WESTERN AUSTRALIAN GUIDELINES FOR

DIRECT LAND APPLICATION OF BIOSOLIDS AND BIOSOLIDS PRODUCTS

FEBRUARY 2002

This guideline has been produced as a working draft. Once the guideline has been in operation for a period of time (probably one year), the Biosolids Working Group, comprising members from the Department of Environmental Protection, the Department of Health and the Water & Rivers Commission, will seek comments from suppliers and users of biosolids, as well as from other interested parties, for possible revision of the guideline.

If you have any comments to make on this guideline, please forward them to the chair of the Biosolids Working Group. Written comments can be forwarded to:

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Cover Photo courtesy of Water Corporation

Biosolids Project Officer Nancy Penney stands with farmer Owen Cocking in a biosolids applied canola crop.

Department of Environmental Protection
Water and Rivers Commission
Department of Health

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1. INTRODUCTION

The objective of these guidelines is to provide guidance on acceptable practices for the beneficial reuse of biosolids on agricultural land, rehabilitation sites and forestry applications. These guidelines are based upon the National Water Quality Management Strategy *Draft Guidelines for Sewerage Systems Sludge (Biosolids) Management 2000* (published by ARMCANZ/ANZECC) but are adapted specifically to Western Australian conditions. These guidelines have been produced jointly by Department of Environmental Protection, the Department of Health and the Water & Rivers Commission, with consultation from key stakeholders.

The above agencies consider that biosolids can be viewed as a resource, and that there can be significant benefits to their reuse. Biosolids reuse is therefore encouraged in Western Australia as long as adequate procedures are put in place to minimise risks to public health and the environment.

These guidelines have been published as a working document. Key stakeholders have been consulted during their preparation and relevant comments from these organisations have been incorporated. The guidelines will be reviewed when the document has been in operation for a period of time (probably one year), and following final publication of the NWQMS Biosolids Management Guideline.

2. SCOPE OF THIS GUIDELINE

Biosolids are organic solids derived from municipal sewage and septage treatment processes. The term is generally used to refer to those solids that have been stabilised to enable beneficial reuse. These guidelines do not apply to sludges and organic solid wastes produced from other industries such as piggeries, feedlots, wineries, woolscourers and abattoirs, or to industries producing inorganic solid wastes, however they may contain information relevant to the reuse of such products (a definition for the term “biosolids” is provided on page 2).

This guideline applies to the reuse of biosolids in direct land applications only (the direct application of biosolids to large tracts of land). It does not specifically apply to the reuse of biosolids in compost, however many concepts within this document may be relevant to such applications. Australian Standard *AS 4454-1999 Compost, Soil Conditioners and Mulches* provides guidance for the application of biosolids products with low concentrations of bacteriological and chemical contaminants (eg: composted material containing biosolids).

This guideline has been developed for use by regulators, producers and users of biosolids. It proposes minimum criteria, procedures and approval processes that should be observed for direct application of biosolids in Western Australia.

Persons needing background information relating to the use of biosolids should also refer to the National Water Quality Management Strategy *Draft Guidelines for Sewerage Systems Sludge (Biosolids) Management 2000* and the New South Wales Environmental Protection Authority *Environmental Guidelines - Use and Disposal of Biosolids Products*.

3. LEGAL RESPONSIBILITY AND STATUTORY REQUIREMENTS

The procedures described in this guideline provide a means of minimising public health risks and environmental harm but will not absolve those responsible from their 'duty of care'. Compliance with these guidelines does not guarantee a defence against penalties in the event of pollution. It remains for both suppliers and end-users of biosolids to be aware of the requirements of relevant statutes and satisfy themselves that they have complied with all necessary safeguards and procedures.

4. DEFINITIONS

Biosolids – stabilised organic solids produced by treatment of sewage or septage that can be beneficially reused (ie: through appropriate management, land application of biosolids can be implemented to the benefit of all parties, and to the environment). It should be noted that other solid organic wastes (eg: animal manures, food processing wastes, woolscouring wastes) and solid inorganic wastes are NOT included under the definition of biosolids. The term "biosolids" does not generally include untreated human sewage and septage wastes, however for the purposes of this guideline they are considered as grade P4 biosolids (refer Table 7.2).

Biosolids Cake - stabilised organic solids that have been dewatered by mechanical or solar means to usually greater than 15% total solids.

Biosolids Products – composted or blended materials that include biosolids as a component.

Blends – A mix or dilution of biosolids with various other materials without further treatment.

Compost – A mix of biosolids and various other products that has been blended to induce heat from microbiological stabilization in the presence of air for a specific period while monitoring time and temperature. This is primarily done to break down organic matter into a more bioavailable form, but also has the effect of reducing pathogens.

Groundwater – All waters occurring below the land surface. For the purpose of this document, the depth to groundwater is that determined using the method described in Australian Standard 5667.11:1998, "Water Quality – Sampling (Part 11: Guidance on Sampling of Groundwaters)".

Leachate – Water discharged from a biosolids storage site, either by surface runoff or groundwater infiltration, that has been in contact with a stockpile and has therefore had the potential to be contaminated.

Lime Amended Sludge – sludge that has had sufficient lime added to destroy or inhibit regrowth of micro – organisms (including pathogens).

Pellets – small compressed balls or granular like product dried to greater than 90% total solids.

Sludge – any unstable concentrated solid or semi solid residue collected at the bottom of a water body. When the term is applied to sewage, sludge refers to solids that accumulate in wastewater treatment plants.

Stabilisation - the treatment of sewage sludge to reduce volume, pathogen levels and volatility of organic matter. Methods of stabilisation include anaerobic digestion, aerobic digestion, addition of chemicals and addition of heat.

Vectors – Insects and animals such as flies, mosquitos and rodents which are attracted to putrescible organic matter and which may spread pathogens. In Western Australia, one of the vectors of most concern is the stable fly.

Waterway - includes wetlands, lakes, creeks, streams, rivers and areas that may not have running water in them at the time, such as road ditches that drain into other waterways.

Wetland – as per the definition of wetland provided under the Ramsar convention, a wetland is an area of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including area of marine water the depth of which at low tide does not exceed six meters. The term may encompass riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands.

5. POTENTIAL BENEFITS OF BIOSOLIDS REUSE

Biosolids produced from Western Australian sewage treatment plants are currently being reused as organic humus and as a fertiliser substitute on selected agricultural properties, incorporated into commercial composts, and are being trialled for minesite rehabilitation and forestry applications.

The benefits of biosolids reuse include:

Soil improvement. In particular, biosolids can be used to build up organic matter in the sandy soils of the coastal plain, and in inland areas where topsoils have been eroded. The organic matter helps stabilise soils, improve water retention and reduce soil erosion.

As a complete or partial fertiliser substitute. Biosolids contain nutrients found in conventional fertilisers, including nitrogen, phosphorus and trace elements.

Alleviating the need to dispose of biosolids at landfill sites.

6. HEALTH, ENVIRONMENT AND ECONOMIC ISSUES

Poor management of biosolids could lead to harm to public health and to the environment.

Infection by microorganisms is a major risk from human contact with partly treated products derived from wastewater depending on the treatment process and source, biosolids may contain bacteria, viruses, helminths (such as hookworm), protozoa (such as Giardia) and fungi. There are a number of recognised exposure pathways including inhalation, ingestion (especially through hand to mouth contact) and contact with broken skin. Therefore all persons handling biosolids need to observe personal hygiene precautions (see Section 14 – Health and Safety Aspects).

Due to the diverse sources of wastewater, biosolids may also contain significant concentrations of chemical contaminants, including heavy metals and pesticides. Chemicals present in biosolids may become dissolved and move through soils. If biosolids are used for agricultural purposes this may allow chemicals to pass into the food chain, which could have both health and economic implications. As some chemical compounds may remain in the environment for long periods of time, the frequency of applications to one site needs to be managed to prevent contaminant levels being built up to harmful levels.

There are also environmental constraints that can limit the acceptability of biosolids application. Issues for consideration include the potential to pollute surface water and groundwater with nutrients or trace contaminants, the importation of exotic plant seeds and spores to sensitive areas and alteration of the pH of some soils, which may increase the mobility of some metals.

