

# Guidelines for Using Compost in Land Rehabilitation and Catchment Management



NSW DEPARTMENT OF  
**PRIMARY INDUSTRIES**

Department of **Environment & Climate Change** NSW



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In April 2007, the name of the Department of Environment and Conservation (NSW) changed to the Department of Environment and Climate Change NSW.

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# OVERVIEW OF THE GUIDELINES

## Objectives

The objectives of these guidelines are to provide stakeholders involved in land rehabilitation and catchment management with a practical framework for promoting and implementing the use of composted mulches and soil conditioners, whilst minimising any potential risks associated with them. This is achieved by drawing upon the outcomes of scientific research experiments and large scale demonstration trials conducted as part of partnership projects which have been undertaken between the Department of Environment and Climate Change NSW (DECC), the NSW Department of Primary Industries (NSW DPI), the Hawkesbury Nepean Catchment Management Authority (HNCMA) and Compost NSW.

## Scope

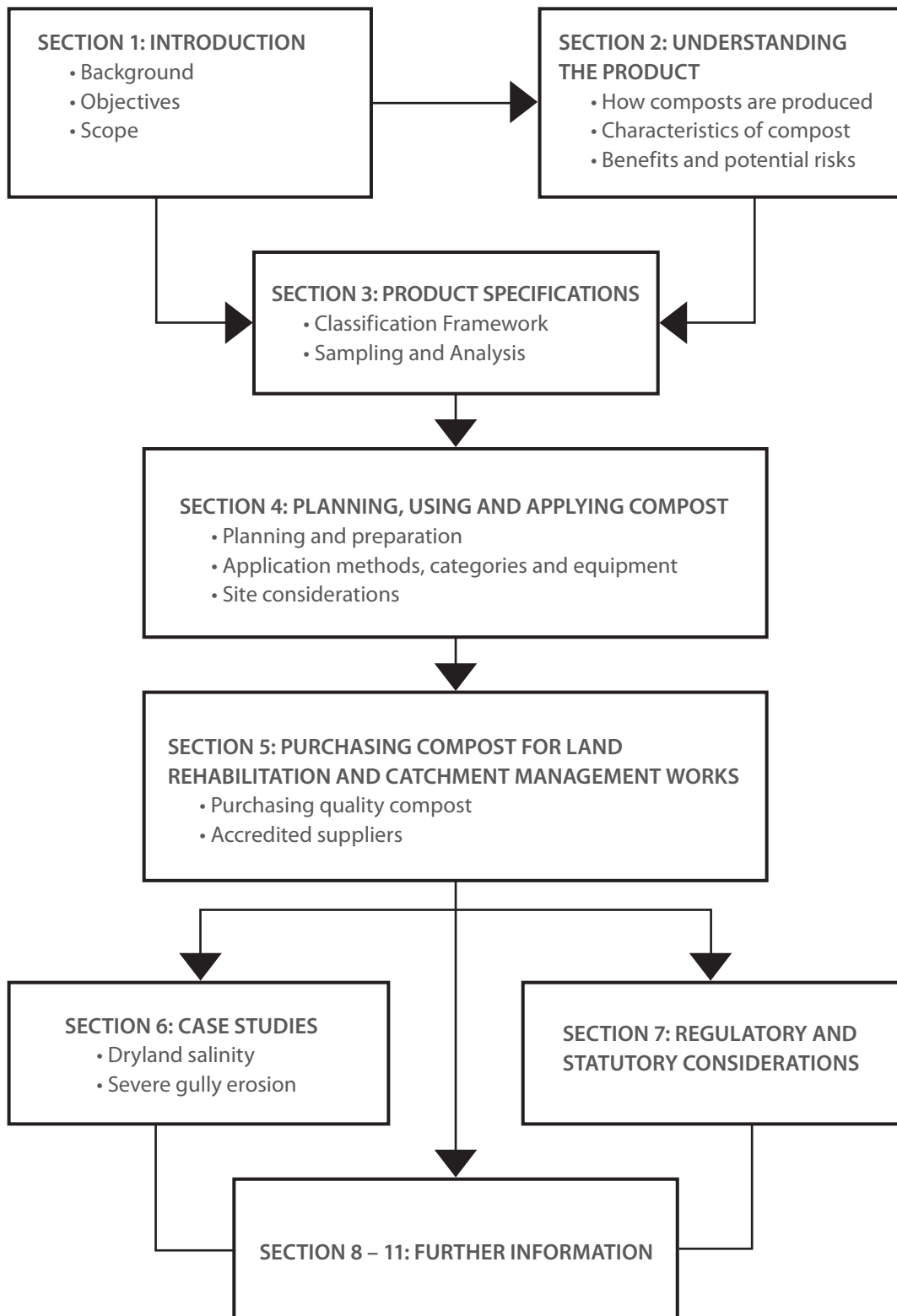
The guidelines are non-statutory and are intended to promote best management practices with respect to applying composted soil conditioners and mulches prepared from garden organics in catchment and land rehabilitation projects. These guidelines are aimed at people and organisations involved with catchment management and land rehabilitation projects, which address:

- Gully erosion (including gully head advancement and sidewall collapse)
- Erosion and sediment control works
- Hillslope erosion
- Saline discharge areas
- Degraded soil environments
- Other relevant catchment works.

## Framework

The guidelines are designed to assist potential users work through the issues that need to be taken into account when considering using composts in catchment management and land rehabilitation. These include: specifying the type and quality of product; understanding the benefits and potential risks; application methods and depths; site considerations; and purchasing the products. Case studies from HNCMA are also included to provide users with examples of how composts have been used to rehabilitate degraded catchments. Sections covering regulatory requirements, references, contact details and links are also provided for users of the guidelines who may require further information. The framework developed for the guidelines is summarised in Figure 1.

Figure 1. Summary of the framework developed for using composts in catchment management and land rehabilitation.



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# 1 INTRODUCTION

## 1.1 Background

Catchment health is important from many social, economic and environmental perspectives. However, land degradation and soil erosion arising from various activities have reduced water quality in rivers, streams and tributaries, as well as catchment health. For example, it is estimated that approximately 11% of the Sydney Catchment is affected by high or very high sheet and rill erosion (DEC, 2005). Consequently, Catchment Management Authorities (CMAs), through Catchment Action Plans, have set specific targets to improve soil and land condition in their respective catchments. For example, the Hawkesbury Nepean CMA aims to reduce the area of land severely affected by erosion by 15% (30,000ha) by 2016 (HNCMA, 2005).

Metropolitan areas generate significant quantities of organic material, which often ends up in landfills. Many landfills are approaching capacity, with limited opportunities to establish new ones within close proximity to metropolitan areas, due to community resistance and/or physical limitations of sites. Consequently, NSW Government policies are placing an increasing emphasis on beneficially reusing the resources contained in garden organics generated in metropolitan areas (Resource NSW, 2003). An example of this is collecting and composting grass clippings, leaves and prunings from residential areas to produce mulches and soil conditioners for urban, agricultural and environmental applications. The nutrients and organic matter in these composted garden organics have the potential to improve plant growth, soil structure and water holding capacity, as well as suppress weeds and diseases.

The Department of Environment and Climate Change NSW (DECC), the NSW Department of Primary Industries (DPI) and the Hawkesbury Nepean Catchment Management Authority (HNCMA) have been working on a joint partnership project aimed at assessing the potential to use composts to improve land condition in the Hawkesbury Nepean catchment. This research (Wong *et al.*, 2005; Dorahy *et al.*, 2006) has demonstrated the potential for composted mulches and soil conditioners to reduce runoff and erosion from degraded catchments, contributing to improved environmental outcomes by beneficially reusing recovered resources to solve issues that impact upon catchment health.

## 1.2 Objectives of the guidelines

The objectives of these guidelines are to provide stakeholders involved in land rehabilitation and catchment management with a practical framework for promoting and implementing the use of composted mulches and soil conditioners, whilst minimising any potential risks associated with them. This is achieved by drawing upon the outcomes of scientific research experiments and large scale demonstration trials conducted as part of the DECC, DPI and HNCMA partnership projects.

## 1.3 Scope of the guidelines

The guidelines are non-statutory and are intended to promote best management practices with respect to applying composted soil conditioners and mulches prepared from garden organics in catchment and land rehabilitation projects, as defined in Table 1.

**Table 1. Definition of composted mulches and soil conditioners adopted in these guidelines (Standards Australia, 2003a)**

Composted mulch	Any pasteurised product, which has undergone composting for not less than 6 weeks (excluding polymers, which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Composted mulch has at least 70% by mass of its particles with a maximum size of greater than 16 mm.
Composted soil conditioners	Any composted product, including vermicast, manure and mushroom substrate that is suitable for adding to soils. This term also includes 'soil amendment', 'soil additive', 'soil improver' and similar terms, but excludes polymers, which do not biodegrade, such as plastics, rubber and coatings. Soil conditioner has not more than 20% by mass of particles with a maximum size above 16 mm.



Raw or partly composted products (e.g. pasteurised mulches) are not recommended for use under these guidelines. These guidelines do **NOT** cover composts, containing construction and demolition wastes, residue wastes\* or composts principally derived from uncomposted animal manures or biosolids. Definitions of other terms used in these guidelines are summarised in Section 9.

Quality assurance is important to ensure composts do not contain weeds, pathogens or contaminants and perform consistently, as well as develop market confidence in the reliability of composed garden organic products. Hence, these guidelines focus on composted garden organics which conform to the Australian Standard for composts, soil conditioners and mulches (AS 4454-2003) (Standards Australia, 2003a).

## 1.4 Legislative considerations

The following pieces of legislation need to be considered in conjunction with these guidelines:

- *Waste Avoidance and Resource Recovery Act (2001)*
- *Protection of the Environment Operations Act (1997)*
- *Sydney Water Catchment Management Act (1998)*
- *Plant Diseases Act (1924)*
- *Noxious Weeds Act (1993).*

Further information on these Acts and associated regulations are provided in Section 6.

## 1.5 Who should use the guidelines

These guidelines are aimed at people and organisations involved with catchment management and land rehabilitation. Target organisations include, but are not limited to:

- Project managers of land rehabilitation works
- Landholders with grants to undertake land rehabilitation works
- Property managers
- Government agencies
- Land rehabilitation specialists
- Private landholders
- Natural Resource Management Consultants
- Compost processors.

The guidelines are intended for use in catchment and land rehabilitation projects which address:

- Gully erosion (including gully head advancement and sidewall collapse)
- Erosion and sediment control works
- Hillslope erosion
- Saline discharge areas
- Degraded soil environments
- Other relevant catchment works.

## 1.6 How to use the guidelines

The following sections are set out to help stakeholders work through the issues that need to be taken into account when considering using composts in catchment management and land rehabilitation. This includes, specifying the type and quality of product; understanding the benefits and potential risks; application methods and depths; site considerations; and purchasing the products. Case studies from HNCMA are also included to provide users with examples of how composts have been used to rehabilitate degraded catchments. Sections covering regulatory requirements; references, contact details and links are also provided for users of the guidelines who may require further information.

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\*Residue wastes are defined in Section 7.1.2.

# 2 UNDERSTANDING THE PRODUCT AND ITS BENEFITS

## 2.1 How are composts produced?

Production processes vary depending on the size of the operation, input material and desired end-product. A general composting process is outlined below:

The raw material is inspected and sorted to remove coarse contaminants such as plastics, metals and glass before it is ground using a tub or horizontal grinder. After grinding, biosolids, cattle manure or poultry litter may be added to increase the nutrient content of the compost mix (e.g. nutrient enriched soil conditioners (NESC) in Table 1), whilst wood chips may be added as a source of carbon.

Composting refers to the process of subjecting organic material to controlled aerobic conditions, which allow microbial activity to pasteurise and mature the material. There are four stages of composting, namely the i) mesophilic, ii) thermophilic, iii) cooling, and iv) maturation (Recycled Organics Unit, 2002). The composting process is initiated during the mesophilic stage through the decomposition of organic material (temperatures 20-45°C), followed by the thermophilic phase when respiration and windrow temperatures (>45°C) increase. The cooling and curing phase occurs once readily available organic carbon is depleted and is followed by the maturation phase, which is important to ensure the compost is stable and does not re-heat (Recycled Organics Unit, 2002). Temperatures >55°C are required during the thermophilic phase to ensure weeds, weed seeds and plant, animal and human pathogens are destroyed (Keen *et al.*, 2002). However, compost temperature varies throughout the windrow (Tee *et al.*, 1999) and so turning and mixing is necessary to ensure all of the material is exposed to these temperatures. As such, the Australian Standard for composts, soil conditioners and mulches (AS 4454-2003) states '*the minimum requirement for achieving pasteurisation is the appropriate turning of the outer material to the inside of the windrow so that the whole mass is subjected to a minimum of three turns with the internal temperature reaching a minimum of 55°C for three consecutive days before each turn*' (Standards Australia, 2003a).

