Areas (5.3)	50	100

Note to Table 8:

1. Recommended buffer distances are based on sites with flat or slight down slope to the designated land use (ie < 5 per cent). Increased or decreased buffer distances may be appropriate depending on the management practices, level of stabilisation and site characteristics.

Table 9. Land characteristics and associated level of restrictions on biosolids application. (adapted from DPIWE (1999) and DEHP (2000))

Site Characteristic	Site limitations			
	Slight	**Moderate**	**Severe**	**Site typically unsuitable**
Saturated hydraulic conductivity (K_s, mm/h) of most restrictive layer in top 90cm	Moderately permeable soils (K_s 2-20)	Low and highly permeable soils (K_s 0.5 – 2 or K_s 20 – 50)	Very highly permeable soils (K_s 50 – 100)	Very low and extremely permeable soils (K_s ‹ 0.5 or › 100)
Depth to regional groundwater (m)	› 5	3 - 5	1.5 – 3	‹ 1.5
Depth to seasonal high water table (including perched watertable) (cm)	› 90	60 - 90	45 – 60	‹ 45
Depth to most restrictive layer (cm)	› 90	60 - 90	45 – 60	‹ 45
Salinity (dS/m) 0–45 cm surface soils	ECE 2	ECE 2 – 4	ECE 4 – 8	ECE › 8
pH 0-10 cm surface soils pH 10-45 cm	6.5 6.0	5.5 – 6.5 5.0 – 6.0	4.5 – ‹ 5.5 4.0 – ‹ 5.0	‹ 4.5 ‹ 4.0
Land slope (%)	3 - 6	6 – 12	12 – 15	› 15

Notes to Table 9. Explanation of table characteristics

Saturated hydraulic conductivity: Low saturated hydraulic conductivity can lead to anaerobic conditions in the soil and increase the risk of run-off. Soils with highly permeable soils may allow rapid movement of nutrients or contaminants into groundwater. However, biosolids application may improve soil structure and permeability, this should be considered when assessing sites with low permeability soils.

Depth to regional groundwater and seasonal high watertable: Perched watertables may cause waterlogging and make biosolids application impractical. Shallow or unconfined regional watertables are most vulnerable to migration of nitrates and other contaminants from biosolids into groundwater.

Depth to most restrictive layer: This criterion is based on bedrock or hardpans. The risk of run-off following rainfall increases with a shallow restrictive layer. If underlying bedrock is fractured there is a risk of movement of nutrients and contaminants into the groundwater. This criteria is also based on clay soil hardpans - the unsuitable criteria being about ‹45cm depth.

Salinity: Biosolids application may increase salinity. At ECE levels › 4 many plant species will not grow. At ECE › 8 most plant species will not grow.

pH : In general, a site is too acidic if pH ‹ 4.5 (0 - 10cm depth) or pH ‹ 4.0 (10 – 45cm depth). Liming of soils may be used to buffer acidic soils;

Land slope : land with a slope of 6-12% generally requires soil conservation practices to minimise erosion (e.g. contour banking), while land with a slope of 12-15% requires at least 80% vegetative ground cover to be suitable for biosolids application.

6.2.1 Site preparation

Prior to commencing use, suppliers and users must have received the necessary approvals (if required) from the EPA (see Section 3.1) and prepared the storage areas and application site to ensure compliance with this guideline.

The preparation stage should include activities such as equipment calibration, soil sampling to enable calculation of application rates, and application site preparation, for example construction of any necessary stormwater management and pollution control facilities.

6.2.2 Transport and storage

Transport

The transport of biosolids is not subject to EPA prescribed waste regulations. However, biosolids is considered as a controlled waste under the NEPM (*Movement of Controlled Wastes between States and Territories*). Therefore, the approval of the relevant regulator is required before interstate movement.

Where vehicular transport of biosolids is required, it should be done in a manner so as not to result in spillage, odours, or contamination of the product being transported.

Suggested best practice measures include:

- choosing transport routes and sites to minimise impacts on public amenity;
- ensuring the quantity of biosolids supplied to the transporter is delivered to the user;
- using fully enclosed or sealed tankers or trailers with locks, water-tight tailgate seals, and waterproof covers for loads (particularly if biosolids are excessively wet or dry/dusty);
- ensuring vehicles used to transport biosolids are not contaminated with wastes (for example residues of prescribed wastes) that will impact upon biosolids quality;
- cleaning of truck tailgates and tyres prior to leaving production and application sites to avoid carryover or spills to roads; and
- preparation and implementation of an incident management plan to ensure rapid clean up of transport spills. Dry clean up methods are always preferred. Flushing of spilt biosolids down drains is prohibited and will result in enforcement action being taken by EPA.

Storage

Biosolids should be stockpiled and stored in a manner to avoid impacts on the beneficial uses of groundwater and surface waters, and avoid generation of offensive odours beyond the site boundary.

Medium to long term biosolids storage should preferably occur at dedicated facilities at the generation or treatment site. Only short-term storage (‹ 60 days and preferably ‹ 30 days) should typically occur at the end use/application site, unless logistics requires longer term storage and environmental protection can be assured. If biosolids are stored at the application site:

- where practical, biosolids that will be regularly stored at a particular site or stored for longer than 30 days, should be stored undercover or retained within a bunded storage area with an impermeable to low permeable base and

designed to capture the first flush of contaminated run-off;

- water from bunded storage areas should be distributed onto the application site or another suitable area;
- stockpile areas should be located on a slope of less than five per cent;
- the buffer distances listed in Table 8 must be adopted;
- stockpiles should not be turned or broken up on windy dry days, to minimise off-site odour and dust generation (light watering of stockpiles could be undertaken to control dust generation); and
- where bunding and impermeable base is not practical at the application site, the stockpiles should be located on flat land, stockpiles should be sloped to reduce water penetration, stormwater flow into the storage site should be diverted, increased buffer distances to surface waters may be required and the duration of storage should be minimised.

6.2.3 Generic management controls

Application method

Unless otherwise stated in Tables 6 and 7, application of biosolids should include the following measures:

- preferably incorporation into land, achieved through direct injection or surface application followed by incorporation;
- very little, if any, biosolids should be visible on the surface after injection or incorporation;
- when incorporation of biosolids is not practicable (for example forestry) or is contrary to farm practices for example 'no till farming' methods, surface application of biosolids products may be acceptable. However, any potential risks require careful consideration. The key risks include contaminant issues such as compliance with food standards for livestock grazing (6.4.2) and potential movement to surface waters in run-off. Specific management practices may be needed to manage these risks, such as controlling run-off via increased buffer distances or land slope restrictions;
- surface soils or subsoils should not become compacted as a result of application operations; and
- the application method should ensure biosolids are evenly spread so that maximum agronomic benefit is obtained.

Application timing

The following practices should be adopted with regard to the timing of biosolids application:

- winter application should be minimised. Low crop nitrogen demand and high rainfall increases the risk of nitrate leaching, particularly on sandy soils;
- application should not occur during rainfall events, or when application will coincide with forecasts for heavy rains; and
- to avoid nutrient losses, biosolids used in agriculture should be applied to fallow land as close as possible to the time of sowing, except where other restrictions apply (Tables 6 or 7).