These guidelines provide information on acceptable uses of biosolids. They have been developed to facilitate responsible, beneficial reuse and minimise the risk of any adverse effects of biosolids application to human health, animal health and the environment.

7. CLASSIFICATION OF BIOSOLIDS

Biosolids are classified on the basis of the amount of chemical contaminants and pathogen indicators present in the product. This is based on analysis of representative samples of the product (procedures for this are explained in detail in Appendix 2). It is the responsibility of the biosolids producer to analyse representative samples of its product for classification prior to distribution.

The classification system involves two separate factors and is used to determine the permissible end uses for biosolids products. These are:

- Contaminant Grade - based on the concentration of chemical contaminants; and

- Pathogen Grade (also called Stabilisation Grade) - based on the levels of treatment to reduce pathogens, vector attraction (ability for the biosolids to attract insects such as flies and mosquitos) and odour.

7.1 Contaminant Grading

Contaminant grading of biosolids products is established by determining the "Biosolids Adjusted Contaminant Concentration" (BACC) for each contaminant in the product, and comparing these with the "Contaminant Acceptance Concentration Thresholds" listed in Table 7.1.

The Biosolids Adjusted Contaminant Concentration for a particular biosolids source is defined as:

$$BACC = m + s.d.$$

where m = mean concentration of a given contaminant calculated from all samples (including historical data)

s.d. = standard deviation of the mean concentration of a given contaminant calculated from all samples (including historical data)

For a single batch of biosolids from a “one-off” source, one sample per 100 dry tonnes (minimum of three samples) is required to calculate the BACC. If the biosolids are sourced from a treatment plant with a continuous monitoring program (minimum of 15 sampling results historically), this sampling requirement may be reduced to three samples to determine the mean for each batch, with all results, including all historical data being used to determine the standard deviation.

Each contaminant is graded C1, C2 or C3 using the Contaminant Acceptance Concentration Thresholds in Table 7.1. Biosolids achieving Grade C1 contaminant grade are the highest quality (lowest concentration of contaminants), while Grade C3 is the lowest quality (highest concentration of contaminants). The contaminant grade for a biosolids product is determined by the lowest grade for any one contaminant. For example, if most of the contaminant concentrations in a biosolids product passed Contaminant Grade C1, but one contaminant was Grade C2, then the entire product would be classified as Contaminant Grade C2. All biosolids products are assumed to be Contaminant Grade C3 until proven otherwise.

A contaminant grade may be improved by blending with other acceptable materials, such as composted green waste. The blended product must be re-sampled, analysed and re-graded to determine the new contaminant grade for classification purposes.

Table 7.1 : Biosolids Contaminant Acceptance Concentration Thresholds

Contaminant	Grade C1 (mg/kg)*	Grade C2 (mg/kg)*	Grade C3
Arsenic	20	60	untested or greater than grade C2
Cadmium	3	20	untested or greater than grade C2
Chromium (total)	100	500	untested or greater than grade C2
Copper	100	2500	untested or greater than grade C2
Lead	150	420	untested or greater than grade C2
Mercury	1	15	untested or greater than grade C2
Nickel	60	270	untested or greater than grade C2
Selenium	3	50	untested or greater than grade C2
Zinc	200	2500	untested or greater than grade C2
DDT/DDD/DDE	0.5 (total)	1 (total)	untested or greater than grade C2
Aldrin	0.02	0.5	untested or greater than grade C2
Dieldrin	0.02	0.5	untested or greater than grade C2
Chlordane	0.02	0.5	untested or greater than grade C2
Heptachlor	0.02	0.5	untested or greater than grade C2
HCB	0.02	0.5	untested or greater than grade C2
Lindane	0.02	0.5	untested or greater than grade C2
PHC	0.02	0.5	untested or greater than grade C2
PCB’s	0.3	0.5	untested or greater than grade C2

* All values in Table 7.1 are mg/kg dry weight.

7.2 Pathogen Grading (Stabilisation Grading)

Four pathogen grades are used – P1, P2, P3 and P4. This grading is dependent upon microbiological criteria as described in Table 7.2, and stockpiling of biosolids for no more than 30 days on -site. If biosolids are stockpiled for longer than 30 days then they should be resampled prior to application to ensure that they still meet the required criteria. Note that the types of treatment listed in Table 7.2 are not intended to be an exhaustive list. If biosolids are produced using different methods than those listed, the supplier should demonstrate that any proposed treatment method meets an equivalent pathogen standard in order to meet a particular pathogen grade for that product.

Table 7.2 : Pathogen Grading Requirements

Pathogen Grade	Maximum Pathogen Levels	Treatment Methods That Typically Achieve the Requisite Pathogen Levels*
Grade P1	Salmonella - less than 1 count per 50g of dry product. **AND** Thermo-tolerant Coliforms - less than 100 counts per gram of dry product.	Digested and then composted in a vessel, heated at >55°C for a 3 day period. OR Composted in a windrow, turned 5 times and maintained at >55 °C for a 15 day period. OR Maintained at a pH >12 for a 3 day period, heated at >53 °C for a 12 hour period, and dried to >50% solids. OR Heated to >80 °C and dried to >90% solids and the product kept dry until used. OR Digested and dried to solids >10% and then stored for >3 years.
Grade P2	Salmonella - less than 10 counts per 50g of dry product. **AND** Thermo-tolerant Coliforms - less than 1000 counts per gram of dry product.	Composted at >53 °C for a 5 day period. OR Composted at >55 °C for a 3 day period. OR Heated to 70 °C for 1 hour and then dried to >90% solids. OR Digested, heated to 70 °C for 1 hour and then dried to >75% solids. OR Aerobic thermophilic digestion (55-60 °C for a 10 day period), with a volatile solids reduction of >38% and total solids reduction of >50%.
Grade P3	Thermo-tolerant Coliforms- less than 2,000,000 counts per gram of dry product	Anaerobic digestion at 35 °C for 20 days with a volatile solids reduction of >38%. OR Anaerobic digestion at 15 °C for 60 days with a volatile solids reduction of >38%. OR Aerobic digestion at 20 °C for 40 days with a volatile solids reduction of >38%. OR Aerobic digestion at 15 °C for 60 days with a volatile solids reduction of >38%. OR Aerobic composting at >40 °C for 5 days, including a period of at least 4 hours at >55 °C.
Grade P4	Thermo-tolerant Coliforms greater than 2,000,000 counts per gram of dry product	Untreated or inadequately treated.

* The list of treatments described in Table 7.2 is not exhaustive, and is included as a guide for estimating the pathogen grade a particular batch of biosolids or biosolids products is likely to be.

7.3 Classification of Biosolids and End Uses

The contaminant and pathogen gradings of biosolids restrict the possible end uses for the product, as described in Table 7.3. For agricultural applications the minimum requirement is contaminant grade C2 and pathogen grade P3. The exception to this is the application to root crops, which require the more stringent pathogen grade P2.

Table 7.3 is for determining the potential end uses for both biosolids and biosolids products.

Table 7.3 - End Uses of Biosolids According to Classification

Biosolids Classification	Minimum Pathogen Grade	Minimum Contaminant Grade	Australian Standard Leaching Procedure
Unrestricted (suitable for public sale and distribution)	P1	C1	not applicable (n/a)
Urban landscaping (not household use)	P2	C2	n/a
Horticulture	P2	C2	n/a
Agricultural direct land application (root crops)	P2	C2	n/a
Agricultural direct land application (not root crops)	P3	C2	n/a
Forestry direct land application	P3	C2	n/a
Mine-site rehabilitation	P3	C2	n/a
Municipal landfill disposal	P4	C3	Pass
Secure landfill	P4	C3	n/a
Thermal processing (incineration, oil extraction, metal smelting or use in building products)	P4	C3	n/a

8. SITE SELECTION

A number of factors need to be considered when selecting appropriate sites for biosolids applications, as summarised in the following sections.