Once the compost has matured, it is screened to different grades to suit the end use of the product. Soil conditioners and coarse mulches are typically screened to <10 mm and >15 mm, respectively.

## 2.2 Characteristics of composted garden organics

Typical characteristics of the composted garden organics soil conditioners and mulches produced within the Sydney Basin are presented in Table 1. The main beneficial chemical characteristic of composted garden organics is organic matter (Wilkinson *et al.*, 2000), which in composted soil conditioners and mulches produced in NSW, can range from 17-65% (fresh weight) (Table 2). The C/N ratio influences the rate and effectiveness of composting and can reduce the availability of nitrogen in soil. The C/N ratio of mature fine fraction (<16 mm) composted garden organics should be in the order of 13-17:1 (Verdonck, 1998). The low N (0.4-1.6%) and P (0.05-0.6%) concentrations in composted garden organics (Table 2) indicate they do not generally offer much fertiliser value (Wilkinson *et al.*, 2000).

However, garden organics co-composted with materials such as biosolids, poultry litter or cattle manure, have higher nitrogen and phosphorus concentrations (NESC) (Table 2), which can be used as a source of nutrients to plants. These products are particularly useful in low nutrient status and degraded areas away from waterways but are not recommended for use in sensitive catchment areas.

**Table 2. Chemical characteristics of composted garden organic mulches, soil conditioners (SC) and nutrient enriched soil conditioners (NESC) derived from source separated garden organics in the Sydney basin (Adapted from Dorahy *et al.*, 2005), as well as the numerical criteria defined in Standards Australia (AS4454 - 2003). Numbers in parentheses in the header row represent the number of samples collected.**

Parameter	Mulch (8)	SC (11)	NESC (10)	AS 4454 -2003
	----- (mean ± s.e.) -----			
pH	6.5 (5.0 – 7.3)	6.9 (5.2-7.5)	7.2 (5.9-7.9)	5.0 - 7.5 <sup>A</sup>
EC (dS/m)	1.2 (0.4-2.0)	2.2 (1.2-3.5)	3.0 (1.3-7.2)	No limit
‡Soluble P (mg/L)	2.7 (0.9-5.3)	2.5 (0.2-7.1)	10.5 (0.2-43.4)	≤5 <sup>B</sup>
NH <sub>4</sub> <sup>+</sup> -N (mg/L)	13.2 (5.0-63.7)	10.7 (0.4-57.4)	87.8 (1.3-231)	<200
NO <sub>3</sub> <sup>-</sup> -N (mg/L)	0.9 (0.4-2.0)	2.4 (0.0-16.0)	88.9 (0.0-527)	≥10 <sup>C</sup>
NH <sub>4</sub> <sup>+</sup> + NO <sub>3</sub> <sup>-</sup> -N (mg/L)	15.9 (0.9-65.7)	14.7 (5.0-57.4)	177.1 (5-530)	>200 <sup>C</sup>
OM (% dw)	59.2 (45.8-65.2)	31.1 (17.4-43.1)	25.9 (18.5-37.4)	≥25
N (% dw)	0.7 (0.5-1.0)	1.0 (0.6-1.3)	1.3 (0.4-2.1)	≥0.6 <sup>C</sup>
P (% dw)	0.1 (0.0-0.1)	0.2 (0.1-0.2)	0.4 (0.1-0.8)	≤0.1 <sup>B</sup>
K (% dw)	0.4 (0.1-0.5)	0.5 (0.2-0.7)	0.4 (0.1-0.8)	-
Ca (% dw)	0.7(0.5-1.1)	1.7 (0.7-3.9)	2.1 (1.0-4.3)	-
Mg (% dw)	0.1 (0.1-0.2)	0.2 (0.2-0.4)	0.3 (0.2-0.4)	-
Na (% dw)	0.1 (0.1-0.2)	0.1(0.1-0.2)	0.2 (0.1-0.3)	<1 <sup>D</sup>
B (mg/kg dw)	12 (6-17)	11.4 (2.8-16)	10 (3-17)	<200 <sup>E</sup>

<sup>A</sup> If pH>7.5 determine total CaCO<sub>3</sub> content;

<sup>B</sup> For products which claim to be for P sensitive plants;

<sup>C</sup> If a contribution to plant nutrition is claimed. No requirement for composted mulches;

<sup>D</sup> At least 7.5 moles Ca plus Mg for each mole of Na in the dry matter.

<sup>E</sup> Products with total B <100 can have unrestricted use;

‡ Measured as Orthophosphate-P (mg/L) in test solution.

## 2.3 Benefits of composted garden organics

### 2.3.1 Runoff and erosion control

Soil erosion degrades land resources at the point of mobilisation, as well as downstream water resources, once transported sediments are deposited. Suspended sediments reduce water quality by increasing turbidity and the concentrations of nutrients, organic matter and other pollutants, which can alter physical, chemical and biological processes in aquatic ecosystems. Moreover, sediment deposits alter streambed morphology and can reduce reservoir storage capacity. There are several types of erosion that can impact upon catchment health, including sheet, rill, gully and tunnel erosion.

Sheet erosion and rill erosion generally occur during high intensity rainfall events when raindrops disrupt the integrity of the soil surface (Hollinger *et al.*, 2001). These impacts can cause the break up or compaction of soil aggregates leading to soil crust formation. The crust then prevents water infiltration into the soil profile, causing runoff to occur (Agassi *et al.*, 1998). When applied to the soil surface, large robust mulch particles are able to physically shield the soil surface from raindrop impact, preventing crust formation (Adams, 1966; Agassi *et al.*, 1998). This shielding also protects the soil from the effects of wind erosion, helps trap entrained soil particles (Wong and Malik, 2004) and increases the volume and time that rainfall stays on the soil surface, resulting in an increase in the amount of water infiltrated and stored in the soil profile (Adams, 1966; De Vleeschauwer and Lal, 1978).

Gully and tunnel erosion are initiated when the equilibrium within a minor drainage line is altered, either by an increase in drainage line discharge or a reduction in soil resistance to erosion (such as runoff coming into contact with dispersive subsoil). This dispersive soil erodes more rapidly than the overlying soil layer and causes the overlying

layer to collapse. Whilst the process of subsoil removal goes on, the gully head continues to retreat up the slope and the gully lengthens. Tunnel erosion is very similar to gully erosion, with the major difference being that during tunnel erosion the underlying subsoil is removed, whilst the surface soil layers remain intact. This causes large hollows to occur below the soil surface which enlarge until they can no longer support the soil above and collapse, creating a large open gully (Rosewell *et al.*, 2000). Wind erosion is also an important issue, particularly in the Western Division of New South Wales, where over 5 million hectares are affected (Rosewell *et al.*, 2000). The application of composted mulch and soil conditioners to these sites helps vegetation establishment, protects the soil surface and promotes site stabilisation.

Composted mulches improve soil structure and break up overland flow (Faucette, 2004) with water leaving the soil surface at a lower velocity than bare soil and therefore having less energy available to entrain particles further down the slope.

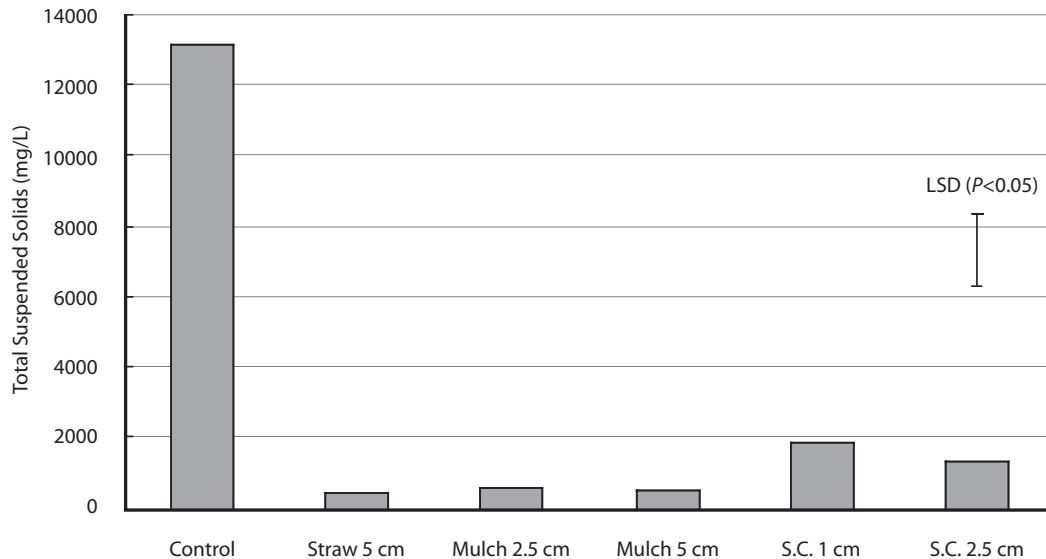
Erosion control blankets, comprised of composted mulches, have been found to be superior to straw or synthetic matting, as rilling can develop under straw or synthetic mats, whilst the runoff from compost blankets has been reported to occur on the surface (Adams, 1966; Faucette, 2004). Research by Wong *et al.* (2005) has shown that composted mulches can reduce soil loss in runoff by over 85% (Figure 2).

Increased organic carbon levels and improved soil health encourages the growth and establishment of plants. Plant tops physically shield the soil surface, whilst developing root systems and decomposing organic matter hold soil aggregates together (Obi and Ebo, 1995; Wong and Malik, 2004). Loch (2000) and Storey *et al.*, (1996) concluded that vegetative cover of the soil surface is the most effective form of erosion control as it:

- Protects the soil surface from raindrop impact, decreasing the potential for surface sealing
- Slows water flow on the soil surface
- Reduces runoff volume due to soil water depletion by plants
- Create soil pores
- Reduces soil water repellence
- Increases infiltration either by reduced surface sealing or plant-root produced macropores
- Returns water back into the atmosphere through evapo-transpiration, which reduces the possibility of waterlogging
- Holds soil together either physically through plant roots or chemically through bonding agents released from organic matter.

These factors combine to reduce erosion and encourage long term site stabilisation.

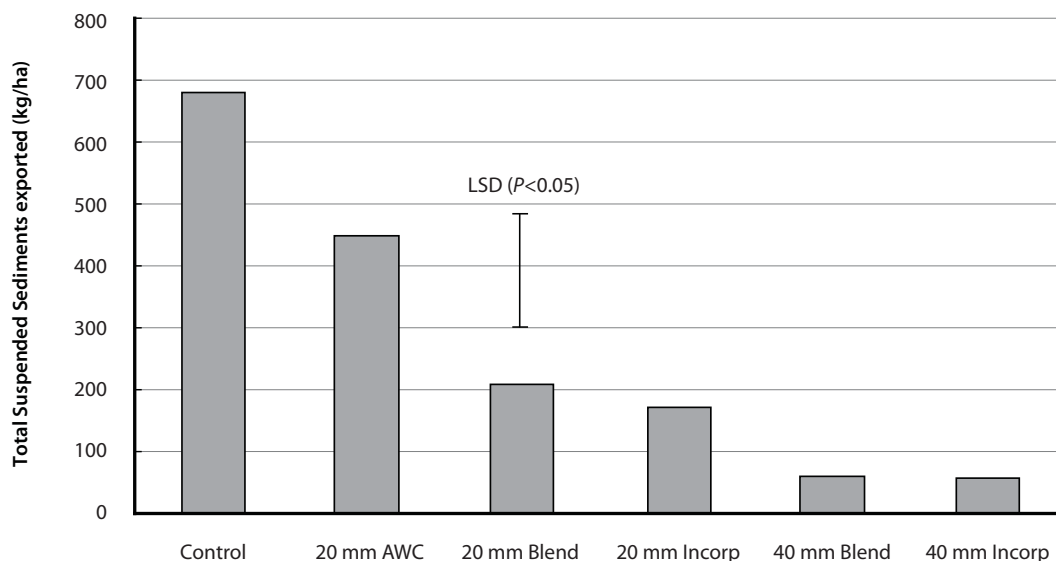
Figure 2. Erosion control performance of composted mulch, composted soil conditioner (S.C.), bare earth (Control) and conventional practice (Straw) before establishment of vegetation at CROA (Wong *et al.* 2005). Vertical bars represent the least squares difference (LSD). Differences between treatment means that are larger than the LSD are significant at the  $P<0.05$  level.



### Benefits of a blended product

The best composted mulch blankets for erosion control contain a mix of fine and coarse particles (i.e. composted soil conditioner (<16 mm) and mulches (>16 mm)). The larger particles physically shield and protect the soil, whilst finer particles enter the soil matrix, increasing nutrient levels, infiltration, water holding capacity and overall soil health (Wong and Malik, 2004). Blends containing composted mulches and soil conditioners in the ratio of 60/40 have been successfully used in large scale demonstration trials conducted by the Hawkesbury Nepean CMA. This is supported by research performed by Dorahy *et al.*, 2006 who found that, applying a 60/40 blend of composted mulch and soil conditioner to a depth of 40 mm has been shown to reduce sediment export by more than 600 kg/ha (>90%) relative to a bare earth control (Figure 3).