Application and wind speed

Biosolids land application should always be undertaken with good practice management measures to minimise dust and aerosol generation. In addition, certain wind conditions may require additional measures to be undertaken:

- in calm to light winds (‹ 19km/h and indicated by rustling of leaves), prescriptive control measures are not mandated;
- in moderate winds (20-29km/h and indicated by movement of small branches on trees and loose paper movement), measures such as wetting of dry biosolids products (‹50 per cent dry solids) and increased buffer distances will typically be required to be implemented downwind of the application site;
- in fresh winds (30-39km/h, indicated by swaying of small trees) application of dry biosolids products should not be undertaken, while application of products with greater than 50 per cent moisture will typically require increased buffer distances downwind of the application site;
- biosolids should not be applied in greater than fresh winds.

In determining the appropriateness of the above measures, consideration will need to be given to the characteristics of the product (for example grade and pecentage of moisture) and local topography (for example presence of tree screen downwind).

Application frequency

Where a site has received a previous biosolids application, the potential residual soil nutrients and contaminants will need to be considered prior to subsequent biosolids application (refer sections 6.3 and 6.4). Therefore, where a site receives repeated applications of biosolids, the acceptable rates for subsequent applications will most likely decrease (due to reducing difference between the receiving soil's nutrient and contaminant levels and the maximum levels permitted).

The optimal application frequency will therefore vary from site to site depending on site history and proponent needs. It is for this reason that this guideline does not include a detailed discussion of biosolids application frequency.

Soil pH

Following application, receiving soils should be managed to maintain soil pH levels at optimum levels for minimisation of metal uptake in plants, as well as migration of nutrients and contaminants into groundwater. Guidance on pH values and the severity of land use limitations are provided in Table 9.

Stormwater management

External surface water (that is from surrounding land) should be prevented from flowing onto the application site. Suggested measures to control run-on include placing diversion banks and/or cut-off drains around the application site, where practical.

Biosolids should not be applied within 48 hours of heavy rains being forecast. Where light rain is forecast within 48 hours, application can proceed provided sites do not have ratings above moderate for hydraulic capacity and slope (see Table 9). If these requirements are not met, site-specific

consideration of stormwater run-off and collection controls will be needed.

Signage and site access restrictions

Wherever biosolids of stabilisation grade T2 or T3 are applied to land, measures need to be taken to restrict access of the general public and stock to the site until vegetation is fully established and withholding periods have passed. These measures will principally involve erection of prominent warning signs in compliance with AS 1319 - *Safety Signs for the Occupational Environment*. The signage should be located on points of access during the specified withholding period. The need for fencing is considered based on the likelihood of public and stock access to the site during the required withholding period.

Site restrictions will generally not be needed solely on the basis that Contaminant Grade C2 biosolids have been applied, although some restrictions may be necessary for surface application of C2 biosolids (6.4.2).

Proponents need to be aware that withholding periods for specific aspects of agricultural land uses (for example growing crops for raw consumption by humans) may be longer than the restrictions on site access. Any changes in land use following biosolids application need to consider these withholding periods (refer Table 6). Planning biosolids end use schemes should involve consideration of possible future land uses (for example change from agricultural to residential). Biosolids use should not place significant limitations on future land uses.

Occupational health and safety precautions

As 'restricted grade' biosolids may contain pathogens and chemical contaminants that require management, routine Occupational Health and Safety precautions should be practiced, including:

- education of on-site workers as to the risks associated with exposure to biosolids (ingestion or inhalation of biosolids dusts);
- worker immunisations where appropriate;
- installation of wash basins and the provision of showering facilities;
- no food or drink consumption while directly working with biosolids and washing hands before meals or smoking;
- adopting techniques that minimise the generation of mists and airborne dust, for example using wet sweeping (but not flushing) techniques rather than dry sweeping, avoiding use of high pressure equipment such as water jet sprays or air pressure devices; and
- minimising worker access to the site during biosolids application, keeping workers upwind during application and using protective equipment for example eye protection and masks should be worn if dusts/aerosols are generated.

Employers should make themselves aware of their occupational health and safety responsibilities and duties under the *Occupational Health and Safety Act* 1985. An OH&S plan should be prepared, staff trained and safe practices integrated into day to day work procedures. The Victorian WorkCover Authority has a number of booklets that assist in establishing a health and safety management program, and are available from WorkCover offices (Appendix G).

6.3 Nutrient application rates

To ensure additions of nutrients in biosolids do not exceed agronomic rates, site-specific application rates need to be calculated. The Nutrient Loading Application Rate (NLAR) is the rate at which biosolids can be applied to land without exceeding the annual nutrient requirements of the vegetation. For most biosolids, the NLAR is expected to determine the overall biosolids application rate.

The NLAR needs to be derived for each nutrient that may limit biosolids application. For fresh sludge, nitrogen is typically the limiting nutrient, while for aged sludge, potassium and phosphorus generally become more important. Detailed data regarding nutrient levels in biosolids is not covered in this guideline and the importance of individual nutrients will need to be considered on a case by case basis according to the biosolids generated.

Calculation of NLAR

The assessment of NLAR for nitrogen is described below. Application rates for other nutrients should consider the generic approach, but acknowledging that some soils may have significant binding capacity for nutrients such as phosphorus.

Central to the calculation of NLAR is **Equation 2**:

$$NLAR = CNR / ABN$$

where:

NLAR= Nutrient Loading Application Rate (tonne/ha)

CNR= Crop Nutrient Requirement (kg/ha)

ABN= Available Biosolids Nutrients (kg/tonne)

Available biosolids nitrogen

Calculation of available biosolids nitrogen requires analysis of biosolids for ammonium nitrogen, Kjeldahl nitrogen and in some instances oxidised nitrogen (nitrate/nitrite). The arithmetic mean concentration (rather than upper confidence limit as per contaminants) of each analyte is then used to calculate available nitrogen in biosolids, based on **Equation 3**:

ABN (Year 1) =

(Ammonia N) + (Oxidised N) + MR{(Kjeldahl N) – (Ammonia N)}

where:

ABN= Available Biosolids Nutrient (kg/tonne)

MR= % Nitrogen Mineralisation Rate

Ammonia N, Oxidised N and Kjeldahl N are the measured levels of the various forms of nitrogen in the biosolids (kg/tonne).

'MR' is nitrogen mineralisation rate of organic nitrogen. This is included in Equation 2 in recognition that organic nitrogen in biosolids is not immediately available and may be released over a number of years. The rate of release is dependent on the biosolids treatment process. Suggested MR values for various treatment processes are provided in Table 10.

Table 10. Estimated nitrogen mineralisation rate in 1st year of application, based on biosolids type (from NSW EPA 1997).

Biosolids type	Nitrogen MR
Anaerobically digested	15%

Aerobically digested	25%
Composted	10%

Year 1 is used in the equation for calculating the NLAR since the rate of mineralisation will decrease each year. Where subsequent applications of biosolids are intended, the residual organic nitrogen in the soil from previous applications will need to be considered for its future contribution to 'available soil nitrogen'.

Note: While oxidised nitrogen content is shown here for completeness, oxidised nitrogen can generally be excluded from the biosolids calculation.

Future applications of biosolids will need to be calculated considering the residual nutrients from previous applications.