8.1 Soil Quality

An assessment of the soil quality prior to a restricted use biosolids application is required to ensure any biosolids application will not exceed acceptable contaminant levels in the soil. The total contaminants from the combined soil and applied biosolids may not exceed the maximum allowable soil contaminant concentrations listed in Table 8.1.

Table 8.1 : Maximum Allowable Soil Contaminant Concentrations following Biosolids Application

Contaminant	Maximum Allowable Soil Contaminant Concentration (mg/kg)*
Arsenic	20
Cadmium	1
Chromium (total)	100
Copper	100
Lead	150
Mercury	1
Nickel	60
Selenium	5
Zinc	200
DDT/DDD/DDE	0.5
Aldrin	0.02
Dieldrin	0.02
Chlordane	0.02
Heptachlor	0.02
HCB	0.02
Lindane	0.02
PHC	0.02
PCB's	0.3

* Maximum Allowable Soil Contaminant Concentrations are measured in mg/kg dry weight of soil and are mean concentration values.

The existing soil should be sampled in accordance with procedures set out in Appendix 3. The soil contaminant concentrations should be determined from the analysis of these soils. The results of the soil analysis are then used in the calculation of biosolids application rates. To calculate the available capacity of the existing soil to assimilate contaminants and also the Contaminant Limiting Biosolids Application Rate (CLBAR), see Section 12 on Beneficial Land Application and Appendix 4.

8.2 Soil Type

Four site vulnerability categories have been selected based on soil characteristics and nutrient risk to waters. Restrictions apply to highly permeable, very slowly permeable and water logged soils. These categories (see Table 8.2) describe the ability of the site to assimilate nutrients.

Table 8.2 is not intended to be exhaustive in terms of categorising every soil type found in Western Australia, but can be used as a guide to estimate the general suitability of a piece of land to be utilised for direct biosolids reuse. The Water & Rivers Commission can provide advice on the vulnerability category applying to a particular piece of land.

Table 8.2 : Soil Vulnerability Categories and Maximum Nutrient Loadings

Vulnerability Category	Soil Description	Maximum P Loading (kg/ha/yr)	Maximum N Loading (kg/ha/yr)
A	Coarse sandy soils/gravels draining to surface waters with moderate/high eutrophication risk	10	140
B	Coarse sandy soils/gravels draining to waters with low eutrophication risk	20	180
C	Loams/clay soils (Phosphorus Retention Index > 10) draining to waters with moderate/high eutrophication risk	50	300
D	Loams/clay soils (Phosphorus Retention Index > 10) draining to waters with low eutrophication risk	120	480

8.3 Soil pH

Biosolids should not be applied to sites with a soil pH less than 5.0 (based on the calcium chloride solution test) to minimise leaching of metals. Liming of soils may be used to provide buffer alkalinity in acidic soils.

8.4 Sensitive Land Areas and Water Resources

Sensitive areas where application of any category of biosolids is not compatible with protection objectives include:

Public Drinking Water Source Areas (PDWSA's) including Underground Water Pollution Control Areas, Water Reserves and Proclaimed Catchment Areas (location of these areas can be obtained from Water & Rivers Commission);

Other areas of environmental significance including relevant Environmental Protection Policy (EPP) areas, Conservation Category and RAMSAR wetlands, National Parks and Conservation Reserves (location of these areas can be obtained from the Water & Rivers Commission);

Areas subject to waterlogging or areas within the 1 in 20 year flood line (location of these areas can be obtained from the Water & Rivers Commission); and

Areas prone to nuisance insects (eg: stable fly), endemic diseases (eg: hookworm), and other issues of public health concern may be subject to certain restrictions and additional conditions of approval. Restrictions would be determined on a case-by-case basis by the Department of Health. Location of these areas can also be obtained from the Department of Health.

8.5 Depth to Groundwater

Leaching of nitrogen and phosphorus is a major concern relating to water resource contamination. The potential risk of contamination to groundwater depends on a number of factors, including the geology of the soil and the distance to the water table. To protect water quality, the Water & Rivers Commission has adopted the following criteria (see Table 8.3). They are based on the soil type, permeability and porosity. Table 8.3 should be interpreted such that for mixed soils the predominant soil type is the determinant, and for duplex soils, the surface strata is the determinant.

Table 8.3 : Depth to Water Table Restrictions

Strata	Depth to Groundwater		
	Unacceptable	**Acceptable**	**Desirable**
Clay	<1.5 metres	>1.5 metres	>2 metres
Sand	<2 metres	>2 metres	>5 metres
Laterite	< 3 metres	>3 metres	>5 metres
Sandy Limestone	<5 metres	>5 metres	>10 metres
Gravels & Hard Rock	---------- unsuitable ----------		
Karstic Limestone	---------- unsuitable ----------		

8.6 Buffer Distances

Buffers are used to reduce the potential impact of activities posing an environmental and health risk. Buffers are required for direct biosolids applications to land for a number of reasons including reduction of odour impacts and protection of sensitive water resources from contamination. Buffers are more effective if they are permanent, stable and covered with a mixture of grasses and native plants to limit the transfer of biosolids from the application area to neighbouring protected areas. Recommended buffer distances are provided in Table 8.4.

Table 8.4 : Minimum Buffer Distances for Direct Land Application of Biosolids

	Buffer Distance (metres)
Boundary of wetland vegetation around estuaries and lakes	400
Conservation wetlands (ie: RAMSAR or ANCA)	200
Drinking water supply bores	100
Agricultural, stock and domestic water supply bores	50
High water mark for agricultural dams reservoirs	100
Permanent creeks, streams rivers and other wetlands	100
Banks of intermittent flow water courses	50
Farm driveways, access roads and fencelines	5
Animal enclosures	50
Occupied dwellings on property where biosolids are applied	100
Occupied dwellings on other properties	500

8.7 Slope of Land

Run-off and seepage of nutrients can be a problem when applying biosolids to land. Surface runoff increases with greater slope and may cause soil erosion. Slope recommendations are provided in Table 8.5.

Table 8.5 : Recommended Slope Limitations for Direct Land Application of Biosolids

Slope (%)	Comment
0-3	Ideal : No concern for runoff or erosion
3-6	Acceptable : Slight risk of erosion
6-12	Acceptable if soil conservation practices are used to minimise erosion levels (eg: contour banking)
12-15	No application of biosolids unless the site is maintained in grass vegetation with at least 80% ground cover
>15	Unacceptable

8.8 Re-Application

Biosolids may contain traces of heavy metals and pesticide residues. The contaminant grading criteria for direct land applications ensures that the amounts of these contaminants is limited to an acceptable level, however repeated applications could result in their accumulation, and for the soil to eventually become contaminated. For this reason, it is important to test the soil to determine the level of contaminants existing in the soil prior to either initial or repeat applications, and reduce the application rate if required. The procedure is outlined in Appendix 4.

9. STORAGE OF BIOSOLIDS

Many of the potential environmental and health risks associated with land application of biosolids are related to storage prior to spreading. These risks include the potential for:

- flystrike in stockpiles;
- ground and surface water contamination;
- reduction of stockpile integrity;
- leaching of contaminants during heavy rainfall events and floods; and
- public and occupational health risks from uncontrolled access.

It is the responsibility of both the supplier and end-user of biosolids to ensure that these risks are considered when selecting and/or constructing a site for biosolids storage, and management of that site whilst product is stored there. Some premises may require a Department of Environmental Protection licence, which may contain conditions related to storage management. These conditions would be considered on a case by case basis. If the biosolids application is not of sufficient scale to require a licence, or if the licence does not contain specific storage conditions, this does not remove the responsibility of the biosolids supplier and end-user to minimise the environmental and health risks.

Factors that may influence the risk associated with biosolids storage include:

- The quantity to be stored;
- The biosolids quality;
- The proposed length of time to be stored;
- The time of the year stored;
- The site vulnerability (eg: nature of groundwater and surface water, slope of land, soil type, site vegetation).

Before determining the location of storage sites, or the type of storage required, a risk assessment should be performed for each site on which biosolids are to be stored, taking into account each of the above factors.

A number of management controls may be employed to minimise the risks associated with biosolids storage. Ideally, each of the management controls below would be employed for all storage sites. However, in practice where potential risks are low, some of these measures may not be necessary. Judgement needs to be employed to ascertain the appropriate controls for storage at each site.