Figure 3. Effect of compost type, application depth and method of application on load (kg/ha) total suspended sediment exported in runoff from a 1 in 10 year simulated rainfall event. Vertical bar represents the least squares difference at the  $P<0.05$  level of significance (Dorahy *et al.*, 2006). AWC, Aquatic Weed Compost; Blend, 60% mulch and 40% soil conditioner; Incorp, incorporation of soil conditioner into soil.



### 2.3.2 Vegetation establishment (pastures, shrubs and trees)

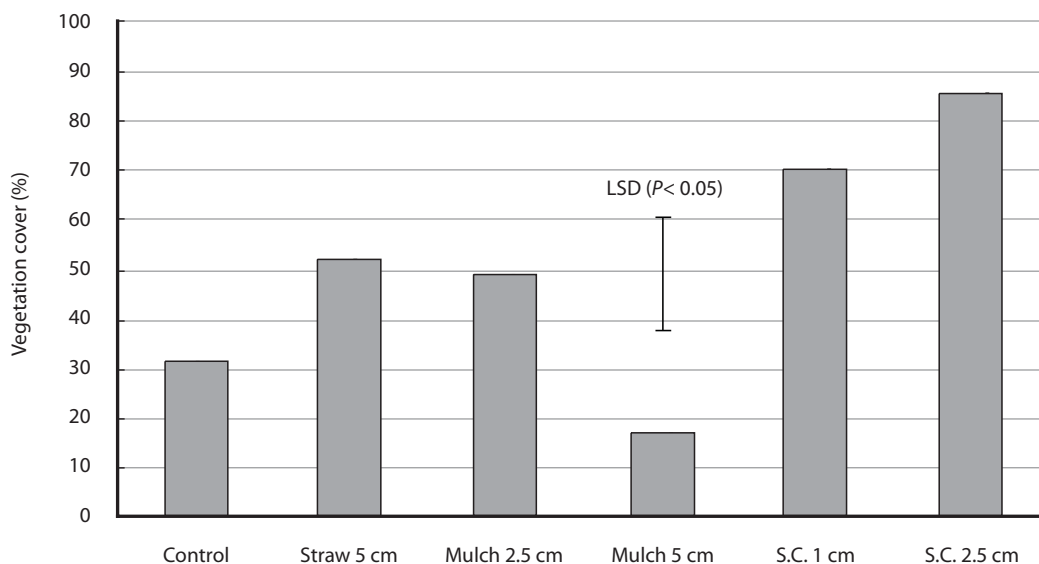
Plant roots help bind soil together, improve water infiltration, reduce runoff and reduce the impact of rain droplets on the soil surface. Hence, in the longer term, vegetation is the key to protecting the soil against erosion (Eldridge, 2007). The main strategies for re-establishing vegetation as part of land rehabilitation projects are to establish pasture cover crops and deep rooted perennial grasses by seed and/or to plant tube stock of deep rooted perennial trees.

Composted soil conditioners and mulches can play an important role in promoting the re-establishment of vegetation in land rehabilitation projects using both of these strategies. For example, research by NSW DPI (Wong *et al.*, 2005; Dorahy *et al.*, 2006) has shown that composted soil conditioners are beneficial for establishing pasture cover crops and deep rooted perennial plants, particularly in areas denuded of topsoil (Figures 5 and 6). Likewise, application of a soil conditioner/ mulch blend or soil conditioner followed by the surface application of a mulch at shallow depths, is also beneficial for establishing vegetation from seed (Dorahy *et al.*, 2006).

In some instances the fine particles in composted soil conditioners can be blown away. To reduce this, soil conditioners should be incorporated into the soil profile, or a mulch can be surface applied to reduce the potential for wind erosion to occur.

High depths of mulch application (>50 mm) should be avoided as this can suppress seedling emergence (Figure 4) and make it difficult to establish vegetation from seed.

**Figure 4. Vegetation establishment on the CROA plots eight months after the application of straw and composted soil conditioner (S.C.) and mulch compared to bare earth (control) (Wong *et al.*, 2005). Vertical bars represent the least squares difference (LSD). Differences between treatment means that are larger than the LSD are significant at the  $P<0.05$  level.**



**Figure 5. Comparison of vegetation establishment in a plot treated with composted mulch (left) against the bare earth control (right) at Bungonia. Picture taken 12 months after the composted mulch was applied to the plot.**



Figure 6. Demonstration of the how the application of composted mulch and soil conditioner contributes towards revegetation and stabilisation of a catchment near Bungonia (Top: September 2003, Below: December 2005 – post seeding and compost application).



### 2.3.3 Improving soil health

#### Soil fertility

Composts can act as sources of nitrogen (N), phosphorus (P) and sulphur (S), exchangeable cations<sup>†</sup> (calcium, potassium, magnesium and sodium) and micronutrients (Table 2) particularly in highly weathered soils. Composts can also decrease the rate of micronutrient leaching and level of P fixation in a soil (Obi and Ebo 1995). Likewise composts can increase pH in acidic soils which enhances the availability of some nutrients. As such, composts can improve soil chemical fertility and plant nutrition.

#### Soil Structure

Compost application leads to an overall improvement in soil physical characteristics by reducing bulk density (Sabrah *et al.*, 1993; Stehouwer and Macneal 2003), resistance to root growth and increasing soil porosity and hydraulic conductivity (Smith *et al.*, 2001). This allows water to move more easily into and through the soil profile. Compost application can also increase water holding capacity and plant available water (Obi and Ebo 1995).

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<sup>†</sup> Exchangeable calcium potassium magnesium and sodium collectively contribute to Cation Exchange Capacity (CEC), which is 'the potential capacity of the soil to interact with and bind elements and compounds in the soil' (Charman 2007).



## Soil Biology

The addition of compost to a soil increases soil faunal and microbial activity (Obi and Ebo 1995), as the labile C in the compost provides an energy source for microbial activity (Chaoui *et al.*, 2003). The addition of composts can suppress root and foliar pathogens and also increase the number and proportion of beneficial bacteria and bio-control agents for other pests such as nematodes (Hoitink and Grebus 1997; Claassen 2000).

## Mitigation of Soil Salinity and Sodicity

In Australia, sodic soils are defined as those where more than 6% of their exchangeable cations are comprised of sodium ( $ESP > 6$ )<sup>‡</sup>, whilst soils with an  $ESP > 15$  are considered highly sodic (Northcote and Skene 1972). The concentration of salt in the soil is determined by measuring the electrical conductivity (EC) of a soil/ water extract. A soil saturation extract ( $EC_{se}$ )  $> 4$  dS/m is defined as saline and is likely to affect plant growth (Charman and Wooldridge 2007).

High salinity levels retard growth through osmotic stress as plants are unable to take up water or other nutrients from the soil solution. High salinity also increases the activity of enzymes responsible for suppressing plant growth (Khalli 2002) and slows germination, meaning that establishing plants are less able to utilise available soil moisture (Grigg *et al.*, 2006).

Plants trying to establish on saline or sodic soils can also encounter toxicity from ions such as sodium (Na), chloride (Cl) and boron (B) (Ford *et al.* 1993; Dagar and Gautam, 2004). Saline and sodic soils may also be low in organic matter and many essential plant nutrients such as nitrogen (N), phosphorus (P), copper (Cu), zinc (Zn), manganese (Mn), iron (Fe) and molybdenum (Mo) (Ford *et al.*, 1993; Grigg *et al.*, 2006). Consequently, plants growing in saline and sodic soils may require more nutrients than plants growing under normal conditions.

Highly saline and sodic soils can also form crusts when dry, which impede infiltration during rainfall events and hamper seedling emergence (Ford *et al.* 1993). Moreover, soils with sodic B horizons are susceptible to tunnel and gully erosion as they disperse upon wetting.

Compost can help mitigate the effects of soil salinity and sodicity in a number of ways:

- Polysaccharide gums produced by microbes during organic matter decomposition and developing plant root systems help bind soil aggregates together increasing soil stability (Storey *et al.*, 1996).
- Increased water holding capacity gives seeds a better chance of germination and establishment. Increased soil moisture levels also reduces the osmotic stress on established plants (Khalli 2002).
- Increased cation exchange capacity decreases and regulates the level of exchangeable sodium and other ions in the soil, reducing nutrient toxicities (Khalli 2002) and lowers the level of soil dispersiveness (Stehouwer and Macneal 2003).
- Increased cation exchange capacity, along with increased microbial activity, improves the retention and cycling of soil nutrients.
- The improvement in soil properties such as cation exchange capacity, organic carbon, soil structure, and exchangeable sodium levels allows an increase in plant response to inorganic fertilisers when they are used (Stehouwer and Macneal 2003).
- The pH of alkaline sodic soils is reduced by the release of organic acids during organic matter decomposition (Sheeba and Kumarasamy, 2001). This can release native soil  $CaCO_3$  and replace exchangeable sodium with calcium (Avnimelech *et al.*, 1994).
- Soluble salts are flushed from the profile as a result of increased rainfall infiltration and improvement in subsurface permeability (Avnimelech *et al.*, 1994).

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<sup>‡</sup>ESP- Exchangeable Sodium Percentage- the fraction of the cation exchange capacity taken up by sodium ions, conveyed as a percentage (Geeves *et al.*, 2000).



- Increased infiltration during rainfall events due to improved structural stability of the soil (Lax *et al.*, 1994) whilst large mulch particles can provide stable pathways for infiltration directly into subsurface soil layers (Grigg *et al.*, 2006).
- Reduced crust strength enabling better emergence of establishing seedlings and improved infiltration rates.

Composts have also been successful in remediating saline discharge sites as demonstrated in Case Study 5.1.

## 2.4 Potential risks associated with composted garden organics

Despite the many benefits of using composted mulches and soil conditioners for catchment management, negative consequences from their use can occur. This risk is mainly associated with variability in product quality and composition arising from:

- Variation in the source and quality of raw materials used to produce the composted product.
- Variation in the environmental conditions encountered by the raw material during composting (e.g. temperature, moisture, aeration, period of exposure).
- Variation in the ratio of mulches and soil conditioners used to create a blended product.

For these reasons, it is important to ensure that products meeting AS4454-2003 and the specifications set out in Tables 3, 4, 5 and 6 are used. Products conforming to this standard are subjected to production and quality control criteria, which aim to minimise the potential for harm. It is the responsibility of those in charge of site rehabilitation to ensure the product used is selected in terms of 'fit for purpose' for the job required. This includes obtaining documentation such as test certificates from suppliers to ensure the product satisfies the recommended specifications in this guideline in accordance with the sampling methodologies and frequencies. These test certificates should provide information on the levels of nutrients and contaminants so that agronomic calculations can be undertaken.

Using compost products which comply with relevant Australian Standards AS4454-2003 and the specifications in Tables 3, 4, 5 and 6 are procured from quality endorsed suppliers reduces most risks. Nevertheless as product certification represents a minimum standard, it does not mean a product is suitable for all end uses and users should select the best product for their needs. As with the use of any agricultural or horticultural product, problems may occur if composted mulches and soil conditioners are used in inappropriate situations.

A brief overview of potential problems occurring with composted products use has been adapted from DEC (2006) and is presented below. For more detailed information on these issues, readers are referred to Recycled Organics Unit (2003a).

### 2.4.1 Phytotoxicity

Phytotoxicity can occur when immature composts are applied to a site, whereby on-going decomposition releases a variety of chemicals which hinder or stop plant growth. Composts complying with AS4454-2003 and the specifications set out in Table 3 should be subjected to a maturation phase and are tested for phytotoxicity.

### 2.4.2 Nitrogen drawdown

Nitrogen drawdown happens when compost containing a high C:N ratio is incorporated into the soil. When added to the soil, products with a high C:N encourage soil microbes to compete with plants for nitrogen leading to nitrogen deficiency and possibly, to plant death. Using products complying to AS4454-2003 and the specifications set out in Table 3 will avoid this as the soil conditioner (suitable for incorporation into the soil) should have an appropriate C:N ratio and sufficient nutrients to support plant growth.

### 2.4.3 Residual chemicals and heavy metal contaminants

Chemical residues may be introduced into the compost from the original feedstock and could potentially affect environmental or human health. Depending on the feedstock's history a number of contaminants may be present. Timber feedstock could contain heavy metals such as copper, chromium and arsenic, which are used as preservatives. Garden organics and manures could potentially introduce pesticide and herbicide contaminants. Products complying with AS4454-2003 and the specifications set out in Table 5 should not have any issue with heavy metals or chemical residues.

### 2.4.4 Physical contamination

Hazardous or unsightly physical contaminants such as stone, metal, plastic and glass can occur in all composted products. However the problem is more common in coarser mulches produced from contaminated feedstock. AS4454-2003 and the specifications set out in Table 4 place limits on the allowable level of physical contamination. Using products complying with these limits should avoid problems caused by physical contaminants.