Other nitrogen inputs

The NLAR is the maximum biosolids loading that will typically be permitted for land application. The use of biosolids for nutrient additions should be integrated into a holistic farm management program such that supplemental fertiliser use does not result in excessive nutrient accumulation within soils.

Indicative crop nutrient requirements

Specific crop nutrient requirements will vary with the site and the crop that is being grown. While indicative nitrogen and phosphorus requirements for various crops and pasture species are provided in Appendix C, they will not be accurate for all situations. Therefore, it may be necessary to obtain advice from an agronomist regarding site-specific nutrient requirements.

Additional considerations for use of NLAR

In some situations it may not be appropriate to base requirements solely on the NLAR. These situations are discussed briefly here.

Land rehabilitation

Biosolids used for land rehabilitation are typically applied as a single application. To provide adequate nutrients and organic matter for vegetation establishment on land rehabilitation sites, the annual nutrient requirements of the particular pasture or tree species may be exceeded.

The maximum total nitrogen application rate allowed on land rehabilitation sites is 2000kg N/ha as a once only application. This is based on total Kjeldahl nitrogen. If repeated applications are intended, the NLAR should be determined on the basis of annual nitrogen requirements.

Forestry

Nitrogen requirements vary over the life of a forest, with many factors affecting the rate of nitrogen uptake. Research indicates that biosolids application rates which apply about 350kg (available N)/ha in the first year can give acceptable growth responses with negligible environmental impacts. Applying biosolids when the demand for nitrogen is highest (initial two to four after planting) is considered effective to maximise uptake by the trees.

Lime amended biosolids

Lime amended biosolids have the benefit of addressing soil acidity problems. These biosolids should be applied based on a rate that will raise soil pH to within limits for satisfactory crop growth as

well as considering an application rate based on the nitrogen content of the biosolids.

Unrestricted biosolids application rates

To assist best practice management, 'Unrestricted' grade biosolids sold to the general public should be accompanied by labels (on bags) or other information forms (for example a pamphlet) describing the contents and indicative application rates, based on a range of expected residential uses.

6.4 Contaminant management and application rates

6.4.1 Contaminant application rates

Although nutrient based application rates will typically limit biosolids applications, all applications of C2 biosolids should involve an estimate of the Contaminant Limiting Application Rate (CLAR). The maximum application rate will then be the most stringent of the NLAR or CLAR.

The CLAR is the rate at which biosolids can be applied without exceeding the RSCL. An important difference between the CLAR and NLAR is that the CLAR will progressively reduce with ongoing applications, while the NLAR will remain relatively constant (if sufficient time between applications for uptake of nutrients).

The processes for calculating CLAR is relatively straightforward, being derived for each contaminant from **Equation 4**:

$$CLAR = SM(RSCL - AS)/BCC$$

where:

CLAR Contaminant Limiting Application Rate (dry tonnes biosolids/ha)

SM mass of soil per hectare to the depth of biosolids incorporation (tonnes/ha)

RSCL receiving soil chemical contamination limit (Table 1) (mg/kg)

AS application site soil concentration determined in accordance with Appendix D (mg/kg)

BCC biosolids contaminant concentration calculated for contaminant grading (Chapter 4, Appendix B) (mg/kg biosolids)

The CLAR is the lowest value for any contaminant.

Soil mass

The incorporated soil mass (SM) is included to convert the concentration of a biosolids contaminant (mg/kg), into a biosolids application rate (tonnes/ha) based on the depth of incorporation.

Assuming an incorporation depth of 75mm, a SM value of 1000 dry tonnes/ha is obtained based on **Equation 4**:

$$SM = (\text{Soil Bulk Density: } 1.333\,\text{dry t/m}^3)\,x\,(\text{Incorporation Depth: } 0.075\text{m})\,x\,(10{,}000\,\text{m}^2/\text{Ha})$$

The incorporation depth should be considered on a case by case basis but would not typically exceed 250mm. Where C2 biosolids are intended to be surface applied without incorporation, that is forestry applications or land rehabilitation, the acceptability of the practice will need to be considered based on the specific risks associated with the proposal. Assuming a nominal depth of

'incorporation' for surface applied biosolids would underestimate the associated risks.

6.4.2 Surface application and other management controls

Surface application

While it is preferred that biosolids are incorporated into the soil layer, it is recognised that this may not always be practical or consistent with the particular agricultural or municipal strategies (for example 'no-till' farming). Surface applications of biosolids must address the key risks associated with the practice: direct human exposure to the material and livestock ingestion of the material. Therefore, biosolids intended for surface application must not exceed the HIL (Health Investigation Levels) in the NEPM (*Assessment of site contamination*) 1999 and must have C1 levels for any material that poses a risk to meat or dairy food standards or livestock grazing. This is particularly relevant to organochlorine pesticides and PCBs, but cadmium may also be of concern if slaughtering includes the collection of relevant organs. Surface applied biosolids in association with livestock grazing would preferably have concentrations of organochlorine pesticides less than 0.02mg/kg, rather than the 0.05mg/kg limit described in Table 2. Obviously, the restrictions need to be relevant to the scenario and the stringent restrictions on organochlorines may not be relevant to forestry or municipal schemes.

Risk management entails that repeat applications of biosolids under grazing scenarios (› 2) should trigger soil incorporation.

Cadmium loading rate

Recent research has raised concerns that under some circumstances, a RSCL for cadmium of 1mg/kg may not be protective of food standards. Therefore, to ensure biosolids applications do not result in significant accumulation of cadmium in soils, this guideline includes a maximum annual cadmium loading rate for agricultural soils. The limit is 30g/ha/year, averaged over 5 years, that is a total of 150g/ha/5 years. This loading rate will be reviewed once research on cadmium bioavailability has been completed.

6.5 Monitoring

6.5.1 Nutrients, chemicals & soil structure

Determination of the NLAR and CLAR requires information on the nutrient and chemical contaminant levels in biosolids and receiving soils. Sampling should be taken as close as practical to use.

Receiving soil contaminant analysis should be undertaken prior to the first biosolids application. Subsequent sampling should occur prior to biosolids applications when either:

- mass balance calculations indicate that biosolids have contributed a load that exceeds 10 per cent of the RSCL since the previous sampling;
- four biosolids applications have been undertaken since the previous sampling; or
- 20 years have passed since the previous sampling.

For agricultural land uses, ongoing monitoring of parameters such as nutrients and acidity/alkalinity should be conducted as part of normal farm nutrient/fertiliser planning and soil health management programs (for example at least annually).

Sampling of biosolids and soil should be undertaken in accordance with good agricultural practice. Many laboratories provide soil sampling kits, perform soil analysis and undertake basic agronomic interpretation (i.e. soil nutrient status) for agriculture and the general public.

DPI have developed a series of *Agriculture Notes* which provide simple soil sampling guidelines for growing pastures, field and fodder crops, flowers, fruit, grape, vegetable production and turf growing (refer to DPI website at: www.dpi.vic.gov.au.)

Given these practical guidelines are freely available, soil sampling will not be covered in detail here. However, additional details of soil sampling and analysis relating specifically to biosolids use are given in Appendix D.

6.5.2 Groundwater monitoring

Although groundwater monitoring will not typically be required for schemes complying with this guideline, monitoring may need to be undertaken where local conditions and volumes of use indicate a potential risk to groundwater. The key message is that the need for monitoring should reflect the risks associated with specific schemes.