9.1 Minimisation of Storage Time

Ideally, biosolids will be spread upon arrival at the agricultural property. If for whatever reason this is not possible, the period of time that biosolids are stored on site prior to spreading should be minimised. If storage time is to be longer than 30 days, then the following controls will almost certainly be required. Even where the storage time is less than 30 days, many of the following controls may still be appropriate. Advice about which factors are critical for a particular application may be obtained from the Department of Environmental Protection.

9.2 Fencing and Signage

Under no circumstances should biosolids be stored in locations where the public has ready access. The property owner must ensure that fencing is adequate around the premises to minimise the potential for unauthorised public access. In addition, the entry to the premises must be signposted, with signs that are weatherproof (e.g. metal or sturdy plastic) and easy to read. As a minimum requirement, the sign must state that biosolids are being stored and used on site, that contact with biosolids may be hazardous to human health, and that unauthorised access is not permitted.

The question of public access is particularly relevant when storing biosolids on-site for forestry applications. If the premises is not fenced, as may be the case with some large tree plantations, then road closures and signage restricting public access should be employed.

9.3 Drainage

Biosolids stockpiles should be managed so that stormwater is diverted away from the stockpile to minimise the potential for contaminant leaching. Ideally, the stockpile should be situated on flat, raised land. If this is not possible, then construction of drainage channels is appropriate.

9.4 Bunding

Bunds should be constructed around biosolids stockpiles, particularly if the material is to be stored for long periods of time, or if the land is sloped. Bunds serve a number of purposes – they ensure that the biosolids are contained within a specific area, they assist in keeping stormwater away from the stockpiles and they provide a physical barrier to assist in restricting access.

In most instances earthen bunding is sufficient. Culverts should be incorporated in the bund walls, particularly if material is to be stored for an extended period, to assist in drainage of the bund.

9.5 Lining

In most instances lining would not be required for biosolids stockpiles, as biosolids applications are not allowed in sensitive groundwater areas. However, it may be appropriate in situations where there is a risk of contaminating local groundwater (eg: a drinking water or stock bore is situated downstream).

9.6 Covering

Covering of stockpiles is appropriate in fly breeding season (usually summer) to minimise the risk of flystrike within the stockpile (see Section 10 Vector Control).

9.7 Monitoring

Biosolids stockpiles should be visually inspected on a regular basis to ensure the integrity of the stockpile itself, and/or the integrity of bunds and drainage channels.

Biosolids stockpiles should be monitored for flystrike on a weekly basis in summer, and regularly in winter. The inspection of biosolids samples is to be carried out by a person with entomology skills (see Section 10 Vector Control).

In the case where biosolids are to be stored for more than thirty days, they should be resampled prior to application to ensure compliance with the set criteria (see Section 7.2 Pathogen Grading).

Only rarely would monitoring be required for groundwater contamination as a result of biosolids stockpiling. Groundwater monitoring may be appropriate where drinking water bores exist downstream, or a sensitive groundwater resource is nearby.

9.8 Contingency Planning

This guideline adopts a risk management approach to biosolids storage. This means that risks are assessed and measures taken to minimise them where appropriate. However, it needs to be recognised that some risk, both to public health and to the environment, will remain.

It may be the case that during the course of storage on site, particularly for extended periods, circumstances change that will influence management of the stockpile. The plan for management of the stockpile, incorporating the control measures above, should be flexible to account for these changing circumstances.

For example, despite the implementation of appropriate vector control measures, flystrike may still be detected within a stockpile. In this case it may be necessary to spread the biosolids immediately.

In all cases, contingency planning needs to be conducted prior to receipt of biosolids from the supplier. This plan should include provisions to spread biosolids, or to remove biosolids from the property altogether, at short notice in an emergency situation.

10. VECTOR CONTROL

A "vector" is an animal that could potentially play a role in transmitting pathogens from biosolids to humans. Vectors could include flies, mosquitoes, fleas, rodents, birds or domestic animals.

Vector attraction reduction is necessary for any use of biosolids. It can be achieved through:

- reducing the moisture content of the biosolids;
- reducing the organic content of biosolids by either aerobic or anaerobic digestion;
- adding alkalis (eg: lime) and/or heating;
- composting; or
- incorporation or injection of biosolids into the soil.

These methods are recommended for use by the supplier when producing the biosolids, or by the user when storing them.

Vectors can also be controlled by reducing the potential for physical contact (eg: minimising the storage time, covering and bunding biosolids stockpiles). Methods proposed for this type of control need to be assessed on a case-by-case basis and are dependent on which vectors are being controlled, seasonal conditions and the type of cover materials used.

10.1 Stable Fly Control

Many of the vectors listed above are nuisances in their own right. Apart from potential of pathogen transfer from biosolids to humans, biosolids stockpiles may provide a substrate for pests to breed in. This is certainly the case for stable fly.

Stable flies (*Stomoxys calcitrans*) are of concern in many areas of the world, including Western Australia. Adult stable flies feed several times per day, and can inflict painful bites on cattle, horses, dogs, humans and other animals. Stable flies have reached epidemic proportions in a number of areas of Western Australia. However, stable flies are present in smaller numbers in other areas of the State, and are capable of flying large distances to potential breeding sites.

Biosolids storage and applications are not permitted in those localities with epidemic stable fly populations (currently the Shires of Gingin, Wanneroo and Kwinana) unless the following precautions have been undertaken. Similar precautions are advised for storage and application of biosolids in other areas:

- Primarily, all biosolids should be incorporated rapidly into the soil sub-surface. Rotary cultivation is considered one of the best control methods for all nuisance flies;
- Biosolids stored in stable fly endemic areas should be covered with a material to provide a physical barrier between the stockpile and fly populations. Each stockpile should be covered with one continuous sheet to eliminate loose overlapping edges where flies can enter;
- Stockpiles should be monitored on a weekly basis for stable fly larvae. A minimum of three subsamples from different parts of each stockpile should be collected each week for the purpose of this monitoring. The inspection of biosolids samples for fly breeding is to be carried out by an entomologist;
- If flystrike is detected in a biosolids stockpile, then provisions should be in place to enable the spreading of that stockpile within one day of detection. The Department of Health and relevant local government authority should be advised in the event of flystrike; and
- Biosolids storage should be avoided in stable fly endemic areas between the months of August and May unless the specific storage site has been constructed in a manner that can enable adequate protection from fly breeding.

11. ACTIVITY CONSTRAINTS FOLLOWING DIRECT LAND APPLICATION OF BIOSOLIDS

Because biosolids are derived from human waste, there is some potential for pathogens to be present. Where the biosolids are Pathogen Grade P2 or P3, it is required that various activities not take place on land treated with biosolids for a period of time after the application. Withholding periods for various activities are provided in Table 11.1.

Table 11.1: Withholding Periods Following Direct Land Application and Incorporation of Biosolids

Activity	Withholding Period
Human Food Crops	• For crops which may be eaten raw, and where harvested parts are close to the soil surface (eg: lettuce), planting should be delayed for 12 months after biosolids application and incorporation. For crops which may be eaten raw, and where harvested parts are below the soil surface (eg: carrots), planting should be delayed for 18 months after biosolids application and incorporation. In all other cases, the crop should not be harvested for 30 days after biosolids application/incorporation
Animal Feed and Fibre Crops	• Should not be harvested for 30 days after biosolids application/incorporation
Animal Withholding Periods	• Animals should not be grazed on the site for 30 days after biosolids application/incorporation • Lactating (including milk for human consumption) and new born animals should not be allowed to graze the site for 45 days after biosolids application/incorporation • Poultry and pigs should not be grazed on land which has been subject to previous biosolids application due to the feeding habits of these animals which results in high levels of ingested soil
Turf	• Turf grown on land to which biosolids have been directly applied should not be harvested for 1 year after biosolids application/incorporation

12. BENEFICIAL LAND APPLICATION

The application of biosolids is considered beneficial use when the application rate of nutrients in the biosolids is compatible with the nutrient requirements of the vegetation, crops or pasture growing on the land. Whenever biosolids application rates greatly exceed the nutrient requirement the application is not considered beneficial and has become land disposal. The topic of land disposal is not covered in this guideline.