### 2.4.5 Weed seeds, plant fragments or pathogens

Weed seeds, plant propagules and pathogen survival in compost is possible as composted products are produced from the remains of plant material, animal manures or biosolids. Immature or poorly composted products can also be responsible for increasing the pathogen populations. Proper composting and pasteurisation procedures ensure that viable seeds, propagules and pathogens present in the feedstock are destroyed by heat and microbial decomposition and meet the microbiological standards suggested in Table 6.

Quality endorsed manufacturers complying with AS4454-2003 use well managed composting systems, ensuring compliance with the criteria and test methods identified in the standard. Consumers can have confidence that products certified by independent Quality System certifiers are compliant with the relevant standards.

### 2.4.6 Detrimental impacts on water quality

Composted mulches and soil conditioners contain nutrients, organic matter and sediments which can negatively impact upon water quality if they are not applied appropriately. Risks to water quality can be reduced by avoiding sensitive riparian zones and limiting the loading of nutrients associated with compost application. In the long-term, composted soil conditioners and mulches should promote site stabilisation through reducing sediment transport (Figure 2) and increasing vegetation establishment (Figure 4), which will lead to improved catchment water quality.

# 3 PRODUCT SPECIFICATIONS

The product specifications outlined in this section are based on national and international research and applied experience gained from using composts in numerous land rehabilitation programs in and around the Sydney Catchment. More information on this work is described by Wong and Malik (2004), Wong *et al.* (2005) and Dorahy *et al.* (2006).

## 3.1 Classification Framework

Quality requirements for composted mulches and soil conditioners products have been put in place for two reasons: 1) to ensure that applied composted organic material is beneficial and avoids impact to the public or environmental health, and 2) to ensure that end-users can buy the product with a degree of quality assurance.

The Australian Standard for composts, soil conditioners and mulches (AS 4454-2003) gives end-users confidence in the quality of product they are using. Composts used in catchment remediation must meet AS 4454-2003<sup>§</sup> and the additional specifications set out in Tables 3, 4, 5 and 6.

These specifications for products suitable for use in catchment management and land rehabilitation have more stringent criteria than the AS 4454-2003 standard for a number of properties such as nitrate, ammonium, phosphorus, EC (Table 3), as well as plastics and glass (Table 4). This has been done to limit the potential for nutrients, such as nitrogen and phosphorus, being transported from areas of product application, causing eutrophication of surrounding watercourses. More restrictive limits on EC and physical contaminants minimises the potential for waterway pollution from applied products and improves the growing conditions encountered by establishing vegetation. Purchasers should use the physical contaminant limits as a guide only and representative product samples should be obtained from suppliers to ensure that the products are suitable for your intended project.

At the time of publishing, the Self Heating Test as required in Table 3.1 of Australian Standard AS 4454 (2003), is not routinely being offered by testing laboratories in Australia. This test is a measure of compost maturity, which can also be indicated by the toxicity test in the Standard. As a result, purchasers should ensure that the soil conditioner fraction of products meet the toxicity (and all other) requirements as outlined in this specification and the Standard, to ensure that products will not harm plants or germinating seedlings following application to soil.

Composted soil conditioners are incorporated into soils with the objective of assisting in vegetation establishment and long term site stabilisation by improving the soil's chemical, physical and biological properties. On the other hand, composted mulches are surface applied products consisting mainly of coarse particles, which protect exposed soil surfaces from the erosive effects of wind and rain. Finer material in the mulch may also provide conditioning benefits through aiding vegetation establishment and promoting long term site stabilisation.

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<sup>§</sup> The Australian Standard for composts, soil conditioners and mulches (AS4454-2003) are reviewed from time to time. At the time of printing AS4454-2003 was under review and so users of this guideline should consult the most current version.

**Table 3. Specifications for composted mulches, soil conditioners and mulch/soil conditioner blends used in catchment management and land rehabilitation.**

Parameter	Composted mulch	Composted soil conditioner	Composted soil conditioner/ mulch blend (40/60)
pH <sup>‡</sup>	6.0 – 8.0	6.0 – 8.0	6.0 – 8.0
Electrical conductivity (dS/m) <sup>‡‡</sup>	≤ 3	≤ 3	≤ 3
Phosphorus, soluble (mg/L)	≤ 5 where P-sensitive vegetation is planted OR 5-50 for other plant species <sup>a</sup>	≤ 5 where P-sensitive vegetation is planted OR 5-50 for other plant species <sup>a</sup>	≤ 5 where P-sensitive vegetation is planted OR 5-50 for other plant species <sup>a</sup>
Phosphorus, total (%)	≤ 0.1 where P-sensitive vegetation is planted OR < 1.5% for other plant species <sup>a</sup>	≤ 0.1 where P-sensitive vegetation is planted OR < 1.5% for other plant species <sup>a</sup>	≤ 0.1 where P-sensitive vegetation is planted OR < 1.5% for other plant species <sup>a</sup>
Ammonium-N (mg/L)	< 200	< 200	< 200
Nitrate-N (mg/L)	< 200 <sup>b</sup>	< 200 <sup>b</sup>	< 200 <sup>b</sup>
Ammonium-N plus Nitrate-N (mg/L)	< 400 <sup>c,d</sup>	< 400 <sup>c,d</sup>	< 400 <sup>c,d</sup>
Total N (%)	< 2.0	< 2.0	< 2.0
Organic matter (%)	≥ 25	≥ 25	≥ 25
Boron (mg/kg)	< 100	< 100	< 100
Sodium (%)	No requirement	<1 or at least 7.5 moles calcium plus magnesium for each mole of sodium in the dry matter	<1 or at least 7.5 moles calcium plus magnesium for each mole of sodium in the dry matter
Wettability (mins)	<7	<7	<7
Toxicity (mm)	No requirement	≥ 60	≥ 60 for the soil conditioner component of the blend
Particle size grading using a 16 mm sieve (%) <sup>e</sup>	- Maximum particle size 200 mm - >70% by mass in the shortest dimension to be retained by the sieve	- Maximum particle size 100 mm - Not more than 20% by mass in the shortest dimension to be retained by the sieve	- Maximum particle size 200 mm - Not less than 40% but not more than 60% to be retained on the sieve
Moisture content (%)	25-50%	25-50%	25-50%

**Footnotes for Tables 3 and 4:**

<sup>a</sup> Upper limits for soluble and total phosphorus are stated to reduce potential for off-site nutrient movement following application.

<sup>b</sup> Upper limits for nitrate are stated to reduce potential for off-site nutrient movement following application.

<sup>c</sup> Upper limits for ammonium and nitrate is stated to reduce potential for off-site nutrient movement following application.

<sup>d</sup> Ammonium and nitrate levels of 400 mg/L are equivalent to 0.078% N in a mulch (assuming density is 510 kg/m<sup>3</sup> and moisture content of 25%) on a dry weight basis and between 0.110% N in a soil conditioner on a dry weight basis (assuming density is 910 kg/m<sup>3</sup> and a moisture content of 40%); Refer to Table 8 for guidance on calculating nutrient loadings associated with composted soil conditioner or mulch application.

<sup>e</sup> Standard test methods are not available to determine particle size. Consequently, it is recommended a random 50L sample of the batch be randomly sorted to determine the proportion of physical contaminants.

<sup>‡</sup> Products up to pH 8.0 may be acceptable for application to acidic soils (pH<7.0). However, application depths should be determined based upon soil test results and estimations of the liming value of the compost.

<sup>‡‡</sup> If EC is > 3 dS/m application rates may be limited depending on the EC of the site soil. Refer to Table 3.3 in AS 4454-2003 for guidance on this matter.

<sup>#</sup> The contaminant limits specified here are the preferred limits. However, should a product exceed these levels: a) it should not exceed the limits prescribed in AS4454- 2003 and b) the supplier should supply test results for and samples of the batch supplied to ensure the product is satisfactory to the client.

<sup>‡‡</sup> and <sup>#</sup> The Australian Standard for composts, soil conditioners and mulches (AS4454-2003) are reviewed from time to time. At the time of printing AS4454-2003 was under review and so users of this guideline should consult the most current version.

**Table 4. Recommended specifications for physical contaminants in composted mulches, soil conditioners and mulch/soil conditioner blends used in catchment management and land rehabilitation.**

Contaminants # (%) Best practice	Best practice recommended for catchment management*	Acceptable levels for land rehabilitation** works	AS4454- 2003
Glass, metal and rigid plastics >2 mm	≤ 0.05	≤ 0.25	≤ 0.5
Plastics – light, flexible or film >5 mm	≤ 0.005	≤ 0.025	≤ 0.05
Stones and lumps of clay ≥5 mm	≤ 5	≤ 5	≤ 5

\*Defined as works and management practices to improve soil quality, vegetation and water quality on lands that are part of water catchment areas. Works often involve the rehabilitation of eroded or degraded agricultural land in water catchments such as gullies, saline/sodic discharge lines and land affected by sheet erosion.

\*\*Defined as works and management practices to improve soil quality, vegetation and water quality on lands that are not in close proximity to water catchment areas. Works often involve the rehabilitation of land such as mine sites, quarries etc.

Composted soil conditioners and mulches that are used in catchment management are likely to be applied in close proximity to water courses. To minimise the potential for composted soil conditioners and mulches to impact on water quality, contaminants should not be present at levels that would make the products unsuitable for use. The concentration of heavy metals and organic contaminants should not exceed the concentrations listed in Table 5. Also, products should not contain any heavy metal or organic contaminants from other source material that would make the products unsuitable for use. Similarly, composted soil conditioners and mulches should achieve the microbiological standards listed in Table 6. Compost produced in accordance with Appendix N of AS4454-2003 will meet these requirements and additional testing for the parameters in Table 6 is not necessary.

**Table 5. Contaminant acceptance concentration thresholds for composted soil conditioners and mulches used in catchment and land rehabilitation applications (Adopted from the Grade A thresholds for biosolids, NSW EPA, 1997).**

Contaminant <sup>‡</sup>	Concentration (mg/kg)
<b>Heavy metals</b>	
Arsenic	20
Cadmium	1
Chromium (total)	100
Copper	100
Lead	150
Mercury	1
Nickel	60
Selenium	5
Zinc	200
<b>Organics</b>	
DDT/DDD/DDE	0.5
Aldrin	0.02
Dieldrin	0.02
Chlordane	0.02
Heptachlor	0.02
HCB	0.02
Lindane	0.02
BHC	0.02
PCBs	ND*

\*No detected PCBs at a limit of detection of 0.2 mg PCB/kg of biosolids. ‡Note that the above list of contaminants was developed using information on the contaminants present in biosolids. Other source material may contain contaminants and appropriate measure should be taken to ensure that products are suitable for use.

**Table 6. Microbiological standards for composted soil conditioners and mulches used in catchment and land rehabilitation applications (Adopted from the Stabilisation Grade A microbiological standards for biosolids, NSW EPA, 1997).**

Parameter <sup>‡</sup>	Standard
<i>E. coli</i>	<100 MPN* per gram (dry weight)
Faecal coliforms	<1000 MPN per gram (dry weight)
<i>Salmonella spp.</i>	Not detected / 50 grams of final product (dry weight)

\* MPN – most probably number.

Refer to AS4454-2003 (Appendix N) for guidance on process requirements for achieving this stabilisation grade.

## 3.2 Compost sampling and analysis

### 3.2.1 Analytical testing of product

Composted products meeting AS 4454-2003 should have their physical and chemical properties checked regularly to ensure they meet the required standards and specifications. These products may be tested for chemical and physical contaminants, as well as nutrient concentrations, plant toxicity and physical properties, such as moisture content. For more information on AS 4454-2003 refer to Standards Australia (2003a).

### 3.2.2 Sampling and testing frequency

Due to differences in methods of compost production, there is no single sampling scheme, which will be appropriate for all processors. However, the following principles should be followed:

- Samples should be taken randomly from the product
- Samples taken should be representative of the product from which they are taken
- The technique used to obtain samples should remain constant within and between batches
- The number of sub-samples per batch should not vary with time
- The product should be divided into sections of no more than 100 tonnes and at least one composite sample should be taken from each section\*\*
- Sampling equipment and containers should be made from materials that will prevent contamination i.e. stainless steel sampling devices and air-tight sealable borosilicate sample containers.

Batch sub-samples should be combined and thoroughly mixed to make a composite sample for subsequent analysis. A composite sample decreases the variation in the material enabling a more accurate estimation of batch characteristics. At least five sub samples should be used to make up each composite sample.

### 3.2.3 Accredited laboratories

It is important to ensure a full analytical test report of the product is carried out and supplied by the producer prior to product purchase. In cases where a test report is not available on the specific batch of product, a full test on the product to AS 4454-2003 should be undertaken and provided to the customer 2-3 weeks prior to the scheduled delivery date.