Regional groundwater would be most vulnerable at sites having:

- highly permeable soils or unconfined aquifers, for example coastal dune sands, alluvial deposits or basalt formations, or soils with hydraulic conductivity of greater than 50mm/h in the most restrictive layer;
- shallow watertable for example less than 1.5-3m depth to groundwater;
- less than 60cm depth to bedrock or clay hardpan.

The assessments should be conducted in accordance with EPA publication *Hydrogeological Assessments, Groundwater Quality* (currently in draft). Where risks are indicated, hydrogeological experts should be consulted to assist with the development of appropriate groundwater monitoring programs according to specific site features and extent of groundwater vulnerability.

6.5.3 Food safety monitoring

Direct testing may need to be undertaken, depending on identified risks to food safety for example potential exceedences of a MRL or ML. DPI have a series of *Agriculture Notes* relating to food safety quality assurance including produce testing. Sampling and analysis required should reflect the identified risks and should be conducted in accordance with *Guidelines for sampling soils, fruits, vegetables and grains for chemical residue testing* (NRE 1999 #AG0889).

For biosolids applied to agricultural grazing land, a stock monitoring program may need to be implemented in accordance with the *Livestock Diseases Control Act* 1994.

Further information can be obtained from DPI (Appendix G) or from their website at: www.dpi.vic.gov.au.

Site Selection and Management

Objective:

To ensure that only sustainable end use sites are selected and that any associated potential risks are effectively managed and monitored.

Suggested measures to meet the performance objectives:

- Biosolids are not applied to land with severe site characteristics, unless there is detailed assessment and mitigating controls can be implemented (Table 9);
- Application sites are managed to ensure there is not off-site movement of micro-organisms, nutrients, chemicals or offensive odours (6.2);
- Transport of biosolids involves appropriately sealed vehicles, low impact road routes, vehicle cleaning and incident (spill response) management plans (6.2.2);
- If biosolids storage at application site is needed, appropriate management practices are implemented (6.2.2);
- Where required, restrict access of the general public and stock to the site through fences and signage in accordance with Australian Standard *AS 3119* (6.2.3);
- At suitable sites, biosolids are applied in accordance with guidance on methods, timing and frequency (6.2.3);
- Implement occupational health and safety responsibilities and duties under the *Occupational Health and Safety Act* 1985 (6.2.3);
- Application rates do not exceed NLAR or CLAR limits (6.3 and 6.4);
- Where necessary, undertake monitoring programs for soil, groundwater and also food safety (6.5).

7. RECORD KEEPING AND INFORMATION TRANSFER

Information transfer and record keeping are both essential components of a management framework for ensuring sustainable biosolids use. In this chapter, the requirements for information transfer and record keeping are discussed with regard to:

- generators, who need to supply information to users and reprocessors and also retain records relating to the quality, quantity and destinations of produced biosolids;
- reprocessors, who need to maintain records regarding the quality and quantity of biosolids received;
- users, who may need to maintain records relating to biosolids quality, application rates and management controls.

This chapter also describes the requirements for supply of information to organisations such as the EPA, and for reporting of non-compliance.

7.1 Producer requirements

7.1.1 Records

Producers of biosolids should maintain the following records regardless of biosolids quality:

- batch identification (or for a continuous operation, the biosolids produced between sampling periods);
- production period;
- contaminant concentrations and batch grade;
- historic trends of contaminant levels;
- treatment process, microbiological testing, stabilisation method and resultant treatment grade;
- concentrations of nitrogen, phosphorus and other relevant nutrients in biosolids;
- details of incidents and the corrective action taken;
- inspection and maintenance reports;
- quantity (dry tonnes) and solids content of the batch; and
- the type of product produced.

For restricted grade biosolids (that is those that do not meet the criteria for Contaminant Grade C1 or Treatment Grade T1), the producer should record the address of the biosolids destination, the expected end use and cross-reference the relevant endorsed EIP. The producer should also retain a copy of the end user information described in 7.3.

Where sewage sludge is to be transferred to a reprocessor for production of biosolids, reduced information requirements than described above may be applicable.

7.1.2 Information transfer

The generator should provide adequate information with the biosolids to inform reprocessors and users of the quality of the biosolids and relevant management controls. *A Guide to Victorian Fertiliser Standards* (DNRE 2000) describes information required to accompany commercially sold fertilisers. This document should be consulted as a basis for labelling and other information requirements (provided by the generator) to accompany biosolids when sold/transferred to buyers (includes

reprocessors and users). At the time of publication of this guideline, the information requirements in *A guide to Victorian Fertiliser Standards* included:

- the distinguishing name of the product;
- a description of the type of product;
- a statement of the intended purpose;
- the quantity of product;
- the name and street address of the source/supplier of the biosolids;
- concentrations of nitrogen, phosphorus, sulfur and other important ingredients;
- concentrations of specified contaminants;
- warning statements where the levels of metals exceed prescribed limits or where fertilisers are sold in volumes › 25kg.

Clearly, since users will need to calculate CLARs for any contaminant that exceeds Contaminant Grade C1 limits, these concentrations should also be supplied.

Suppliers should also consider AS 4454-*Composts, soil conditioners and mulches* for suitable information, which includes (among other things) a warning that use near surface water is prohibited.

7.2 Reprocessors

Options for treating biosolids include composting, vermiculture, alkali and/or heat treatment, or other processes. Mixing or blending of biosolids with other compatible materials is permitted. Reprocessors should refer to publications such as *Environmental Guidelines for Composting and Other Organic Recycling Facilities* (EPA 1996) and AS 4454-1999 *Composts, soil conditioners and mulches*.

Reprocessors of biosolids should keep relevant records as required for a producer (7.1.1) as well as the following:

- address of the producer;
- volume of biosolids and the date received from the producer.

For restricted grade biosolids (that is those that do not meet the criteria for contaminant grade C1 or treatment grade T1), the reprocessor should record the address of the biosolids destination, the expected end use and cross-reference the relevant endorsed EIP. The producer should also retain a copy of the end user information described in 7.3.

Reprocessors should supply similar information to users as described for generators (7.1.2)

7.3 End users

Restricted Grade biosolids end users need to maintain the following records:

- source of biosolids, batch identification and date received;
- biosolids classification information from producer;
- details of application site including, location, name of occupier or owner, area involved, date of application;
- the calculated NLAR;
- the concentrations of contaminants in soil prior to biosolids application;
- the calculated CLAR;
- the application rate and method of application;
- the soil pH and salinity;

- monitoring data and analysis of trends in the parameters;
- when quality limits are exceeded and the corrective action taken; and
- cross reference to the relevant EIP and associated management controls.

A copy of this information should also be retained by the supplier of the biosolids.

Users of unrestricted grade biosolids (contaminant grade C1 and treatment grade T1) do not need to maintain records. However, users of large quantities of unrestricted grade biosolids are encouraged to maintain good records similar to that listed for restricted grade biosolids but appropriate to the scale and potential heath, environmental and agricultural impacts of the biosolids use activity.

7.4 Transfer of information

Producers (and reprocessors, if relevant) should send a copy of their biosolids records annually to the EPA.

Records should be made available to the EPA upon request. Records need to be maintained for at least 10 years in order to analyse trends and demonstrate ongoing compliance with the objectives of this guideline.