The suitability of land for the application of biosolids is determined by the biosolids product classification and the site characteristics, in particular the site land use (ie: agricultural or non-agricultural).

The quality of the soil should be assessed prior to biosolids application. The soil contaminant concentrations should be determined from the analysis of soils at the proposed application site which have been sampled in accordance with Appendix 3. The results of the soil analysis are then used in the calculation of biosolids application rates.

12.1 Calculating the Biosolids Application Rate

Biosolids application rates are calculated to maximise nutrient availability for the crop in question without providing excess nutrients or other contaminants that may otherwise be leached into the environment.

The quantity of biosolids per hectare that can be applied directly to land is restricted by the Nitrogen Limited Biosolids Application Rate (NLBAR), the Phosphorus Limited Biosolids Application Rate (PLBAR) and the Contaminant Limited Biosolids Application Rate (CLBAR). The final maximum application rate will be limited by the lowest of these values. Details of how to calculate these values are provided in Appendix 4.

13. PHYSICAL APPLICATION OF BIOSOLIDS

All biosolids applied to land in a rural setting should be spread evenly and then incorporated into the topsoil within 36 hours. Very little, if any, biosolids should be visible on the surface after incorporation.

Biosolids applications in forests and timber plantations are the only applications exempt from compulsory incorporation within 36 hours. However, public access to the forestry biosolids application area should be restricted for a minimum period of 12 months after surface application.

Even spreading ensures maximum agronomic benefit, and reduces the risk of excess contaminants being applied to sections of the land. Incorporation reduces odour problems, vector attraction, nitrogen loss through volatilisation and surface run-off. Purpose built spreaders which give a predictable application rate should be used.

14. HEALTH AND SAFETY ASPECTS OF BIOSOLIDS HANDLING

Biosolids are sourced from human waste, and therefore may contain harmful pathogens. Biosolids of pathogen grade P2 quality, which may be used for direct land applications, are treated to reduce pathogen levels, however the microbiological criteria for such biosolids (less than 2 million thermo-tolerant coliform units) is still relatively high. In addition, it has been shown that regrowth of salmonella is possible in biosolids stockpiles. For these reasons it is essential that the following minimum health and safety precautions are followed when storing and handling biosolids:

- The length of time that biosolids are stockpiled on a property should be minimised;
- Publicly accessible biosolids stockpiles should be fenced and signposted;
- Children should not be allowed access to biosolids, either during storage or application;
- Persons handling biosolids should wash their hands and scrub their nails with soap before eating, drinking, smoking, and at the end of the working day;
- Cuts and skin abrasions should be covered with waterproof dressings;

- Food and drink should not be consumed, and smoking should not occur, when handling biosolids;
- Suitable clothing covering hair, body, arms and legs, and boots, should be worn. Clothing and boots should be thoroughly washed prior to being worn again;
- Readily accessible showering facilities should be available to all persons handling biosolids;
- Eye protection and dust masks should be worn when applying biosolids to protect against airborne dust. For the same reason, persons applying biosolids should remain upwind of the application process; and
- All persons required to handle biosolids should be made aware of these basic health and safety requirements.

15. TRANSPORTATION OF BIOSOLIDS

Grade P2 biosolids, suitable for direct land application, may trigger permitting requirements under the *Environmental Protection (Controlled Waste) Regulations 2001*. These Regulations provide a licensing system for the transport of designated controlled wastes. Further information about controlled waste permit requirements can be obtained from Department of Environmental Protection.

Biosolids products shall be transported and applied to land in ways that avoid public nuisance, particularly with respect to odour. Transport routes and site access shall be chosen to minimise public nuisance.

To minimise the risk of spillage, biosolids should have a solids content of 15% or greater. Vehicles used to transport such biosolids products should:

- be fitted with grain locks;
- have water-tight seals on rear tailgates; and
- have the load covered with a waterproof cover (eg: tarpaulin).

Transport vehicles should not be used for backloading foodstuffs for animal or human consumption.

Truck tailgates and tyres should be cleaned prior to leaving the sewage treatment plant and the application site to ensure that biosolids are not spilt on roadways. All transport vehicles should be disinfected before being used for any other purpose, including the carting of soil mixes or composts.

16. INCIDENT MANAGEMENT PLANS

An incident management plan for application of Grade P2 (microbiological criteria) or Grade C2 (chemical criteria) biosolids, or lesser grades, should be developed to ensure rapid clean up of spills both en route and at the end-use site. The incident management plan should also incorporate a response to unexpected storage incidents such as flooding of a stockpile area or flystrike within a stockpile. It is important that the local government authority in the area of the application operation has input into the incident management plan. The local government authority, the Department of Health and Department of Environmental Protection should be informed in the event of a spill. A dry clean-up for spills is recommended.

17. PROCEDURE FOR GAINING GOVERNMENTAL APPROVAL

All direct land biosolids applications require approval from the Department of Health. Information required to assess such applications includes, but is not limited to:

- the site owner's name and contact details;
- the site address;
- the proposed use of biosolids;
- the source and classification of biosolids, and the basis for that classification (eg: provision of batch sample results and details of treatment process);
- a plan of application areas (the plan should show locations of any watercourses and biosolids stockpile sites);
- the total area to be treated;
- a description of the site, identifying any restrictions as per section 8;
- provision of actual distances between the application site and houses and bores;
- the proposed dates of delivery of biosolids to the property, application of biosolids, and the method of application;
- the proposed application rate, and the calculations used to derive it;
- a contingency plan in case the removal or reassignment of biosolids is required;
- confirmation that the land owner has been advised of the health and safety issues associated with the use of biosolids and is aware of the application restrictions, buffer zones and holding periods to be observed; and
- confirmation that the application will be performed in accordance with the requirements of this guideline.

Some activities associated with direct land application of biosolids also require approval from the Department of Environmental Protection. Where 1000 or more wet tonnes of biosolids is proposed to be applied to a property via direct land application in any 12 month period, then that property is defined as a solid waste facility under the *Environmental Protection Regulations 1987*, and requires a licence from the Department of Environmental Protection.

This licence is valid for 12 months and would contain conditions related to the storage and application of biosolids.

Licence application packages, including information required for such an application are available from the Department of Environmental Protection.

In addition to the above requirements, local Government authorities may have specific local restrictions on biosolids applications. Discussions with and approval from the relevant local authority should be obtained prior to application.

In all cases, application of biosolids should be conducted in accordance with the recommendations contained within this guideline, unless they conflict with site-specific requirements imposed by any regulatory agency.

A process flowchart describing the biosolids application and approval process in contained in Appendix 1.

18. RECORD KEEPING AND MONITORING

The supplier of biosolids is expected to maintain accurate records of the quality and quantity of biosolids supplied, the date of supply, and the location of properties supplied.

The end-user of biosolids is expected to maintain accurate records of the dates of spreading and of subsequent uses of land for a period of one year after spreading. The end-user should also note any difficulties with the application, and inform the supplier as soon as practicable.

Depending upon the location of the application site, it is possible that the regulatory agencies may request monitoring to be performed at the site for a specified period after application to ensure that such application is not having adverse effects on human health or the local environment. Such monitoring may be included in Department of Environmental Protection licence conditions or Department of Health approval conditions for the premises.

19. RESPONSIBILITIES

It is the responsibility of regulatory agencies to ensure that:

- the benefits of direct land applications of biosolids outweigh the potential adverse health or environmental effects;
- compliance with relevant legislation is maintained.

It is the responsibility of the supplier to:

- conduct sampling of its biosolids product;
- ensure that biosolids are provided for purposes in keeping with the recommendations of this guideline;

- screen potential clients to ensure that they are in areas where direct land application of biosolids is suitable;

- make potential clients aware of their responsibilities, and to provide them with sufficient knowledge to conduct the application in such a way that risks to public health and the environment are minimised.