A small number of analytical laboratories can provide full testing of composts to AS 4454-2003. Laboratories that have an independently audited quality management system in place (complying with NATA or ISO 9001) are preferred. A list of laboratories is available from the Recycled Organics Unit at the University of New South Wales<sup>††</sup>. This list is provided for information only and is not endorsed by this guideline.

Alternatively, contact the National Association of Testing Authorities (NATA), NSW Department of Primary Industries or the Department of Environment and Climate Change NSW for information on testing laboratories (Section 8).

\*\*Further guidance on sampling methods can be found in Standards Australia (1999) (AS1141); Standards Australia (2003b) (AS4419) or Standards Australia (2003c) (AS3743) or Cement Concrete & Aggregates Australia (2006).

†† (<http://www.recycledorganics.com/lab/commercial/commlabs.htm>).

# 4 PLANNING, USING AND APPLYING COMPOST

## 4.1 Planning and Preparation Required for Compost Application

The following information is general in nature and included to make users aware of the factors which need to be considered before using composted mulches or soil conditioners for catchment rehabilitation. In some instances, it may be appropriate to initially trial product performance on a small area.

### 4.1.1 Remedial Earthworks

Local natural resource management agencies should be consulted before any remedial earthworks are undertaken. Earthworks should be designed and undertaken in accordance with Landcom (2004).

### 4.1.2 Determining application depth

In determining the optimal application depth for composted mulches, it is necessary to balance the need to protect exposed soil surfaces from erosion and promote vegetation establishment for long-term site stabilisation. For example a thick composted mulch blanket (50 mm depth) will reduce sediment transport, but could suppress the emergence and establishment of pasture species (Wong *et al.*, 2005). Likewise, the fine particles and nutrients in composted soil conditioners may increase vegetative cover and dry matter production (Wong *et al.* 2005) but be less effective in reducing sediment transport than composted mulches and may increase the rate of nutrient export from the site (Dorahy *et al.*, 2006). As such, it is recommended a blend of composted soil conditioners and mulches be used to maximise the benefits from using them.

Recent research by the NSW DPI found that surface applied composted soil conditioner and mulch blends in the ratio 40/60 at depths of 20 and 40 mm were effective in reducing sediment transport and promoting vegetation establishment (Dorahy *et al.*, 2006). Therefore, the optimal application depth for composted soil conditioners and mulches in land rehabilitation projects is likely to be between 20 and 40 mm.

### Relationship between application depth and rate

Indicative bulk densities of composted soil conditioners and mulches are 950 and 480-540 kg/m<sup>3</sup> (Recycled Organics Unit, 2003b). However, the bulk density of soil conditioners and mulches (kg/m<sup>3</sup>) is variable because it is influenced by particle size, moisture content and type of input material. As such, composted soil conditioners and mulches are generally sold by volume (m<sup>3</sup>), rather than weight (kg or tonnes). Quantities are generally determined on depth of coverage (mm) or application rates (m<sup>3</sup>/ha). A 10 mm depth of soil conditioner or mulch corresponds to an application rate of 100 m<sup>3</sup>/ha. The method used to calculate the quantity of material required to achieve the desired depths and application rates of composted garden organics soil conditioner (SC), mulch and blends is illustrated in Table 7. Further guidance on evaluating bulk density can be found in Standards Australia (2003b) (AS4419-2003).

**Table 7. Illustration of the method used to calculate the quantity of material required to achieve the desired depths and application rates of composted garden organics soil conditioner (SC), mulch and blends.**

	Depth			Application rate		
	----- (mm) -----			----- (m <sup>3</sup> /ha) -----		
	SC	Mulch	Blend	SC	Mulch	Blend
SC incorp @ 8 mm + mulch @ 12 mm	8	12	-	80	120	-
SC incorp @ 16 mm + mulch @ 24 mm	16	24	-	160	240	-
40/60 blend surface applied @ 20 mm	-	-	20	-	-	200
40/60 blend surface applied @ 40 mm	-	-	40	-	-	400



### 4.1.3 Calculating nutrient loadings

It is important to understand the potential nutrient loadings associated with applying composted soil conditioners and mulches for the purposes of restoring degraded land to evaluate the potential for the products to supply nutrients, such as N. and P. It is also important to ensure that nutrients are not applied in excess and do not impact upon soil or water quality.

Nutrient loadings can be easily calculated using the information provided in the results from analytical testing, by taking into account the nutrient concentration in the material, the intended application depth and rate. An example of this is provided in Table 8, which demonstrates that applying a 40/60 blend of composted soil conditioner/ mulch to a depth of 20 and 40 mm, would supply approximately 420 & 839 kg/ha of N and 71 & 142 kg/ha of P, respectively. It is recommended application depths of composted soil conditioners and mulches be limited so that the total N loading does not exceed 1200 kg/ha (NSW EPA 1997).

Whilst only a small proportion of these nutrients will be in a plant-available form, they will mineralise over time and provide some benefits with respect to soil fertility and plant nutrition. The extent of nutrient mineralisation is dependent upon a number of factors and so soil testing should be used to assess soil nutrient status in the years following application to determine the nutrient requirements of the vegetation growing in the rehabilitated areas. Further information on calculating the availability of nitrogen, phosphorus and potassium from composted mulches and soil conditioners can be found in Recycled Organics Unit (2007).

**Table 8. Estimate of nitrogen total (N) and phosphorus total (P) loading (kg/ha) from applying a total of 20 and 40 mm depth 40/60 blend of composted soil conditioner and mulch for land rehabilitation purposes.**

Parameter	20 mm depth		40 mm depth	
	SC	Mulch	SC	Mulch
<b>Nitrogen</b>				
(A) Concentration (%)	1.2	0.6	1.2	0.6
(B) Moisture content (%)	38	40	38	40
(C) Density (kg/m <sup>3</sup> )	537	232	537	232
(D) Application depth (mm)	8	12	16	24
(E) Application rate (m <sup>3</sup> /ha) (D*10)	80	120	160	240
(F) Application rate (product kg/ha) (C*E)	42938	27893	85875	55786
(G) Application rate (dry kg/ha) (F*(1-(B/100)))	26583	16814	53165	33628
(H) Nutrient loading (kg/ha) (A/100*G)	315	104	631	208
<b>(I) Total (kg/ha) (SC + Mulch)</b>	<b>419</b>		<b>839</b>	
<b>Phosphorus</b>				
(A) Concentration (%)	0.2	0.1	0.2	0.1
(B) Moisture content (%)	38	40	38	40
(C) Density (kg/m <sup>3</sup> )	537	232	537	232
(D) Application depth (mm)	8	12	16	24
(E) Application rate (m <sup>3</sup> /ha) (D*10)	80	120	160	240
(F) Application rate (product kg/ha) (C*E)	42938	27893	85875	55786
(G) Application rate (dry kg/ha) (F*(1-(B/100)))	26583	16814	53165	33628
(H) Nutrient loading (kg/ha) (A/100*G)	60	11	121	21
<b>(I) Total (kg/ha) (SC + Mulch)</b>	<b>71</b>		<b>142</b>	



## 4.2 Application methods

Two application methods have been trialled in the large scale demonstration trials conducted by the Hawkesbury Nepean CMA, namely:

- i) applying composted soil conditioner on the soil surface and incorporating it using harrows, followed by the surface application of composted mulches; or
- ii) applying a blend of composted soil conditioner and mulch in the ratio 40/60, respectively directly onto the soil surface.

Both application methods have promoted site stabilisation and revegetation. At lower application depths (e.g. 20 mm) application method does not appear to influence erosion control performance. Applying a 40/60 blend of soil conditioner and mulch may be advantageous in these situations because it reduces the number of handling operations and spreading costs.

However, at higher depths (e.g. 40 mm depth), it is preferable to incorporate the composted soil conditioner followed by the application of a mulch blanket, rather than broadcasting an equivalent soil conditioner/ mulch blend onto the soil surface, as it reduces the potential for sediments and nutrients to be exported from the site (Dorahy *et al.*, 2006). Similarly, incorporation of high depths of composted soil conditioner followed by the application of a mulch blanket (40 mm) produces more pasture dry matter production than broadcasting an equivalent soil conditioner/ mulch blend onto the soil surface (Dorahy *et al.*, 2006).

## 4.3 Application categories

The methods used to apply composted soil conditioners in land rehabilitation projects will depend upon the characteristics of the site (e.g. area and slope) and the nature of the works undertaken. Some of these considerations are listed below.

### 4.3.1 Flumes and heads of gullies

Due to the steepness of the batter grades of flumes (gradient > 2:1 - Horizontal: Vertical, 50% or 27°), excavators are generally used to apply composted soil conditioners and mulches around flumes and heads of gullies. The excavator broadcasts the material around the target area and then uses the bucket and arm to distribute the material as evenly as possible around the site. A suitable mulch spreader can reverse onto the edge of flumes and spread down the bank provided the flumes are not too deep.

### 4.3.2 Embankments and steep areas

Again an excavator is generally used to apply composted soil conditioners and mulches along the banks of re-shaped gullies, embankments and steep areas. A bulldozer may then be used to spread the material by pushing it along the walls with the blade and/or pulling a set of harrows across the treated area. If larger quantities of material are being used (e.g. > 500 m<sup>3</sup>) and it is possible to straddle the batters of the gully, a spreader may be used to evenly distribute the composted soil conditioners and mulches across the site. However, care must be taken to ensure that the weight of the tractor and spreader does not create wheel tracks along the batter walls, which could de-stabilise the newly formed structure.

### 4.3.3 Gently sloping areas adjacent to gully structures

Tractor-drawn or truck-mounted spreaders are the most efficient method of applying composted soil conditioners and mulches across gently sloping areas adjacent to gully structures (Figures 7 and 8). Spreaders are able to evenly apply the material and rapidly cover large areas, although they may increase application costs. If possible, use a spreader specifically designed for coarse materials as normal V shaped fertiliser spreaders can bridge and block.

### 4.3.4 Saline and sodic drainage lines and discharge areas

Bulldozers are used to rip and shape saline and sodic drainage lines in preparation for compost application. The composted soil conditioner is broadcast across the site using a spreader and then incorporated using harrows (Figure 9). Composted mulch may then be applied on top of the incorporated soil conditioner. Alternatively, a soil conditioner/mulch blend can be applied directly to the soil after ripping and harrowing to reduce the number of spreading and handling operations, as well as the costs associated with them.

## 4.4 Application equipment

The previous section demonstrates there are a variety of options available with respect to equipment for applying and/ or spreading composted mulches and soil conditioners in catchment rehabilitation works. These options are summarised in Table 9.

**Table 9. Summary of options available for spreading composted mulches and soil conditioners in catchment rehabilitation works.**

Spreader Type	Capacity (m <sup>3</sup> spread/ day)	Approx. Cost (\$/m <sup>3</sup> )	Comments
Open backed spreader with vertical or horizontal beaters	500	6-8*	Product can be accurately applied at required depth with a single pass. Highly suitable for larger applications and a broad range of mulches and soil conditioners May not be cost effective on spreading quantities <500m <sup>3</sup> .
Truck or trailer fertiliser spreader	150	8-12	Suitable for spreading smaller volumes and blended finer products. Requires a number of passes to obtain required depth of application. This can also lead to compaction of site. Can have problems with bridging and blockages in spreaders
Excavator/Dozer	200	4	Suitable for walls of reshaped gullies and steep areas not accessible by conventional spreaders. Less control over application rates and depths.
Bobcat	150	5-7	More control than Excavator / Dozer, but slower.
Pneumatic Blower Truck	100	30	Suitable for near impossible to access sites and any slope. Hoses can effectively pump up to 100 metres. Tackifier can be injected for greater than 3:1 slopes (H:V, 33% or 18°). Disadvantages are the cost and loading requirements for the trucks.
Bulka Bags	n/a	15 plus crane costs.	Specialised applications, e.g. bridge near creek etc. Would need to be used in combination with other spreading options.
6 Wheel All Terrain Articulated Dump Trucks	300 <sup>§</sup>	3.5	Used in conjunction with other spreading methods. Used to shuttle run material to steep gullies and embankments. This is additional to spreading costs.

<sup>§</sup>Based on a previous project at a steep gully in Gerringong. Material was shuttled about 300-400 m.

The following should be considered when deciding which equipment to use and negotiating hire rates.

- It is recommended quotes for spreading material be obtained on a m<sup>3</sup> basis rather than an hourly (\$/hr) or per tonne (\$/t) rate.
- Float fees can significantly affect spreading rates, thus quantity to spread versus distance to transport machinery are highly rate dependant variables. Float fees and spreading costs can be reduced by hiring the equipment for more than one site.
- If any machinery is to be utilised that has not previously spread the appropriate mulch or compost, it is recommended that a sample be trialled through the machine prior to commencing the job.

Figure 7. Open backed tractor drawn spreader.



Figure 8. Truck mounted fertiliser spreader in operation.



Figure 9. Harrowing is done to incorporate the soil conditioner and seed into the topsoil to protect it from drying out and blowing away. This also aids in vegetation establishment.