7.5 Reporting emergencies or non-compliance

In the event of an emergency incident following biosolids use, the user and/or supplier must notify the relevant regulatory body. This would include incidents such as:

- breach of RSCLs (Table 2); or
- violations of food standards (i.e. MRLs or MLs).

Notification should be as soon as practical and include details of testing results, cause and effect, and corrective and future preventative actions being taken.

The appropriate regional office of EPA should be notified of any event or emergency that significantly increases risk to the environment. This includes spills of biosolids onto roads, into or immediately adjacent to waterways.

The Department of Human Services should be notified in the case of an emergency or an incident that significantly increases the risk to public health or food safety.

DSE should be notified in the event of an emergency or event that presents a risk to native flora or fauna, National Parks, conservation reserves or other sensitive land referred to in Section 5.3.

Contact details of regulatory bodies are provided in Appendix F.

Information Transfer & Record Keeping

Objectives

To ensure appropriate ("cradle to grave") biosolids management records are maintained and effective information transfer occurs.

Suggested measures to meet the performance objective

Records

- Producers of biosolids should maintain records and supply these to the EPA, reprocessor or subsequent user as relevant (Section 7.1);
- Reprocessors should maintain records and supply these to the EPA or subsequent user as relevant (Section 7.2);
- Producers and reprocessors should provide appropriate labelling and other information requirements with any biosolids sold/transferred (7.1);
- Restricted grade biosolids users and suppliers should retain appropriate records of applications (7.3).

Emergency Incidents

- Significant incidents (involving environmental, public health, food safety) associated with biosolids use must be promptly reported to the relevant regulatory body (7.4).

8. ENVIRONMENT IMPROVEMENT PLANS

The development of an Environment Improvement Plan (EIP) is a key component of sustainable biosolids use. An EIP should bring together all of the roles and responsibilities, management and monitoring practices, that are necessary to ensure a safe, sustainable and compliant (and therefore successful) biosolids end use scheme.

As described in Chapter 3, biosolids suppliers need to ensure that restricted grade biosolids are only supplied to schemes that have an endorsed EIP.

For the purposes of this discussion, suppliers include biosolids producers and reprocessors.

8.1 When is an EIP required

For all restricted grade schemes (that is, involving Contaminant Grade C2 or Treatment Grades T2 or T3) the supplier and user will need to jointly develop an EIP appropriate to the scale of operation and potential exposure involved. The EIP must be submitted to either EPA or an appointed auditor for confirmation that the proposal complies with the requirements of this guideline.

EIPs are also a recommended best practice management tool for large schemes using unrestricted grade biosolids.

8.2 Preparing an EIP

A documented EIP should be based on the specifics of the end use scheme, environmental risks posed and drawing on the objectives, concepts and suggested measures/practices described throughout Chapters 2 to 7 of these Guidelines.

The prime objectives of an EIP should be to:

- demonstrate that the performance objectives of these guidelines can be achieved by detailing the procedures and practices that will be followed;
- address all aspects of the scheme which pose a risk to the environment, food safety, and human and stock health; and
- provide a framework for assessing the long-term performance of the biosolids scheme.

To meet these objectives the EIP should at least address the following issues:

- the type of use and the details of the biosolids quantity and quality to be used;
- biosolids transport, storage and distribution systems;
- application frequency and scheduling, and rates based on nutrient and contaminant restraints;
- for agricultural uses, the use restrictions and relevant withholding periods, the crop management practices, including crop nutrient utilisation practices, soil structure and productivity controls;
- site selection and management controls such as buffer distances (Table 8) and land capability (Table 9);
- if needed, controls for drainage, stormwater run-on and run-off and for groundwater protection;
- inspection and maintenance programs;
- training programs;
- contingency planning; and

- monitoring, reporting, quality assurance and auditing programs including HACCP programs.

Appendix E provides a checklist for biosolids end use site EIPs.

8.3 Use of regional EIPs

Where a supplier will provide biosolids to a number of related reuse schemes for example broad acre cropping, it may be most effective to seek endorsement of a 'regional EIP'. The regional EIP will establish a framework for all relevant biosolids reuse schemes for that supplier, with the advantage that each individual site EIP does not need EPA or EPA appointed auditor endorsement. Therefore, while all the issues relevant to this guideline will need to be addressed, the specified controls will apply to all application sites. The risk assessment will be conducted at a regional level and therefore boundaries will need to be defined in the EIP. The boundaries will limit the applicability of the EIP to the described site characteristics. Application sites that have characteristics outside the boundaries of the endorsed regional EIP (for example for stated land use, minimum soil pH, background contaminant limits) will need to have an individual EIP that is separately endorsed by EPA or an appointed auditor.

Adoption of the regional EIP provisions at each application site will need to be ensured via a contractual arrangement and ongoing audit program.

8.4 Submission of EIP to EPA

A copy of the EIP must be endorsed by EPA or alternatively, endorsed by an auditor appointed under the *Environment Protection Act 1970*. If an appointed auditor endorses the scheme, the auditor must advise EPA in writing that the scheme has been found to be in accordance with this guideline. Copies of the EIP for any end use scheme must be made available for EPA inspection upon request.

The EIP should be subject to an audit program, the scope and frequency of the audit depending on the size of the scheme and the level of any identified risks. For larger schemes, the audit program should involve an independent, experienced, auditor such as those appointed under the *Environment Protection Act 1970*.

The EIP should form part of an overall quality assurance system for the end use scheme. If a premises or industry (for example dairy, meat or horticultural industries has adopted a quality assurance (QA) system (for example HACCP), the EIP should be integrated into the QA system.

From time to time the EPA produces updated information bulletins and guidelines relating to EIPs. Preparation of EIPs should also consider the additional guidance provided by such supplementary publications.

Environment Improvement Plans

Objectives

Preparation of an EIP that ensures a safe, sustainable and compliant biosolids end use scheme.

To ensure schemes using restricted grade biosolids have endorsed EIPs.

Suggested measures to meet the performance objective

- EIPs should be prepared for use of restricted grade biosolids and endorsed by either EPA or an appointed auditor, (8.1, 8.3);
- The EIP document should be prepared in appropriate detail relevant to the scale of specific end use scheme, the risks posed and drawing on the objectives and suggested measures described throughout Chapters 2 to 7 (refer to list of items in section 8.2 and EIP checklist in Appendix F).
- Regional EIPs describing generic management controls can be developed by biosolids suppliers, but need defined boundaries for site characteristics;
- Biosolids use should be undertaken in accordance with the EIP to ensure compliance with this guideline.

9. GUIDELINE REVIEW AND RESEARCH NEEDS

It is anticipated that a review of this guideline will be undertaken in approximately 3 years. However, the timing of the review will reflect market needs. If feedback indicates that the guideline remains consistent with best practice, the review may be delayed for four to five years post-publication.

The need for a review of this guideline will also reflect any recent findings from research into the risks and benefits of biosolids use. Currently, this guideline is structured to take a conservative approach where there are identified areas of uncertainty. Potential research topics that could assist this guideline and possibly reduce the conservatism include:

- Bioavailability of metals, particularly cadmium, copper and zinc, in biosolids applied to land;
- Indicators for pathogen removal in treatment processes;
- Levels of organic contaminants in Victorian sewage treatment plants;
- Levels of survival and regrowth of micro-organisms following land application of biosolids; and
- Assessments of the treatment grade classifications associated with common processes, such as lagoon storages and drying beds.