It is the responsibility of the end-user to:

- obtain approval from the relevant regulatory agency to apply biosolids;

- store, apply and monitor the biosolids application in accordance with conditions set by any regulatory agency and with the recommendations of this guideline;

- provide appropriate signage; and

- notify adjacent land-holders of storage and application of biosolids on-site.

20. FURTHER INFORMATION

Please contact one of the following organisations for further information about direct land application of biosolids, or to make comments about these guidelines.

Department of Environmental Protection
Environmental Regulation Division
ph : (08) 9222 7104
fax : (08) 9222 7099

Department of Health of Western Australia
Environmental Health Service
ph : (08) 9388 4999
fax : (08) 9388 4910

Water & Rivers Commission
Resource Management Division
ph : (08) 9278 0300
fax : (08) 9278 0585

21. REFERENCES

Australian Standard AS 4454-1999. Compost, Soil Conditioners and Mulches.

Biosolids – Application to Land, Draft Water Quality Protection Note, Western Australian Water and Rivers Commission, 1999.

Draft Environmental Guidelines for Biosolids Management, Victorian Environment Protection Authority, Government of Victoria, 2000.

Draft Guidelines for Sewerage Systems – Sludge (Biosolids) Management, National Water Quality Management Strategy, ARMCANZ/ANZECC, 1997.

Draft Guidelines for Sewerage Systems – Sludge (Biosolids) Management, National Water Quality Management Strategy, ARMCANZ/ANZECC, 2000.

Effluent and Biosolids Reuse and Disposal, Procedures Manual, Western Australian Water Corporation, 1998.

Environmental Management Guidelines – Use and Disposal of Biosolids Products, New South Wales Environment Protection Authority, October 1997.

Environmental Protection Act (WA) 1986 (as amended)

Guidelines for Sewerage Systems – Biosolids Management, ARMCANZ, Occasional Paper Water Technology Committee No. 1/95, October 1995.

Health Act (WA) 1911 (as amended)

Land Application of Sewage Biosolids for Crop Production Factsheet, Ontario Ministry of Agriculture, Food and Rural Affairs, 1996.

Microbial Health Hazards Associated with the Land Application of Biosolids, J. Sidhu, 2000.

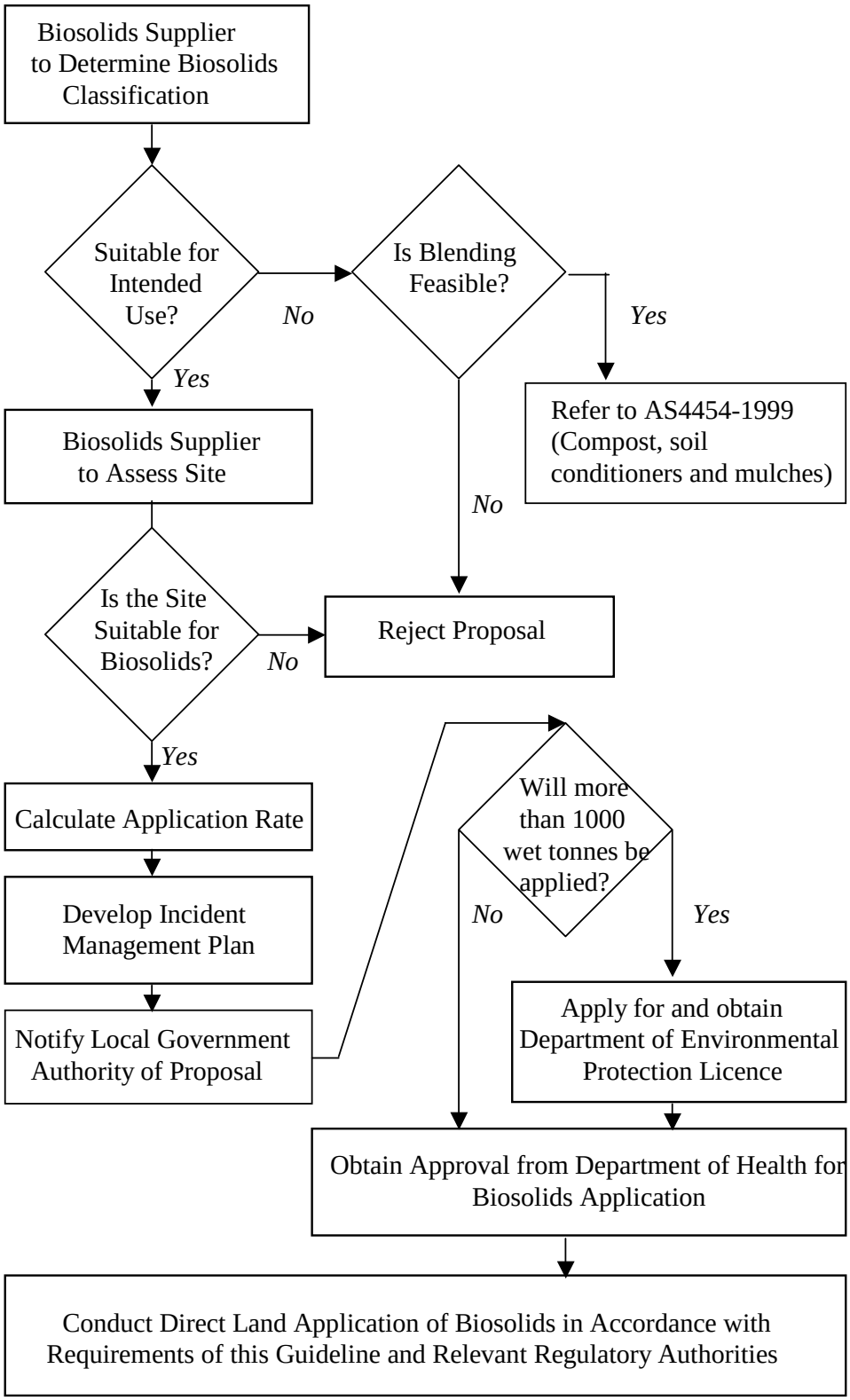
Nowergup Site – Fly Breeding in Biosolids Covered versus Uncovered, Western Australian Water Corporation, 2000.

Part 503 – Standards for the Use or Disposal of Sewage Sludge, US Environmental Protection Agency, 1993.

South Australian Biosolids Guidelines for the Safe Handling, Reuse or Disposal of Biosolids, Environment Protection Authority, South Australian Department of Environment and Natural Resources, December 1996.

Tasmanian Biosolids Reuse Guidelines, Tasmanian Department of Primary Industries, Water and Environment, August 1999.