## 4.5 Vegetation establishment

### 4.5.1 Pasture cover crops and deep rooted perennial vegetation from seed

After earthworks have been completed, a blend of pasture crops and deep rooted perennial grasses (Table 10) is generally applied at a rate of ~20 kg/ha to the reformed areas to promote vegetation establishment. Seeds of shrubs and trees can also be sown to establish more permanent vegetation on the site. Use of locally adapted native species is encouraged to maximise success and biodiversity on the site. A suitable starter fertiliser may also be applied at low rates to provide nutrients to establishing seedlings. Starter fertiliser application rates should be based on the results of soil tests and plant nutrient requirements.

**Table 10. Example of the composition of a pasture seed mix used by the Hawkesbury Nepean Catchment Management Authority in catchment rehabilitation works.**

Common name	Botanical name
Goulburn Sub clover	<i>Trifolium subterraneum</i> cv. Goulburn
Dixie Crimson clover	<i>Trifolium incarnatum</i> cv. Dixie
Seaton Park clover	<i>Trifolium subterraneum</i> cv. Seaton Park
Haifa white clover	<i>Trifolium repens</i> cv. Haifa
Tahora white clover	<i>Trifolium repens</i> cv. Tahora
Meridian Rye clover	<i>Lolium perenne</i> cv. Meridian
Australian II Phalaris	<i>Phalaris aquatica</i> cv. Australian II
Vic Rye	<i>Lolium perenne</i> cv. Victoria
Kingston Rye	<i>Lolium perenne</i> cv. Kingston
Currie Cocksfoot	<i>Dactylis glomerata</i> cv. Currie
Rye Corn	<i>Secale cereale</i>

### 4.5.2 Deep rooted perennial vegetation from tube stock

Pasture cover crops and perennial grasses are essential for short-term site stabilisation. However, the persistence of grass and legume swards can decline over time, particularly during periods of drought, which increases the risk of surface soil exposure and subsequent erosion. As such, deep rooted perennial vegetation plays an important role in long term site stabilisation. Tube stock are the most commonly used method for establishing deep rooted perennial species on land rehabilitation sites.

After earthworks have been completed, the slopes are deep ripped along the contour in preparation for tube stock planting (Figure 10) followed by the application of a pasture seed mix, composted soil conditioner and/or mulch.

**Figure 10. Example of where a composted soil conditioner/mulch blend has been applied to the surface of a degraded sodic site near Goulburn. Perennial pastures and cover crops have been sown between the rip lines, which will be planted with tube stock of deep rooted perennial trees and shrubs to promote longer term site stabilisation.**





The tube stock species selected will depend upon the locality and climatic conditions of the site. Examples of species which have been used in catchment rehabilitation works in the southern highlands of NSW are provided in Table 11. Tube stock are planted at a density of 1 per 3 m along the rip lines, or approximately 1 plant per 10 m<sup>2</sup>. At a cost of \$1.20 -1.50 / tube, the costs of purchasing tube stock is in the order of \$1200-1500/ ha, excluding labour and equipment, which add to project costs. Therefore, the decision to include tube stock in the rehabilitation project will depend upon the site, project budget and longer term erosion control needs.

**Table 11. Tube stock species planted as part of a catchment rehabilitation project near Bungonia in the Shoalhaven Catchment.**

Botanical name	Common name
<i>Acacia decurrens</i>	Black wattle, Green wattle
<i>Acacia mearnsii</i>	Black wattle
<i>Acacia pravissima</i>	Tumut wattle
<i>Acacia rubida</i>	Red-stemmed wattle
<i>Callistemon citrinus</i>	Common red bottle brush, Crimson bottle brush
<i>Casuarina littoralis</i>	Black She-oak, Bull oak
<i>Eucalyptus amplifolia</i>	Cabbage gum
<i>Eucalyptus camphora</i>	Mountain swamp gum
<i>Eucalyptus cinerea</i>	Argyle apple
<i>Eucalyptus mannifera</i>	Brittle gum
<i>Eucalyptus ovata</i>	Swamp gum
<i>Melaleuca ericifolia</i>	Swamp paperbark

## 4.6 Site considerations

It is important to carefully consider site characteristics, such as soil types, slopes and vegetation, as well as any requirement for buffer zones and product containments, to ensure the products are applied correctly. This will optimise product performance and minimise the potential for off-site impacts. Initial site assessments also provide a good opportunity to monitor site recovery over time and evaluate the success of the project.

### 4.6.1 Soils

Many degraded catchments may have had their topsoil removed as a consequence of erosion and/or have inherently low physical and chemical fertility. They may also be limited by other factors such as soil acidity, sodicity, or salinity. Soil testing improves understanding of any underlying soil constraints and enables appropriate remediation strategies for them to be developed. Therefore, soil testing should be conducted at an early stage in the rehabilitation project. The Department of Primary Industries, Department of Environment and Climate Change NSW and/ or local Catchment Management Authority should be contacted for advice on appropriate soil sampling, analysis and remediation strategies. Likewise, additional information on soil testing can be found in Gray *et al.* (2006).

### 4.6.2 Slope

Slope assessment is a critical step in site evaluation as it determines the erosion hazard of the site and whether proposed measures will be sufficient to stabilise the site. Slope also influences the way in which the composted soil conditioner and mulch should be applied (Section 4.4). Erosion and sediment control structures may be required on rehabilitation sites with slopes less than 25% (4:1 (H:V) or 14°) (Goldman, 1986; Landcom 2004). On very steep slopes (>25%, <4:1, or > 14°) it may be appropriate to also consider the use of compost filter berms<sup>††</sup>, which filter runoff and reduce its flow rate (Wong and Malik, 2004).

<sup>††</sup>Compost filter berms are contoured run-off and erosion filtration methods usually used for steeper slopes with high erosive potential (Goldstein 2002).

### 4.6.3 Vegetation

Existing vegetation on the site, including native trees, shrubs and grasses, also needs to be considered. Consideration will need to be given to protecting important species, either through modifying planned earthworks or lowering rates of product application in sensitive areas. Where possible, damage to native vegetation should be avoided or minimised. Refer to the *Native Vegetation Act (2003)* for more information in this regard.

Application depths <50 mm should also be used to avoid the suppression of seedlings and to prevent retained vegetation from being suppressed. Tube stock are generally regarded as the best method of establishing trees in mulch blankets.

### 4.6.4 Pasture agronomy

Planting from seed is normally recommended in spring or autumn. It is generally too hot and dry in summer, whilst it is usually too cold for germination and growth in winter. The seed mix can be applied through spinning it onto the soil surface immediately before compost application. Alternatively, the seed mix can be drilled into the compost after application. Care needs to be taken to avoid planting the seed too deep to ensure adequate germination and emergence.

To ensure successful establishment of perennial vegetation from seed, it is essential that correct agronomic practices are followed. Therefore, NSW DPI District Agronomists or seed suppliers should be consulted to determine the optimum planting time and method for your area. Further information on managing pastures for encouraging protective groundcover and reducing soil erosion can be found in *NSW Agriculture (2004)*.

### 4.6.5 Site access and stockpiling compost

Users need to consider how spreading equipment and supply vehicles will access the site, as well as where purchased composted products will be stockpiled. It is extremely important to locate compost stockpiles as close as possible to the areas which will be treated to reduce travelling times and spreading costs. It may be beneficial to have more than one dump site depending on the size of the job. However, consideration should be given to ensuring machinery has good access to the stockpile and that it is located away from watercourses and sensitive areas. Similarly, compost stockpiles should be located on flat ground or gently sloping terrain. If possible, minimise the length of time compost is stockpiled to preserve product quality and reduce the risk of mobilisation during storm events.

### 4.6.6 Measures to limit product movement

Where composted mulches and soil conditioners are to be applied to areas with high erosion hazards, such as steep slopes or large run-on volumes, control measures will be required to ensure the applied products do not move from their intended position. Earthworks may be needed to divert or slow water from moving onto the areas where products have been applied. Product application to drainage and flow lines receiving concentrated, high velocity water flow should be avoided where possible. However product application is suitable in these areas where erosion control measures have been put in place to divert surface water runoff, therefore reducing potential for erosion and loss of compost material. Netting may also be required to retain the compost in areas with steep slopes. Buffer zones, compost filter berms or silt control structures should also be installed between areas of product application and the watercourse to prevent unwanted transport of composted materials into surrounding waterways. Similarly, contour banks or sediment traps in gullies can be used to limit product movement. Additional information on compost filter berms and sediment control structures can be found in Goldman (1986), US EPA (1997) and Landcom (2004).

### 4.6.7 Record keeping, ongoing monitoring and maintenance

It is important to maintain good site records for future reference and provide a benchmark for evaluating the success of a rehabilitation project. The following information should be recorded:

- Site history.
- Initial site condition i.e. slope, existing vegetation, land use, location of water bodies within and surrounding the site, as well as any other notable features.
- Soil test results, including sampling date and location.

- Any earthworks carried out during site remediation.
- The type and depth of products used.
- Date of product application, vegetation planting and/or sowing.
- Rate and type of fertiliser applied.
- Pasture and tree species planted as part of any re-vegetation program.
- Cumulative nutrient loading associated with compost application.

Photo and monitoring points should also be established, so that site managers can keep accurate records of plant growth and site recovery, as well as track progress of site rehabilitation. Regular monitoring also allows the detection of rilling or slumping at the site and signals the need for remedial maintenance at an early stage. Recording this information in a formal rehabilitation or rehabilitation plan, particularly for larger projects, is recommended (Gray *et al.*, 2006).

## 4.6.8 Costs

The costs associated with a land rehabilitation project will depend upon the nature of the site, earthworks, application rates, revegetation strategies and location of compost suppliers. An example of the costs associated with applying a 30 mm application of a 60/40 blend of composted mulch and soil conditioner, including fertiliser, ripping, shaping, labour and spreading are provided in Table 12.

**Table 12. Example of the costs associated with applying a 30 mm application of a 60/40 blend of composted mulch and soil conditioner, including fertiliser, ripping, shaping, labour and spreading.**

Activity	Description	Unit Cost (Inc GST)	Total Cost (incl. GST) (\$)
Compost supplied (60/40) @ 30 mm application depth	Supplied 300m <sup>3</sup> / ha	\$32/ m <sup>3</sup>	9,600
Seed (Table 10)	20 kg/ ha	\$5.20/ kg	104
Fertiliser (page 30)	80 kg/ ha	\$0.75/ kg	60
Ripping and Shaping	Dozer 3 hours/ ha	\$160/ hr	480
Labour (seed/fertiliser application)	1 hour/ ha	\$25/ hr	25
<b>Total Cost (\$/ha)</b>			<b>10,269</b>
Spreading Costs (Table 9)	Open backed spreader	\$8.80/ m <sup>3</sup>	2,640
<b>Total Cost (including spreading) (\$/ha)</b>			<b>12,909</b>

## 4.6.9 Other considerations

Users need to take into account the proximity of works to sensitive areas and any potential negative consequences. Users must also take regulatory requirements into consideration (Section 9). For example, if the composted products contain biosolids, the user must also comply with the NSW Biosolids Guidelines (NSW EPA 1997). Weather is also an important consideration as storms could increase the potential for product movement. Vehicle and machinery movements should be restricted after wet weather to avoid compaction and bogging, which can cause expensive delays and damage the site.

# 5 PURCHASING COMPOST FOR LAND REHABILITATION AND CATCHMENT MANAGEMENT WORKS\*\*\*

## 5.1 Purchasing quality compost

The Buyers Guide for Recycled Organics Products (Recycled Organics Unit, 2003a) provides a detailed overview of the process of identifying quality compost products that are fit for purpose and suitable for a particular project. A brief overview of the process of identifying quality products is given below.

It is important for catchment managers to be able to identify quality products. Indicators of product quality are summarised below, offering a high level of quality assurance (product certification) to a low level of quality assurance (no product certification or product testing). Given that product specifications set out in this guideline, in cases, are stricter than the requirements in Australian Standard AS 4454 (2003a), batch testing will still be required to confirm the quality of the product.

### 5.1.1 Product certification

Certified products offer the highest level of confidence that products can be safely and reliably used with consistent performance. Select products which are quality certified to the relevant Australian Standards (e.g. AS 4454) and the specifications in Tables 3, 4, 5 and 6. Certified products are required to identify the relevant Australian Standard product category, making it easy to identify the best product for your requirements.

Batch tests of products will ensure it meets the specifications outlined in Tables 3, 4, 5 and 6. Additional features of the supplier are also important, particularly their quality control systems and ability to produce consistent composts. Batch test certificates should be available from processors upon request.

Certified manufacturers have an independently audited quality system in place and are required to regularly test product quality to confirm full compliance with the Standard.

For bulk purchases, the 'Certified Product' logo should be on the product specification sheet, with a licence number.