Specific sections or requirements in this guideline may be updated from time to time as new information becomes available. Such updates will be provided in addendums via the EPA website.

EPA will be pleased to receive comments on these guidelines. Comments will, where appropriate, be incorporated in future editions.

Comments on this guideline should be sent to:

Project Manager: Biosolids Land Application
EPA Victoria
GPO Box 4395QQ
MELBOURNE VIC 3001

APPENDIX A. KEY LEGISLATION RELATING TO BIOSOLIDS USE

Acts

Agricultural and Veterinary Chemicals Act 1992

Environment Protection Act 1970

Health Act 1958

Livestock Disease Control Act 1994

Occupational Health and Safety Act 1985, No 10190/1985

Trade Practices Act 1974

Food Act 1994

Food (Amendment) Act (1997)

Regulations

Environment Protection (Scheduled Premises and Exemptions) Regulations 1996, No. 66/1996

Agricultural and Veterinary Chemicals (Fertilisers) Regulations 1995

Health (Infectious Diseases) Regulations 1990

State environment protection policies, Industrial Waste Management Policies and other statutory instruments

State environment protection policy (Waters of Victoria) 2003;

State environment protection policy (Groundwaters of Victoria) 1997;

State environment protection policy (Ambient Air Quality) 1999;

State environment protection policy (Air Quality Management) 2001;

State environment protection policy (*Prevention and Management of Contamination of Land*) 2002;

Industrial Waste Management Policy (Prescribed Industrial Waste) 2000

Environment Protection Authority, Victoria, *Enforcement Policy*, 1993 Publication No. 384.

APPENDIX B. CALCULATING BIOSOLIDS CONTAMINANT GRADE

There are a number of contaminants (9 heavy metals and selected organochlorine contaminants) which need to be analysed to ensure biosolids contaminant quality is suitable for use (refer Table 2). However, use of biosolids from a specific generator is generally limited by only one or two contaminants and therefore the sampling program should be structured to reflect the risks associated with particular contaminants.

The framework for sampling and analysis involves initial characterisation of biosolids quality using a default minimum of 5 samples. The data is then compared with the contaminant grade limits and a second phase of sampling and analysis is undertaken. The detail of this second phase depends on the outcome of the initial characterisation. It may involve relatively extensive sampling when contaminant levels are close to a grade limit or concentrations are highly variable, through to no further sampling when there is a defined batch with contaminants at homogenous levels or present at low concentrations relative to the grade limits.

B1. Calculating BCC and initial comparison with grade criteria

As described in section 4.1 biosolids contaminant grading involves the following steps:

(i) establishing a monitoring program based on biosolids generation processes and volumes of production;

(ii) testing contaminant levels using accredited (for example NATA) laboratories;

(iii) statistical examination of the results, with determination of biosolids contaminant concentrations (BCC) and classification against chemical grades (Table 2);

(iv) refinement of the monitoring program and ongoing classification.

Deriving the BCC

To ensure sustainable biosolids use, the fundamental objective in analysing biosolids and calculating a BCC value is to ensure that *no more than 5 per cent of biosolids are incorrectly classified as belonging to a lower grade* that is, classifying a biosolids product as T1 when the product is actually T2, or classifying as T2 when the product is actually T3.

Biosolids producers are able to propose a process for statistical analysis of their data to achieve the above objective. However, before use, the process will need to be endorsed by EPA or an appointed auditor. Alternatively, the producers can adopt the generic approach described below (formula 1). Although this generic approach does not fully adopt strict statistical principles (such as the need for

transformation of skewed data), the conservatism inherent in the C1 and C2 limits means that it is a pragmatic method for classification, particularly by small producers.

Formula 1 Generic method for calculating BCC (sourced from Gilbert (1987):

$$BCC_n = m + (y * s)$$

Where

m = arithmetic mean of n samples;

s = standard deviation of n samples;

y = coefficient derived from Table 1.

Table 1 Coefficient based on sample number for calculating BCC

Sample size (n)	Coefficient (a)
5	0.95
6	0.82
7	0.73
8	0.67
10	0.58
11-14	0.52
15-20	0.44

Calculated BCC values for each contaminant are compared with the corresponding threshold values in Table 2. The biosolids contaminant grading is the most stringent grading of any individual contaminant. For example, if zinc was the only contaminant within the C2 grading and all other contaminants were C1, the biosolids classification would be C2.

Sampling frequency and analysis

In addition to describing the statistical framework for assessing analytical data, this guideline also establishes minimum requirements for sampling frequency and other aspects of QA/QC. The combination of these requirements is to minimise the risk that a biosolids batch is incorrectly classified as belonging to a higher quality grade.

Biosolids producers may wish to have a more extensive monitoring program, to minimise the risk that a high quality biosolids is incorrectly classified in a lower quality grade. Approaches for reducing the risk of this later error are not prescribed in this guideline, since the approaches represent a trade-off between increasing the sample size and statistical power, versus sampling and analytical costs.

The minimum sampling frequencies are described below -

Stockpiles

A number of treatment plants have stockpiles representing several years of biosolids production. A sampling program should be developed from a desktop/field assessment to define discrete 'batches' of biosolids based on periods of historical production. These discrete 'batches' should then be individually sampled and analysed. This approach is necessary due to potential differences in contaminant concentrations in current versus historical production. Improvements in contaminant concentrations have been progressive, so 'mixing' biosolids of different ages will increase the data variability and also the risk that a localised amount of relatively contaminated material could be missed in the sampling regime.

As a default, each discrete stockpile batch should have an initial sampling screen of one sample for every 100 to 500 dry tonnes. The frequency of the sampling should reflect the size of the stockpile, with a minimum of five samples needed for initial characterisation. An initial sampling regime for large stockpiles ie greater than 5,000 dry tonnes can potentially be justified at a frequency lower than one per 500 dry tonnes. Individual grab sample analysis rather than composite sampling is preferred for stockpiles, to maximise the likelihood of identifying batch variability.

A second round of more intensive sampling should be undertaken when initial sampling indicates the data is highly variable or contaminant concentrations lie close to the contaminant grade limits. Variable data is of particular concern in low frequency sampling programs due to the potential for a localised area of high contamination being missed. However, high variability in data will also result in high BCC values being calculated (due to the increased standard deviation) and therefore relatively conservative grades.

Variations in sampling regime

An approach requiring less than five samples is not described and would need to be considered for EPA sign-off on a case by case basis. Generally, where only three or four samples are obtained, all data for a contaminant will need to be less than the relevant grade limit, rather than using a statistical distribution.

Stockpiles prepared based on turning/drying to create a relatively homogenous material may be considered for reduced sampling requirements.

Lagoons

Lagoons should be sampled after dewatering as per a stockpile.

Continuous production

Continuous production refers to treatment plants that regularly produce biosolids. In contrast to stockpile sampling, which is focused on a discrete batch, continuous production involves components of both initial characterisation and ongoing monitoring. Prior to use of biosolids from continuous production, initial characterisation is required with five samples taken at a minimum frequency of one sample per 50 dry tonnes. Sampling should not occur in 'clumps', rather each sample should be evenly spaced with at least 25 dry tonnes of biosolids having been produced since the previous sample.