APPENDIX 1: PROCESS FLOWCHART DIRECT BIOSOLIDS APPLICATIONS TO LAND



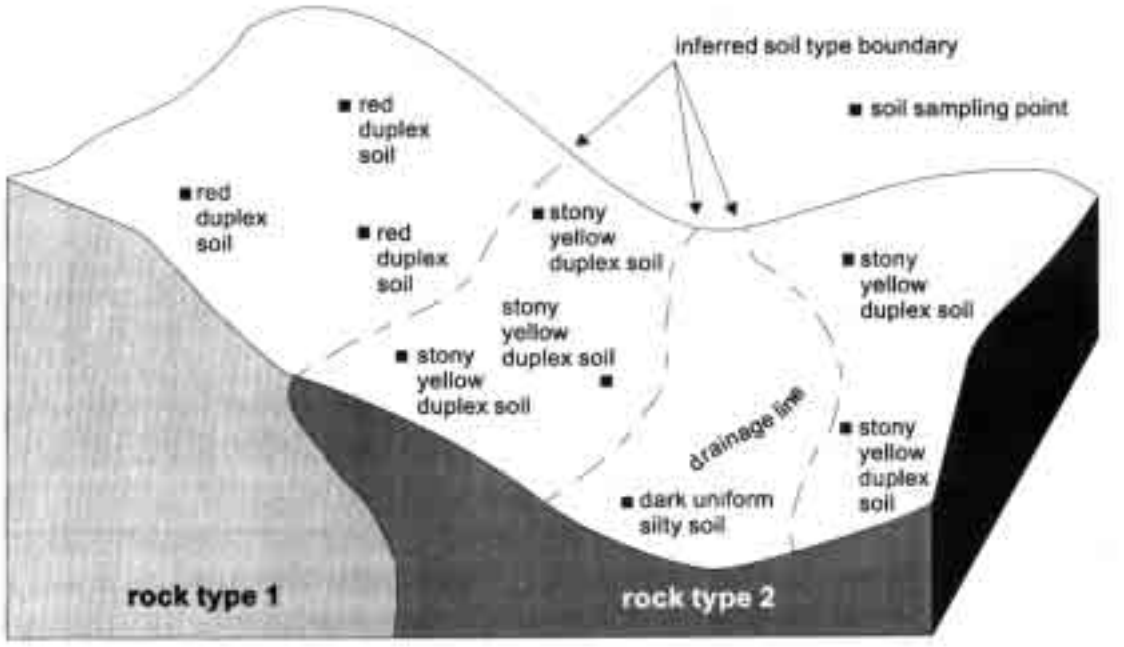
APPENDIX 2: SOIL SAMPLING PROCEDURES

This appendix sets out the procedure of sampling land for direct biosolids applications, and is a modified version of Schedule 3 of the Environmental Guidelines for the Use and Disposal of Biosolids Products (NSW EPA 1997).

Agriculture and Forestry Biosolids Applications

Sites should be sampled using an unbiased sampling pattern such as a rectangular or triangular grid. Sites should be not more than 250 metres apart. The grid may start at a convenient location with the proposed application site. For a 20 hectare site this strategy will require a minimum of four soil profiles, and for sites less than 10 hectares at least two soil profiles should be sampled. Soils should be sampled to at least 90 cm. The depths for sampling should be 0-15 cm, 15-30 cm and 60-90 cm. If less than 5 dry tonnes of biosolids per hectare are to be applied then only the topsoil samples (0-15 cm) require sampling.

Once the sites have been sampled and described, a soil type map of the site should be prepared using topographical and geological information to infer boundaries, as shown in the diagram below.



Soil type should be determined on the basis of a recognised soil classification system. The areas considered suitable for biosolids application based on the site characteristics criteria in tables 8.2 and 8.5 should be identified. All surface and soil profile samples in suitable areas that fall into one soil-type should be combined or bulked together at each sampling depth and tested for the contaminants contained in Table 8.1, as well as total nitrogen, total phosphorus and available phosphorus.

Where metal concentrations are close to the maximum allowable soil contaminant concentrations shown in Table 8.1, the area should be re-sampled more intensively before biosolids application, and more than one composite should be taken for each soil map unit. If, after the second sampling, the composite samples from the same map class show similar results to the first sampling, it is likely that the sampling strategy is adequate. However, where composites from the same map class are very different, then the sampling strategy should be reviewed.

Avoid sampling any unusual zones such as old or present fence lines, dung patches, spots where piles of timber have been burnt, trash heaps, places where fertilisers have been stacked or spilled, swampy areas and soil near roads or buildings.

This sampling should involve approximately one day's field work per 50 hectares for an experienced land assessor and field assistant.

Minesite Rehabilitation Biosolids Applications

The sampling of sedimentary rock material covering coal seams or mineral veins areas ("overburden" areas) on open cut coal mines should be conducted by obtaining one composite sample (20-40 topsoil subsamples) for every 10 hectares. The overburden area should be sampled and tested for the metals contained in Table 8.1 before topsoil spreading. Where topsoil is being used on the overburden area, the topsoil layer should be sampled and tested in the same manner. Testing of organic compounds in required in the topsoil but not in the overburden material.

The application of biosolids on reject materials from flotation and similar processes, tailings dams or spoil materials from metalliferous dams may require more intensive sampling die to the possible different composition of these sites. More intensive sampling is also required where metal concentrations are close to the maximum allowable contaminant concentrations in Table 8.1. The Water & Rivers Commission can provide advice regarding a suitable soil sampling strategy for these areas.

The composite sample should weigh less than 1 kg. If it is much greater, reduce it by

- mixing the sample thoroughly on a flat sheet, removing large stones;
- heaping into a mound and carefully dividing the heap into four with a piece of board;
- discarding two diagonally opposite quarters, retaining and thoroughly mixing the other two;
- repeating the procedure until the sample is less than 1 kg.

APPENDIX 3: BIOSOLIDS SAMPLING PROCEDURES

This appendix sets out the procedure of sampling biosolids, and is a modified version of Section 5 of the Tasmanian Biosolids Reuse Guidelines (Dept of Primary Industries, Water and Environment 1999).

Sampling Requirements – Contaminant Grading

There are a total of 18 contaminants (9 heavy metals and 9 organic pollutants) which need to be monitored to ensure biosolids quality is suitable for reuse. However, very few sewage treatment plants ever show unacceptable levels for more than a few of the contaminants.

An initial screening analysis prior to the implementation of reuse operations can reduce the ongoing costs of chemical analyses. For treatment processes which produce biosolids regularly (ie: all except lagoon systems), samples should be taken monthly for 3 months and analysed for the full list of contaminants (Table 7.1) as part of a screening analysis. Any contaminant which is present at less than 50% of the Contaminant Acceptance Concentration Threshold (Table 7.1) for the target end use of the biosolids can be dropped from future sampling procedures, with the proviso that a full screening is repeated:

- at yearly intervals; and
- when there is reason to suspect a change in the composition of the influent to the sewage treatment plant, such as might occur with the connection of new industries to the sewer.

Having established if there is opportunity to reduce the analysis requirements for contaminants, the frequency of sampling for contaminant grading depends on the production rate.

For plants producing biosolids continuously (such as large metropolitan plants) one sample should be collected for each 100 dry tonnes produced, except at the following times, when one sample should be collected for each 50 dry tonnes produced:

- at the start of a sampling program, when a minimum of 12 analyses is required to improve the confidence of the initial contaminant grading and to provide baseline data for future comparisons. The first 3 screening samples can be used as the start of this database. All analytical data should be added to the database, as this improves the reliability of the contaminant grading and also helps to identify changes in contaminant concentrations over time;
- if the actual concentration of any of the monitored contaminants in a sample is greater than 0.8 of the Contaminant Acceptance Concentration Thresholds (Table 7.1). In this case, the higher sampling frequency should be used until there are at least three consecutive samples in which the actual concentrations of all monitored contaminants are less than 0.8 of the Contaminant Acceptable Concentration Thresholds; or
- if there is reason to believe that the contaminant concentrations in the biosolids is variable during a particular period of time.

For biosolids sourced from pond based sewage treatment plants, one sub-sample per 100 dry tonnes, (minimum of two sub-samples) should be collected, and combined to form a single composite. Samples may be collected at any time prior to application.

Sampling Requirements – Pathogen Grading

Initial pathogen grading of biosolids can be estimated based upon the method of treatment, however samples should be collected prior to stockpiling to verify that the pathogen limits are met.

For biosolids stockpiled for longer than 30 days, samples should be collected both prior to stockpiling and prior to the actual application. This is required because evidence suggests that regrowth of some pathogens, such as salmonella, can occur in biosolids stockpiles.

A minimum of three sub-samples from each biosolids stockpile should be collected to vary the pathogen grading.

APPENDIX 4: DETERMINATION OF APPLICATION RATES

This appendix explains procedures for determining biosolids application rates, and is a modified version of Appendix B of the Tasmanian Biosolids Reuse Guidelines (Dept of Primary Industries, Water and Environment 1999).

Limitations to Application Rate

The nitrogen, phosphorus and contaminant analysis data of the biosolids and the soil are used to calculate the maximum allowable biosolids application rate for a given site. The maximum allowable application rate is the lower rate of the Nitrogen Limited Biosolids Application Rate (NLBAR), the Phosphorus Limited Biosolids Application Rate (PLBAR) and the Contaminant Limited Biosolids Application Rate (CLBAR).

The NLBAR and PLBAR are the rates at which biosolids can be applied without exceeding the annual nutrient requirements of the crop or vegetation grown on the land. The CLBAR is the rate at which biosolids can be applied without exceeding the maximum allowable concentration of contaminants in the soil.