### **Compost Australia product certification and marketing scheme**

Building upon the existing Australian Standards (AS4454), Compost Australia is in the process of developing a Compost Product Certification Scheme. The scheme will enable buyers to identify quality compost products, which are specifically designed to meet customer requirements. Certified Products are represented by the Leaf Brand (Figure 12). Under the scheme, products are independently certified, which includes: registering application specific products; auditing of composting processes; and, laboratory testing of compost products. Further information on the scheme can be found at: [www.certifiedcompost.com.au](http://www.certifiedcompost.com.au)

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\*\*\*This section has been adapted from DEC (2006).



Figure 11. The 'Leaf' Brand will be used to represent composted products, which comply with Compost Australia's Compost Product Certification Scheme.



### 5.1.2 Quality endorsed processor

Quality endorsed company and batch testing offer a moderate level of confidence that products can be safely and reliably used with consistent performance. If certified products are unavailable or too expensive, catchment managers may want to purchase non-certified products from quality-endorsed companies. Quality endorsed companies need to have documented and consistent manufacturing processes. They are therefore likely to produce a more consistent and biologically stable product.

These products should have batch test certificates from accredited laboratories to prove that they are compliant with the AS 4454-2003 and the specifications listed in Tables 3, 4, 5 and 6.

### 5.1.3 Batch test certificate

A batch test certificate offers a minimum level of confidence that products can be safely and reliably used with consistent performance. If neither a certified product nor a product from a quality endorsed company is available, catchment managers can purchase a product that has been tested by a reputable laboratory. A batch test certificate (for the current batch) can be produced to show product compliance with relevant Australian Standard. Be aware of processors that verbally state that their products 'meet the Australian Standard'. In some cases their products may only meet a few parameters of the standard, and not the 'full' standard. Ask for a copy of the test certificate to check compliance with all parameters in the standard.

### 5.1.4 Non-certified product with no batch test certificate

Non-certified product with no batch test certificate is a case of 'buyers beware'. The purchase of products which lack certification and have not been batch tested carries many risks, such as those described in Section 2.4. If a buyer cannot identify the qualities of a product, the effects of a product will remain uncertain after application. Such products and suppliers should be avoided, as they may cause serious problems to soils, plants, animals and even human health.

### 5.1.5 Product names

Compost producers may use unique brand names to describe the products they sell. This may create some confusion for some consumers as to whether a product has been fully composted or is classified as a soil conditioner or mulch.

Australian Standards certified products are categorised, which helps reduce ambiguity surrounding labels. These product categories provide consumers with a means of identifying products which meet their needs. Moreover, purchasing products on specifications helps reduce product variability between suppliers and avoids possible confusion regarding how the product should be used.

## 6 CASE STUDIES

These case studies present an overview of two of the seven large scale demonstration trials established by the Hawkesbury Nepean CMA aimed at evaluating the potential for composted soil conditioners and mulches to restore degraded land in the catchment.

### 6.1 Using compost to repair dryland salinity

#### 6.1.1 Location

'Bibaringa' was a wool production property, which was sub-divided into small rural holdings consisting of mixed farming enterprises. The site is located 1 km South of Tarago on the Southern Tablelands of NSW.

#### 6.1.2 Site details

The project site (5 ha) comprised severe salt scalds with an  $EC_{1.5}$  of 5.4 dS/m. This high salt concentration had resulted in vegetation loss, as well as severe sheet and rill erosion (up to 0.5 metre deep) with saline discharge from the site draining directly into the Mulwaree River 200 metres downstream.

#### 6.1.3 Strategies and treatments

Structural works including: diversion banks, gully control structures and outlet banks were designed and implemented on site to control surface water runoff and prevent further sheet and rill erosion. These works were followed by the application of composted soil conditioners and mulches applied at depths of 25-30 mm and 20-50 mm, with 1840 m<sup>3</sup> of soil conditioners and mulches being used in total.

#### 6.1.4 Site preparation and product application

1. Salt scalded areas were deep ripped, shaped and mounded in preparation for seeding with a salt tolerant pasture mix and tree planting.
2. Composted soil conditioners with a particle size of <15 mm and mulches with a diameter of 15-40 mm were applied using a chain driven spreader (Figure 13).
3. Soil conditioners were surface applied, followed by a salt tolerant pasture mix and fertiliser. Incorporation of these products was carried out using harrows. Composted mulch was then surface applied over the site. These products were procured against the specifications defined in Tables 2-6.

**Figure 12.** A chain driven spreader was used to apply the composted soil conditioner and mulch to a depth of 25-30 mm.



## 6.1.5 Costs

The costs associated with purchasing and applying the composted soil conditioner, mulch, pasture seed mix and fertiliser, as well as undertaking ripping and shaping were approximately \$64,300. These costs do not include the erosion control works undertaken at the site.

## 6.1.6 Results

Significant short term changes occurred on the site with enhanced vegetation establishment the most significant (Figure 14). Other results from the application of the composted soil conditioners and mulches included:

- Enhanced and rapid vegetation establishment
- Soil stability on disturbed areas
- Soil moisture retention
- Prevention of sheet and rill erosion.

**Figure 13. Salt affected land prior to (left, 2/3/2005) and 8 months after (right, 23/11/2005) compost application at the 'Bibaringa' demonstration trial site.**



Prior to project commencement testing was conducted to gain a better understanding of the type and concentration of salts present at the site. The soils present on the site consisted of a metasediment sandy loam soil which was sodic (ESP 54%), mildly acidic (pH 6.20) and low in organic matter (0.94%) (Table 12). Soil samples were collected from the same area 18 months after the composted soil conditioners and mulch were applied.

Soil quality at the site had improved considerably, whereby:

- $EC_{1:5}$  had decreased from 5.4 to 4.0 dS/m
- Exchangeable sodium percentage (ESP) had decreased from 54 to 14%
- Soil  $pH_{1:5}$  ( $CaCl_2$ ) had increased from 6.2 to 7.1
- Soil organic carbon had increased 0.94 to 1.4 % (Table 12).

**Table 13. Summary of soil chemical characteristics from 'Bibaringa' demonstration site pre- and post-application of composted soil conditioners and mulch.**

Soil parameter	Pre-application	18 months after application
EC <sub>1:5</sub> (dS/m)	5.4	4.0
pH <sub>1:5</sub> (CaCl <sub>2</sub> )	6.2	7.1
Organic carbon (%)	0.94	1.4
Exch. Al (cmol <sub>c</sub> /kg)	<0.1	<0.1
Exch. Ca (cmol <sub>c</sub> /kg)	2.4	5.6
Exch. K (cmol <sub>c</sub> /kg)	0.16	0.54
Exch. Mg (cmol <sub>c</sub> /kg)	11	2.8
Exch. Na (cmol <sub>c</sub> /kg)	11	1.5
CEC (cmol <sub>c</sub> /kg)	29	10.5
ESP (%)	54	14

## 6.2 Using compost to repair severe gully erosion

### 6.2.1 Location

This demonstration site was located at Big Hill, approximately 25km north of Marulan on the Southern Tablelands. The property consists of 40ha which had formerly been part of a large sheep and wool property.

### 6.2.2 Site details

The project site consisted of a series of severely eroded drainage lines, with gullies up to 4 metres deep draining into the Wollondilly River 2km downstream. The soils on the site were derived from decomposed granite, known to be both sodic and acidic and as such characterised as possessing a high sheet and rill erosion hazard.

### 6.2.3 Strategies and treatments

Structural works including: diversion banks, flumes, gully shaping and revegetation were designed and implemented on the site to control surface water runoff and prevent further erosion of active gully heads. A total of 660m<sup>3</sup> of composted soil conditioner and mulch was applied to the site. Composted soil conditioner (0-15mm) was applied at 30 mm depth, followed by composted mulch (15-40 mm) applied at 20 mm depth. In some areas a 40/60 (ratio) blend of composted soil conditioner and mulch was applied to a depth of 50 mm.

### 6.2.4 Site preparation and product application

- Erosion control works were constructed, followed by the application of composted soil conditioners and mulches to the disturbed gully areas and earthworks.
- Due to the steepness of batters and flumes, composted soil conditioners were spread using an excavator and bulldozer.
- Composted mulches and the 40/60 composted blend were applied using a truck-mounted spreader (Figure 8).
- Incorporation of composted soil conditioners was carried out using harrows.
- All sites were seeded with a pasture mix and fertiliser.
- Composted mulch was applied on top of the areas treated with composted soil conditioner.

### 6.2.5 Costs

The costs associated with purchasing and applying the composted soil conditioner, mulch, pasture seed mix and fertiliser, as well as undertaking ripping and shaping were approximately \$22,100. These costs do not include the erosion control works undertaken at the site.

## 6.2.6 Results

Significant short term changes occurred on the site, particularly in relation to vegetation establishment (Figure 15). Other results from the application of the composted soil conditioners and mulches included:

- Soil stability on disturbed areas
- Good soil moisture retention
- Rapid vegetation germination
- Increased percentage ground cover, compared with conventional straw mulching.

**Figure 14. Gully erosion before (left, 8/4/2005) and 8 months after (right, 8/12/2005) compost application at the 'Big Hill' demonstration site.**



# 7 REGULATORY AND STATUTORY CONSIDERATIONS

It is important to consider regulatory and statutory requirements when planning projects that aim to use composts for rehabilitating degraded land.

## 7.1.1 *Waste Avoidance and Resource Recovery Act 2001*

The objectives of this Act, which is administered by the Department of Environment and Climate Change NSW, are to:

- (a) encourage the most efficient use of resources and to reduce environmental harm in accordance with the principles of ecologically sustainable development
- (b) ensure that resource management options are considered against a hierarchy of the following order:
  - (i) avoidance of unnecessary resource consumption
  - (ii) resource recovery (including reuse, reprocessing, recycling and energy recovery)
  - (iii) disposal.
- (c) to provide for the continual reduction in waste generation
- (d) to minimise the consumption of natural resources and the final disposal of waste by encouraging the avoidance of waste and the reuse and recycling of waste
- (e) to ensure that industry shares with the community the responsibility for reducing and dealing with waste
- (f) to ensure the efficient funding of waste and resource management planning, programs and service delivery
- (g) to achieve integrated waste and resource management planning, programs and service delivery on a State-wide basis
- (h) to assist in the achievement of the objectives of the *Protection of the Environment Operations Act 1997*.

As such, this Act encourages the diversion of organic wastes from the waste stream destined for landfill to be beneficially re-used and recycled into other products such as composted mulches and soil conditioners. This policy also encourages the production of mulches from recycled or waste products rather than new raw materials.

## 7.1.2 *Protection of the Environment Operations Act 1997*

The objectives of the *Protection of the Environment Operations Act 1997* (PoEO Act), which is administered by the Department of Environment and Climate Change NSW are to:

- (a) protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development
- (b) provide increased opportunities for public involvement and participation in environment protection
- (c) ensure that the community has access to relevant and meaningful information about pollution
- (d) reduce risks to human health and prevent the degradation of the environment by the use of mechanisms that promote the following:
  - (i) pollution prevention and cleaner production
  - (ii) the reduction to harmless levels of the discharge of substances likely to cause harm to the environment
  - (iii) the elimination of harmful wastes
  - (iv) the reduction in the use of materials and the re-use, recovery or recycling of materials
  - (v) the making of progressive environmental improvements, including the reduction of pollution at source
  - (vi) the monitoring and reporting of environmental quality on a regular basis.



- (e) rationalise, simplify and strengthen the regulatory framework for environment protection
- (f) improve the efficiency of administration of the environment protection legislation
- (g) assist in the achievement of the objectives of the *Waste Avoidance and Resource Recovery Act 2001*.

As a guiding principle the PoEO Act prohibits the pollution of air, land, soil and water, unless it is done in accordance with the conditions of an environment protection licence issued by the DECC. An environment protection licence is not required for applying quality composted garden organics mulches and soil conditioners to land, although it must be done in a manner which does not cause pollution.

The appropriate use of composts in catchment management can contribute towards meeting the objectives of the PoEO Act through reducing soil erosion and nutrient transport into water bodies, as well as improving soil structure and overall soil health.

## **Environmental Guidelines: Use and disposal of biosolids products**

The Environmental Guidelines: Use and Disposal of Biosolids Products (NSW Biosolids Guidelines) (NSW EPA 1997a), are administered by the Department of Environment and Climate Change NSW and provide a framework for determining the end use of biosolids products based on considering contaminant concentrations (e.g. heavy metals and organic compounds) and the level of stabilisation required for controlling pathogens.

Biosolids which are used in accordance with the requirements of the NSW Biosolids Guidelines are exempt from regulation under the PoEO Act. If composted soil conditioners or mulches contain biosolids then they must be managed in accordance with the NSW Biosolids Guidelines.

## ***Protection of the Environment Operations (Waste) Amendment (Waste on Land) Regulation 2005 (under the PoEO Act 1997)***

This regulation provides that it is an offence to apply any residue waste, or to cause or permit such waste to be applied, to any land that is used for a purpose related to the growing of vegetation, it also provides for the granting of exemption, both general and specific, in relation to activities involving residue waste.