As with the sampling of stockpiles, the BCC calculated from initial sampling is compared with the contaminant grade limits. Depending on the BCC values, either low or high frequency sampling should be undertaken.

High frequency sampling is the default requirement and involves one sample for every 100 dry tonnes. With each new sample, the data is combined with relevant historical data and the BCC recalculated. The use of historical data is limited to the more stringent of:

- data from the previous 2000 tonnes; or
- data since the last significant change in biosolids quality for example changes to trade waste inputs, or an alteration in treatment processes.

Low frequency sampling is appropriate only where all of the initial five characterisation samples for a particular contaminant are less than half of the relevant C1 limit value. A contaminant achieving this criteria can be removed from high frequency sampling, provided sampling and analysis is repeated:

- at six monthly intervals for the first year, followed by annual samples, provided the contaminant remains below 0.5 of the grade C1 limit; and
- when there is reason to expect a reduction in the quality of the biosolids, such as might occur with the connection of a significant new industry to the sewer.

Variations in sampling regime

An approach requiring less than five samples is not described and would need to be considered for EPA sign-off on a case by case basis. Generally, where only three or four samples are obtained, all data for a contaminant will need to be less than the relevant grade limit.

Plants with a history of relatively consistent contaminant concentrations and/or large volumes of production may be able to develop a reduced 'high frequency' sampling program. Proposals for reduced sampling frequency will be considered on a case by case basis.

Table B4. Overview of sampling categories and associated requirements.

Production category	Sampling regime
Stockpile or lagoon	Minimum of 5 samples per stockpile/lagoon, with one sample per 100-500 dry tonnes. Case by case variations. Additional sampling reflecting operator needs.
Continuous *Initial characterisation*	Minimum of 5 samples, with 1 sample every 50 dry tonnes. Additional sampling reflecting operator needs.
Continuous *High frequency*	Minimum of 1 sample every 100 dry tonnes, combined with historical data. Case by case variations. Additional sampling reflecting operator needs.
Continuous *Low frequency*	1 sample per year or where inputs alter (only where initial 5 samples are less than half of the relevant C1 limit). Additional sampling reflecting operator needs.

B2. Sample and analytical QA/QC

Sampling and analysis should be completed under the direction of suitably qualified persons in accordance with EPA (2000) Publication 441 *A Guide to the Sampling and Analysis of Water, Wastewater, Wastes and Soils*. Sampling techniques should be constant for all samples and should not vary over time.

Composites

Samples from continuous production may be obtained as a composite of individual grab samples. Where composite samples are taken during continuous sampling, an individual grab sample should be taken at regular intervals (for example daily, weekly). Where composites are taken, the number of individual grab samples should be consistent for all composites and each grab sample in the composite should contain equal dry-weight quantities. Note: composites can only be used to obtain a more representative picture of biosolids quality, they cannot be used to reduce actual sample analysis frequency.

Individual grab sample analysis rather than composite sampling is preferred for stockpiles, to maximise the likelihood of identifying batch variability.

Sample timing and location

Biosolids should be sampled at the end of processing and as close as practical to the time of use. The biosolids may be sampled as either liquids or solids depending on the end use. For sampling of continuous production, collection points should be located where the biosolids are well mixed. When sampling, ensure that the:

- biosolids in the tank are well mixed;
- pump line is clear of stagnant biosolids; and
- the first flush of biosolids is discarded to avoid the risk of collecting stagnant material that may have accumulated within the sampling port.

Contaminants below detection limits

Where data is reported as being below the detection limit, half the value of the detection limit should be used in contaminant grade calculations. Note: this approach is only appropriate where the limit of detection is less than the relevant contaminant grade criteria.

APPENDIX C. EXAMPLE NLAR AND CLAR CALCULATIONS

C1. Example calculation – NLAR

The following example illustrates the calculation of the nitrogen NLAR for biosolids application to land used for potato crops. The available information is:

- the nitrogen requirement of a potato crop is 200 kg/ha (Table C1 lists common crops and indicative nitrogen and phosphorus requirements); and
- the available nitrogen in biosolids is 20 kg/tonne.

Applying the following equation (6.3 Equation 2):

$$\text{Nitrogen NLAR} = {}^{\text{CNR}}\!/_{\text{ABN}}$$

Therefore, Nitrogen NLAR (t/ha) = (200 kg/ha) / 20 kg/tonne

Nitrogen NLAR = 10 t biosolids/ha

Note: nutrient applications should be integrated into farm management and NLAR calculations should consider residual nutrients from previous biosolids applications.

C2. Example calculation – CLAR

The following example illustrates the calculation of CLAR for copper and uses the following information:

- the BCC (biosolids contaminant concentration) is 500mg/kg;
- the BG (background soil concentration) is 10mg/kg;
- the RSCL (soil limit) is 100mg/kg; and
- SM (soil mass) is 1000, based on 75mm depth of incorporation.

Incorporating these values into the following equation (from Section 6.4.1 Equation 4):

$$\text{Copper CLAR} = \text{SM}(\text{RSCL} - \text{AS})/\text{BCC}$$

CLAR (t biosolids/ha) = 1000 (100 – 10) / 500

CLAR (t biosolids/ha) = 180

For convenience, the NLAR for individual nutrients and CLAR for each individual contaminant can be compared by undertaking calculations in a tabulated format. A tabulated proforma is provided in Table C2.

Table C1 Indicative Nitrogen and Phosphorus requirements for selected crops (Source: *Guidelines for Wastewater Irrigation* EPA Publication 168, 1991).

Plant species	Nitrogen uptake (kg/ha/year)	Phosphorus uptake (kg/ha/year)
Bent grass	170	-
Bermuda grass	280	30 - 50
Clover	180	20
Eucalypts	90	15
Grapes	20	-
Lemons	60	-
Lucerne	220 - 540	20 - 30
Oats	60	50
Oranges	40	-
Poplars	115	25
Radiata pine	95	10
River sheoak	140	20
Ryegrass	200 - 280	60 - 80
Rye/clover (2:1)	220	50
Sorghum	90	15
Tall fescue	150 - 320	30

Table C2 Proforma sheet for calculation of CLAR (Source: *Tasmanian Biosolids Reuse Guidelines August*, DPIWE 1999)

	Column 1	Column 2	Column 3	Column 4	Column 5
Contaminant	RSCL (mg/kg)	Soil concentration (mg/kg)	Soil capacity (mg/kg)	BCC (mg/kg)	CLAR (t/ha)
	(Table 1, Grade C1)	From soil analyses	= Col (1) – Col (2)	(Section 4.1, App. B)	= SM (Col 3/Col 4)
Arsenic					

APPENDIX D. FIELD SAMPLING

D1. Overview

Field sampling is required for 'restricted grade' biosolids to provide effective nutrient and contaminant management. The scale of the sampling program should reflect the end use scheme.

The scope of a field sampling program could encompass:

- sampling of site soil prior to a biosolids application to enable inclusion of background levels in the calculation of the CLAR;
- sampling of site soil to monitor for accumulation of contaminants or nutrients; and
- sampling of groundwater to monitor if contaminants or nutrients are reaching groundwater in concentrations of concern.

This section describes guidance on when such sampling should be undertaken, and the approaches that should be followed.