Nitrogen Limited Biosolids Application Rate (NLBAR)

Because part of the nitrogen in biosolids is in organic form, it is not readily available for plant use immediately after application. The available nitrogen content of the biosolids includes the soluble nitrogen (nitrate/nitrite), ammonium nitrogen and a fraction of the organic content of the biosolids. The fraction of the organic content available will depend on the mineralisation rate in the year following application. There are a number of ways of calculating the amount of nitrogen available from biosolids, of which the following is one:

Available Nitrogen (Year 1) = ammonia N + 0.15(Total Kjeldahl N – Ammonia N)

For agricultural applications the NLBAR, in dry solid tonnes per hectare, is based on the crop requirements and the available nitrogen content of the biosolids in the soil. The higher the available nitrogen in the soil, the lower the NLBAR.

NLBAR (t/ha) = Crop Requirement (kg/ha) / Available Nitrogen (kg/t)

Phosphorus Limited Biosolids Application Rate (PLBAR)

For the purposes of calculating the PLBAR, all of the phosphorus present in biosolids is assumed to be readily available to plant use immediately after application, and also to be leachable through the soil profile. The PLBAR is therefore:

PLBAR (t/ha) = Crop Requirement (kg/ha) / Phosphorus (kg/t)

Both of the above assumptions appear overly conservative in practice, as some phosphorus is likely to be not readily available, and the soil on which biosolids are spread is likely to have some phosphorus retention capacity. This equation is accordingly under review.

Typical Crop Nutrient Requirements

For agricultural applications the NLBAR and PLBAR will vary on the crop and site history. The following table contains indicative nitrogen and phosphorus requirements for various crops, but should be used only as a guide. For example, grazing pastures have little need for nitrogen, but applications of up to 100 kg/ha of N can be useful in certain circumstances. The nutrient requirements of a crop or pasture are dependent upon management practices, soil and climate, and advice should be sought from an agronomist to determine the specific requirements for a given site.

Crop or Pasture	Nitrogen (kg/ha)	Phosphorus (kg/ha)
Wheat, barley, oats	50	9
Beans, poppies	60	21
Canola	70	12
Broccoli, cabbage, cauliflower	150	52
Carrots	80	35
Dairy pasture	0	18
Extensive grazing pasture	0	5
Onions	80	28
Peas	20	10
Potatoes	200	87

Nutrient requirements for forestry and land rehabilitation applications should be considered on a site specific risk management basis.

Contaminant Limited Biosolids Application Rate (CLBAR)

The CLBAR is the rate, in dry solid tonnes per hectare, which will cause the concentration of the limiting contaminant to reach the Maximum Allowable Soil Contaminant Concentration (Table 7.1) after application is completed.

The CLBAR for a particular biosolids product at a particular site is determined by calculating the CLBAR for each contaminant using the following equation:

$$CLBAR = \frac{(MASCC - ASCC)}{BACC} \times SM$$

where:

CLBAR = Contaminant Limited Biosolids Application Rate (dry tonnes/ha)
MASCC = Maximum Allowable Soil Contaminant Concentration (mg/kg)
ASCC = Actual Soil Contaminant Concentration (mg/kg) obtained from soil samples
BACC = Biosolids Adjusted Contaminant Concentration (see section 7.1)
SM = Incorporated Soil Mass per hectare (dry tonnes/ha)

The CLBAR for each individual contaminant can be compared by undertaking calculations in a tabulated format. The contaminant with the lowest CLBAR is the limiting contaminant, and its CLBAR is the maximum application rate permitted.

It would be unusual for typical sewage plant biosolids to be limited by contaminants other than nutrients. In most instances in Western Australia the limiting factor will be the PLBAR, although overlooking this limiting factor may be appropriate, especially where the application is being performed on a soil with high phosphorus retention capacity.

APPENDIX 5: SAMPLE BIOSOLIDS INDUCTION CHECKLIST

This sample checklist has been derived from a Water Corporation document "Biosolids Application Introduction Checklist". It may provide the basis of a contract between the supplier and user of biosolids to demonstrate that the supplier has taken all reasonable care to ensure that the user is aware of the nature of, and hazards associated with biosolids, and the precautions required to ensure that the application does not result in unacceptable risks to either public health or the environment. The document should be signed by both parties.

SAMPLE CHECKLIST ONLY

1. I am aware of the nature of biosolids, in accordance with the definition provided in the Guidelines for Direct Land Application of Biosolids and Biosolids Products (September 2001)
2. I possess a copy of the Guidelines for Direct Land Application of Biosolids and Biosolids Products (September 2001), and will follow the application requirements contained within that document.
3. Biosolids supplied to me will not be used for any purpose other than that which have been approved by relevant regulatory agencies.
4. I am aware that all biosolids contain some levels of pathogens. The major risk through human contact is derived from viruses which can survive for prolonged periods in moist conditions.
5. I am aware of the personal protection requirements described in the document "Occupational Hygiene and Safe Handling of Biosolids" (see appendix 6).
6. I will follow all application requirements relevant to me as set by relevant regulatory agencies.
7. I will not allow stock in areas where biosolids are stockpiled unless the area has been fenced.
8. I am aware that stock is not permitted to enter areas where biosolids have been applied for a period of 1 month (45 days for lactating and newborn animals).
9. I am aware that the withholding period for crop harvesting is 1 month from completion of the biosolids application (12 months for crops which may be eaten raw and where harvested parts are close to the soil surface, 18 months for root crops).

APPENDIX 6: OCCUPATIONAL HYGIENE AND SAFE HANDLING OF BIOSOLIDS

This appendix is derived from a Water Corporation document of the same name.

Health Hazard Information

Acute Effects

- **Eyes**: contact with eyes may cause infection.
- **Skin**: breaks in the skin will increase the risk of infection.
- **Inhaled**: Workers handling dry biosolids to land may risk infection from inhaled dust. There is a risk of inhaling fungal spores when working with dried biosolids. In certain situations sewage gases may be present.
- **Swallowing**: Ingestion is generally the major route of infection. Touching the mouth with the hands will increase the possibility of infection. Eating or smoking before washing hands will increase the risk of infection. Best practice is to never touch yourself above the neck whenever you are in contact with biosolids.

Other Health Effects

While most health effects studies suggest that infections from specific biological agents are not common, all personnel should take a conservative approach and presume that biological hazards exist within facilities where biosolids are processed and reused. Studies have indicated that new workers in their first few years of employment have experienced increased rates of gastrointestinal or upper respiratory illnesses.

Chronic Effects

- Extrinsic allergic alveolitis may be a chronic manifestation of repeated exposure to dust.
- Infective diseases are generally of short duration and successfully treated with antibiotics.

Safe Handling Information

- **Storage and Transport**: keep biosolids moist to prevent dust formation. Transport in covered trucks. Drivers should be trained on safe handling procedures.
- **Reactivity Data**: no data.
- **Fire/Explosion Hazard**: burning biosolids may produce carbon monoxide and ammonia gas.

Precautions for Use

- **Exposure Standards**: biosolids are complex mixtures. Health hazards may exist for specific components.
- **Engineering Controls**: fungal spores may be present in dried biosolids. Breaking the surface of dried biosolids should be avoided to reduce the potential for release of spores becoming airborne and posing an inhalation risk to workers and the surrounding population. Keeping biosolids moist will prevent release of spores.
- **Flammability**: biosolids can release both toxic and flammable gases. Ventilation is required to prevent build-up of vapours and gases. Avoid ignition sources where flammable gas concentrations could reach hazardous levels.

Personal Protection: Sound workplace and personal hygiene practices should be adopted.

- Hands should be washed and nails scrubbed well with soap after contact with biosolids before eating, drinking, smoking, going to the toilet, and at the end of work.
- Cuts and abrasions should be covered with waterproof dressings.
- A suitable change of clothes should be worn during work. Footwear and gloves are required to protect against injury from sharp objects. Discard torn gloves. Eye protection should be worn to protect against dust.
- Wear masks if biosolids are extremely dry. Workers should be upwind of the application process.
- Wherever possible separately launder and store work clothes.
- Clean soiled work tools after use.