**Residue waste** means any of the following substances (and includes any substance incorporating, mixed with or made from of the following substances):

- Fly ash or bottom ash from any furnace.
- Lime or gypsum residues from any industrial or manufacturing process.
- Residues from any industrial or manufacturing process that involves the processing of mineral sand.
- Substances that have been used as catalysts in any oil refining or other chemical process.
- Foundry sands and foundry filter bag residues.
- Residues from any industrial or manufacturing process that involves the refining or processing of metals or metallic products.
- Any substance that is hazardous waste, industrial waste or Group A waste i.e. Non-aqueous liquid waste or Controlled aqueous liquid waste.

If a composted product contains any residue wastes and it is to be applied to land, then proponents must apply to the Department of Environment and Climate Change NSW, for an exemption from this regulation.

## **Proposed 3F regulation**

The proposed 3Fs regulation will enable the DECC to approve exemptions from the waste regulatory framework (including requirements for licensing, levy payment and tracking) for wastes or waste derived materials used as fuel or applied to land, where it is demonstrated that the proposed application is of benefit, that the use is 'fit for purpose' and does not cause harm to the environment or human health.

For composts produced from source separated garden organics, an exemption might be facilitated through an appropriate quality control specification, where the development of such a specification considers:

- Potential contaminants in the source material
- How these potential contaminants will be assessed and monitored for
- How any contaminants will be managed through to the delivery of final outputs, including any conditions related to the use of those outputs.

This amendment to the legislative framework is aimed at providing certainty to those involved in resource recovery operations, allowing legitimate organisations applying waste to land, including waste derived composts, to establish their bona-fides. This will also provide industry with the significant benefit of clarifying where such activities are no longer required to be managed under the waste regulatory framework.

### 7.1.3 *Sydney Water Catchment Management Act 1998*

The *Sydney Water Catchment Management Act 1998*, which is administered by the Sydney Catchment Authority (SCA), allows areas of Sydney's drinking water catchment to be gazetted special areas in an attempt to protect the quality of stored waters and/or to maintain the ecological integrity of a parcel of land. The SWCMA Act and Regulation controls access and activities in SCA's 'Special Areas'.

### 7.1.4 *Drinking Water Catchments Regional Environmental Plan No. 1*

Drinking Water Catchments Regional Environmental Plan No. 1, which is administered by the NSW Department of Planning, prohibits the application of biosolids or composts containing biosolids (except those that are unrestricted in their use), from being applied within other areas of the Sydney drinking water catchment unless development consent is obtained from the approval authority. Composts which contain biosolids, but meet the requirements for Unrestricted use in the NSW Biosolids Guidelines (NSW EPA 1997a) and composts derived from source separated garden organics and complying with AS4454-2003, can be used within the Sydney catchment without the need for approvals from the Department of Environment and Climate Change NSW, Department of Planning or Sydney Catchment Authority.

### 7.1.5 *Plant Disease Act 1924*

The *Plant Disease Act 1924*, which is administered by the NSW Department of Primary Industries, aims to prevent the introduction into New South Wales of diseases and pests affecting plants or fruit, to enable the eradication of such diseases and pests, and to prevent the spread of these pests and disease.

Therefore any person without reasonable excuse who sells/brings onto/removes from a person's premises, plant/fruit/covering/thing of any nature whatsoever with the knowledge that the plant/fruit/covering/thing:

- (i) is infected or is likely to convey infection, or
- (ii) was imported, introduced or brought into New South Wales or any part of New South Wales in contravention of a provision of a proclamation, notification or undertaking made or given under this Act,

is guilty of an offence.

This means that the transportation of viable disease or pest material in composted material is an offence. Composts produced to AS4454-2003 and specifications set out in this guideline undergo a pasteurisation phase to ensure that viable pests, pathogens and disease are destroyed during the composting process.

## **Phylloxera Compliance Agreement (CA 05)**

As part of the *Plant Diseases Act 1924*, restrictions have been placed on the movement of machinery and materials in an attempt to control the spread of the *Phylloxera*, an aphid like insect of concern to the grape and viticulture industry. The movement of uncomposted garden organics is prohibited from the Sydney Region Infested Zone (SRIZ). The SRIZ is bounded to the north by the Hawkesbury River and to the west by the Nepean River and extends southward to and includes the Local Government Area of Wollongong and the portion of Wollondilly within the counties of Cumberland and Camden.



Under revised regulations gazetted on the 22 December 2006 (as Proclamation P176 under the *Plant Disease Act 1924*, garden organics are only allowed to be moved from the SRIZ into the rest of New South Wales only if the material has been:

- a) composted or pasteurised in accordance with Australian Standards AS 4454 (2003)
- b) packed into a sealed container
- c) the container and transport vehicles has been cleaned free of soil and organic matter
- d) and the consignment accompanied by a Plant Health Certificate issued by a NSW DPI Regulatory Officer or under a Plant Health Assurance Certificate (if the business is accredited by NSW DPI under Compliance Agreement (CA-05)) certifying that all the applicable conditions of movement have been met and specifying the origin of the garden organics.

Specific information on the treatment and movement of garden organics and accreditation Compliance Agreement CA-05 can be obtained by contacting the Plant Biosecurity and Risk Management Unit, NSW DPI, Orange NSW telephone 02 6391 3174.

### 7.1.6 *Noxious Weeds Act 1993*

The objects of this Act, which is administered by the NSW DPI, are to:

- (a) reduce the negative impact of weeds on the economy, community and environment of this State by establishing control mechanisms to:
  - (i) prevent the establishment in this State of significant new weeds
  - (ii) restrict the spread in this State of existing significant weeds
  - (iii) reduce the area in this State of existing significant weeds.
- (b) to provide for the monitoring of and reporting on the effectiveness of the management of weeds in this State.

A person (including a public authority) must not sell or purchase:

- (a) any notifiable weed material or other noxious weed material prescribed by the regulations
- (b) any animal or thing which has on it, or contains, notifiable weed material or other noxious weed material prescribed by the regulations, knowing it to be, or to have on it or to contain, any such weed material
- (c) a person must not scatter or cause to be scattered on any land or water any notifiable weed material or other noxious weed material prescribed by the regulations, knowing it to be such weed material.

An occupier of land (including a public authority) must not:

- (a) knowingly remove or cause to be removed from the land any animal or thing which has on it, or contains, notifiable weed material or other noxious weed material prescribed by the regulations
- (b) use or permit the land to be used for the purpose of disposing of, transporting or selling soil, turf or fodder, if the occupier knows, or ought reasonably to know, that there is a weed on the land that is a notifiable weed in any part of the State.

Composts meeting AS4454-2003 have undergone a pasteurisation phase to ensure the destruction of all viable plant propagules and seeds, including noxious weeds, which may be present in the initial garden organics feedstock.

## 8 FURTHER INFORMATION

### 8.1 Department of Environment and Climate Change NSW

Sustainability Programs Division  
Department of Environment and Climate Change NSW  
PO Box 644, Parramatta NSW 2124

Tel: (02) 8837 6000  
Fax: (02) 8837 6099  
sustainability@environment.nsw.gov.au  
www.environment.nsw.gov.au

### 8.2 NSW Department of Primary Industries

Centre for Recycled Organics in Agriculture  
NSW Department of Primary Industries  
PMB 8, Camden NSW 2570

Tel: (02) 4640 6333  
Fax: (02) 4640 6300  
www.dpi.nsw.gov.au

### 8.3 Hawkesbury Nepean CMA

Hawkesbury Nepean Catchment Management Authority  
Locked Bag 2048, Goulburn NSW 2580

Tel: 4828 6747  
Fax: 4828 6750  
www.hn.cma.nsw.gov.au

### 8.4 Standards Australia

Standards design, development and innovation promotion:  
[www.standards.org.au](http://www.standards.org.au)

Finding a list of certified suppliers, buying standards and searching the catalogue:  
[www.saiglobal.com/shop](http://www.saiglobal.com/shop)

### 8.5 Compost Australia

For information on suppliers who have quality assured systems:  
[www.compostaustralia.com](http://www.compostaustralia.com)

### 8.6 RO Library

For more information on composted mulches, soil conditioners and other types of recycled organics:  
[www.rolibrary.com](http://www.rolibrary.com)

### 8.7 Department of Lands

For more information on soil conservation earthworks and project management:  
[www.lands.nsw.gov.au](http://www.lands.nsw.gov.au)

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# 10 GLOSSARY

**Table 14. Definitions of terms used in these guidelines (Recycled Organics Unit (2003a), <sup>A</sup>Semple and Johnston (2007), <sup>B</sup>Standards Australia (2003a) and <sup>C</sup>Centre for Land Rehabilitation (2007)).**

<b>Term</b>	<b>Definition</b>
Biosolids <sup>B</sup> (sewage sludge)	Solid, semi-solid or slurry material produced by the treatment of sewage
Catchment management	Works and management practices to improve soil quality, vegetation and water quality on lands that are part of water catchment areas. Works often involve the rehabilitation of eroded or degraded agricultural land in water catchments such as gullies, saline/sodic discharge lines and land affected by sheet erosion
Compost <sup>B</sup>	An organic product that has undergone controlled aerobic and thermophilic biological transformation to achieve pasteurisation and a specified level of maturity. Optimum process conditions will need to be followed if compost that conforms with AS4454-2003 is to be produced
Composting <sup>B</sup>	The process whereby organic materials are microbiologically transformed under aerobic conditions for a period of not less than 6 weeks, which includes a pasteurization phase
Composted mulch	Any pasteurised product, which has undergone composting for not less than 6 weeks (excluding polymers, which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Composted mulch has at least 70% by mass of its particles with a maximum size of greater than 16 mm
Composted soil conditioners	Any composted product, including vermicast, manure and mushroom substrate that is suitable for adding to soils. This term also includes 'soil amendment', 'soil additive', 'soil improver' and similar terms, but excludes polymers, which do not biodegrade, such as plastics, rubber and coatings. Soil conditioner has not more than 20% by mass of particles with a maximum size above 16 mm
<sup>A</sup> Degradation of land.	Salinisation, acidification, sedimentation, structural breakdown and other problems
<sup>B</sup> Fine mulch	Any pasteurised or composted organic product (excluding polymers that do not degrade, such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Fine mulch has more than 20% but less than 70% by mass of its particles with a maximum size above 16 mm and complies with the appropriate criteria in Table 3.1 of AS4454-2003
Garden organics	The garden organics material definition is defined by its component materials including: Putrescible garden organics (grass clippings); non-woody garden organics; woody garden organics; trees and limbs; stumps and rootballs. Such materials may be derived from domestic, commercial, industrial and demolition sources. Garden organics is one of the primary components of the compostable organics stream
Land rehabilitation	Works and management practices to improve soil quality, vegetation and water quality on lands that are not in close proximity to water catchment areas. Works often involve the rehabilitation of land such as mine sites, quarries etc
Manure <sup>B</sup>	Any organic product composed mainly of animal excreta, which has undergone either the 'composting' or 'pasteurization' processes defined in this glossary
Pasteurization <sup>B</sup>	A process whereby organic materials are treated to significantly reduce the numbers of plant and animal pathogens and plant propagules
Pasteurized product <sup>B</sup>	An organic product that has undergone 'pasteurization' as defined in this glossary but is relatively immature and lacking in stability
Plant propagule <sup>B</sup>	Plant or part of a plant that could generate a new plant, e.g. a seed, part of a rhizome, corm, bulb, etc
Recycled organics	The term recycled organics has been adopted as a generic term for a range of products manufactured from compostable organic materials (such as garden organics, food organics, residual wood and timber, biosolids and agricultural organics)

# 11 ACRONYMS AND ABBREVIATIONS

AS4454	Australian Standard for composts, soil conditioners and mulches
BSC	blended soil conditioner
CEC	cation exchange capacity
CMA	Catchment Management Authority
CROA	Centre for Recycled Organics in Agriculture
DECC	Department of Environment and Climate Change NSW
EC	electrical conductivity
ESP	exchangeable sodium percentage
MACC	maximum allowable contaminant concentration
mg/kg	milligrams per kilogram
N	nitrogen
NATA	National Association of Testing Authorities
NH <sub>4</sub> <sup>+</sup> -N	ammonium-nitrogen
NO <sub>3</sub> <sup>-</sup> -N	nitrate-nitrogen
DPI	NSW Department of Primary Industries
OC	organic carbon
OCPs	organochlorine pesticides
P	phosphorus
PCBs	polychlorinated biphenyls
pH	acid-alkaline balance
PoEO Act	<i>Protection of the Environment Operations Act (1997)</i>
RO	Recycled Organics
SEPP	State Environmental Planning Policy
SC	soil conditioner
SCA	Sydney Catchment Authority
SWCM Act	<i>Sydney Water Catchment Management Act</i>





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