D2. Sampling for nutrients and soil characteristics

The biosolids end use scheme should be assessed for the risks posed by off-site movement of nutrients. The assessment should considering factors such as the application rates, volumes and frequency, and also application site characteristics. Unless low risks from off-site movement can be expected (for exaple small scale residential use) the receiving soil should be characterised prior to biosolids application for relevant parameters such as:

- acidity or alkalinity of the soil; and
- nutrients including Kjeldahl nitrogen, ammonium nitrogen, and total available phosphorus.

Guidance on appropriate methods for soil nutrient sampling are described in the following 1998 AgNotes:

- *Sampling soils used for growing pastures, field and fodder crops* (AG0375)(1998);
- *How to sample soils used for flower, fruit, grape and vegetable production* (AG0376) (1998);
- *Sampling recreational turf or soil analysis* (AG0395)(1998).

These publications include the following guidance that should be incorporated into a sampling program:

- where a site contains different soil types, land forms for example sloped versus flat, crops or areas that have historically been treated differently, one sample should be taken to represent each different 'unit area';
- each sample from the unit area should be a composite of at least 30 cores;
- surface soil should be sampled to 100mm for pastures, turf, field and fodder crops; and 150mm for woody perennials and farrow crops;

- for woody perennial crops a subsurface depth of 150-300mm should also be sampled, while for other crops, subsurface sampling should be undertaken on a needs basis;
- soil core locations should be evenly distributed, but should avoid areas such as where there is particularly good plant growth, stock camps, fence lines, trough surrounds, or recent fertiliser additions; and
- samples should be taken as close as practical prior to biosolids application.

Personnel with expertise in soil science should be consulted to assist in developing a soil monitoring program appropriate to the risks the scheme poses and the sensitivities of the site.

D3. Contaminant analysis

Prior to land application of biosolids, the need to quantify soil contaminant concentrations should be assessed based on the risks associated with individual contaminants. This assessment should consider:

- the concentrations of contaminants in biosolids;
- whether a desktop site assessment indicates areas of concern such as geological formations with high metal concentrations (for example arsenic), or there have been applications of fertilisers containing high metal concentrations; and
- the scope of the biosolids end use scheme in terms of intended application rates and repeat application frequency.

Where measurement of soil contaminant concentrations is considered necessary, the process to be followed should reflect the type of contamination likely to be present at the site. If 'hot spots' (point sources) of contamination are expected, the sampling program should reflect guidance in the National Environment Protection (*Assessment of Site Contamination*) Measure (1999) and AS4482.1 –1997 *Guide to the sampling and investigation of potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds*.

Where soil contamination is expected to be relatively uniform for example as a result of broad scale agricultural application, the structure of the sampling program should reflect the following guidance, predominantly derived from DPI publication AG0889 (2000) *Guidelines for sampling soils, fruits, vegetables and grains for chemical residue testing*:

- Where a site contains different soil types, landforms for example sloped versus flat, crops or areas that have been treated differently, each 'unit area' should be treated separately;
- The default is a composite sample for every five hectares, with altered sampling regimes considered on a case by case basis;
- Each sample should be a composite of 20-40 cores, taken to a depth of 100mm (a greater depth should be considered if relatively higher contaminant concentrations are expected in the sub-surface layer;

- Soil core locations should be evenly distributed and targeted at 'typical' areas that is, areas to be avoided include stock camps, fence lines, trough surrounds, roads and gates.

Sampling and analysis should be done under the direction of suitably qualified persons in accordance with EPA Publication 441 *A Guide to the Sampling and Analysis of Water, Wastewater, Wastes and Soils*. Sampling techniques should be constant for all samples.

The calculation of background soil concentrations for each land unit should be undertaken as per guidance for calculating the biosolids contaminant concentrations BCC (Appendix B).

APPENDIX E. ENVIRONMENTAL IMPROVEMENT PLAN CHECKLIST

Suggested EIP checklist for restricted use biosolids supply and end use schemes • Type of use and the details of the biosolids quantity and quality to be used; • Biosolids transport, storage and distribution systems; • Roles and responsibilities for day to day management and compliance issues; • Biosolids application and soil incorporation method, operation and maintenance procedures; • A scaled locality plan of the end use site showing site all important features, sensitive land uses within 200 metres of the site boundaries; • Above plan also showing locations of prominent warning signs in accordance with the principles of AS 1319 - *Safety Signs for the Occupational Environment);* • Contaminant and nutrient application rate calculation methods and resultant application rates, frequency/scheduling based on nutrient/contaminant restraints;	• For agricultural uses, the crop management practices, including crop nutrient utilisation practices, soil salinity, soil structure and productivity controls; • Access controls – public and/or stock, including withholding periods (if relevant); • Site selection and management controls including buffer distances (Section 6.1, Table 8) and land capability (Table 9); • Controls for drainage, stormwater run-on and run-off, and (if relevant) for groundwater protection; • Biosolids dust and odour controls; • Occupational health and safety controls; • Training programs for workers; • Inspection and maintenance program/s; • Monitoring programs for biosolids and receiving soils and if relevant, agricultural produce and groundwater; • Food safety quality assurance programmes such as HACCP; • Recording and reporting programs; • Emergency/contingency implementation plans and procedures; • Auditing programs; and • EIP review process.

APPENDIX F. GOVERNMENT DEPARTMENTS & AGENCIES

EPA Victoria Head Office

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40 City Road SOUTHBANK VIC 3006
GPO BOX 4395QQ, MELBOURNE VIC 3001
Tel: (03) 9695 2700
Fax: (03) 9695 2710
Internet Site Address: www.epa.vic.gov.au
Information Centre: (03) 9695 2722

West Metropolitan and Yarra regions

Refer EPA Head Office details

Gippsland Region

7 Church Street
Traralgon Victoria 3844
Tel: (03) 5176 1744
Fax: (03) 5174 7851

North East Region

24 Ely Street
Wangaratta Victoria 3677
Tel: (03) 5721 7277
Fax: (03) 5721 2121

North West Region

43 Williamson Street
Bendigo Victoria 3550
Tel: (03) 5442 4393
Fax: (03) 5443 6555

South Metropolitan Region

45 Princes Highway
Dandenong Victoria 3175
Tel: (03) 9794 0677
Fax: (03) 9794 5188

South West Region

State Government Offices
Cnr Little Malop & Fenwick Streets
Geelong Victoria 3220
Tel: (03) 5226 4825
Fax: (03) 5226 4632

DEPARTMENT OF HUMAN SERVICES

Environmental Unit
120 Spencer Street
MELBOURNE 3000
Tel: 9637 4153

DEPARTMENT OF PRIMARY INDUSTRIES

General queries to:
Customer Service Centre
136 186
www.nre.vic.gov.au/dpi/index

DEPARTMENT OF SUSTAINABILITY AND ENVIRONMENT

General queries to:
Customer Service Centre
136 186
www.nre.vic.gov.au/dse/

STANDARDS AUSTRALIA

9 – 25 Raglan Street
SOUTH MELBOURNE VIC
Tel: 1300 654 646

WORKCOVER

WorkCover Advisory Service:
(03) 9641 1444
www.workcover.vic.gov.au/

SELECTED REFERENCES

(This list is not exhaustive, representing only key literature for further reading or reference.)

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