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environmental management for business

Licensing Unit,
Office of Licensing & Guidance,
Environmental Protection Agency,
Headquarters,
P.O. Box 3000,
Johnstown Castle Estate,
Co. Wexford.

Environmental Protection Agency
07 JUL ...

5th July 2005

RE: Notice in Accordance with Article 14(2)(b)(ii) of the Waste Management (Licensing) Regulations - Kings Tree Services Ltd - Reg. No. 218-1

Dear Sirs,

Please find enclosed, on behalf of Kings Tree Services Ltd, an original and 2 no. copies of Article 12 Compliance. Also enclosed is 2 no. copies of Article 12 responses on CD in pdf format as requested.

If you have any queries, please call me.

Yours sincerely,

Jim O'Callaghan

Jim O'Callaghan

0411701/JOC/PS
Encs.
c.c. Mr. Paddy King, Kings Tree Services Ltd.

email. info@ocallaghanmoran.com Website: www.ocallaghanmoran.com
O'Callaghan Moran & Associates. Registration No. 8272844U

ARTICLE 14(2)(B)(II) FURTHER INFORMATION

PARTICULARS AND EVIDENCE FOR

KINGS TREE SERVICES LTD

WASTE LICENCE APPLICATION NO. 218-1

ARTICLE 12 COMPLIANCE

Prepared For: -

Kings Tree Services Ltd.,
Glaskenny,
Enniskerry,
Co. Wicklow.

Prepared By: -

O' Callaghan Moran & Associates,
Granary House,
Rutland Street,
Cork.

5th July 2005

environmental management for business

Article 14(2)(b)(ii) Further Information

Particulars and Evidence For

Kings Tree Services Ltd

Waste Licence Application No. 218-1

Article 12 Compliance

Prepared For: -

Kings Tree Services Ltd.,
Glaskenny,
Enniskerry,
Co. Wicklow.

Prepared By: -

O' Callaghan Moran & Associates,
Granary House,
Rutland Street,
Cork.

5th July 2005

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1. INTRODUCTION

In accordance with the Notice issued in accordance with Article 14(2)(b)(ii) of the Waste Management Licensing Regulations, Kings Tree Services Limited (KTS) has prepared the following information requested by the Environmental Protection Agency (Agency) in relation to the application for a Waste Licence, Application Register No. 218-1, for a green waste composting facility at Coolbeg, Co. Wicklow.

Section 2 contains the responses to the various requests by the Agency. For ease of interpretation each of the requests are presented in italics followed by KTS's response.

2. ARTICLE 12 COMPLIANCE REQUIREMENTS

1. *Please provide a site-specific risk assessment, based on clear, independent scientific evidence which shows that bioaerosol levels can be maintained at appropriate levels at the above proposed facility which may arise from the receipt, shredding, composting and storage of green waste. In your assessment, please provide evidence that this proposed operation will not have any negative impacts on the nearest sensitive receptor site i.e. the residential property that is in the vicinity of the proposed facility or any proposed development adjacent the site.*

A site-specific risk assessment which shows that bioaerosol levels will be maintained at appropriate levels is included in Appendix 1. The report concludes that the distance from bioaerosol generating areas of the site to the nearest sensitive receptors (all >200 m) and the measures specified in the proposed bioaerosol control plan will mitigate any potential negative impacts at each of the receptors.

2. *Please provide a description of any proposed mitigation measures (e.g. berms etc) pertaining to noise levels that might arise from the shredding and screening operations of green waste at this proposed facility taking into account any negative impacts on the nearest sensitive receptor site i.e. the residential property that is in the vicinity of the proposed facility or any proposed development adjacent to the site.*

Attachment E.5 of the Waste Licence Application and Section 6.5 of the Project Description that accompanied the application refer to noise prediction modelling. The modelling was conducted by AWN Consulting Ltd and the objective was to determine the likely impact of noise from the facility at the nearest noise sensitive locations. The results of the modelling are summarised in the application, but it appears that the full report was not included. A copy of the report, which takes into account local sensitive receptors, is included in Appendix 2 of this response.

The influence of a proposed dual carriageway which includes a proposed noise barrier between the site and the receptors to the east was not taken into account in the modelling, as it's precise location was not known at that time. It is however considered likely that the noise impacts from the site would be further reduced due to this noise barrier.

3. *Please provide a description of the proposed mitigation measures pertaining to dust arising from the shredding screening, composting and curing operations of green waste at this proposed facility taking into account any negative impacts on the nearest sensitive receptor site i.e. the residential property that is in the vicinity of the proposed facility or any proposed development adjacent the site.*

There is the potential for dusts generation during the pre-treatment (shredding) stage. The shredding unit will be fitted with a dust suppression system which will be activated when the shredder is in use.

The moisture content of the material during all stages of the composting process, including maturation and post composting screening will be maintained at a level that optimises the composting process. The windrow turner will be fitted with a water sprinkler system which will be used to maintain the moisture content in the windrows in the optimum range. This will minimise the potential for the generation of dusts during the composting process. The finished product will have a relatively high moisture content that will minimise the potential for dust emissions during the screening process and wind blow from the finished product stockpiles. In addition a dust suppression system will be fitted to the screen machine and will be activated if required during the screening.

The nearest residential property is located approximately 150 m north east of the north eastern boundary. It is proposed to use the northern and north eastern sections of the site for finished product storage and a maturation area. It is considered unlikely that there will be significant dust generation from these activities. The activity which has the greatest potential for dust generation i.e. the pre-treatment (shredding) will be located in the southern portion of the site approximately 350 m from the nearest residence. The impacts of dust from the proposed operations on the nearest residential property is considered to be negligible.

The Greenstar landfill is located downwind (west) of the KTS facility. The areas where Greenstar staff will be based i.e. the landfill footprint and the site administration offices are both greater than 400 m away from the site boundary. Considering the proposed mitigation measures, the facility location and prevailing wind direction it is considered unlikely that dust emanating from the facility will have a significant impact on the landfill.

4. *Please provide details on the method(s) that you propose to use to transfer water from the lagoon storage facility to the composting material in the windrows. Provide an estimate of the quantity of water that will be required in the composting process and how this amount fits into your water balance calculations as outlined on Page 21 of the Project Description proposal?*

The windrow turning machine will be fitted with water sprinkler nozzles, which will be used to add water as required. These will be located on the arm of the machine, which goes across the top of the windrow and are supplied from a connection at the base of the machine.

Water will be removed from the leachate storage lagoon using a flexible hose and vacuum tanker. The tanker will be taken to the windrow machine using a tractor and the flexible hose connected to the windrow machine as required.

Water balance calculations were prepared to assess the likely volumes of leachate that will be generated in order to provide adequate storage capacity. As stated on Page 21 of the Project Description, the water balance calculations assume that no water is removed from the lagoon in the one week storage period and that there will be no evaporative losses. This assumption is made as a precaution against under sizing the leachate storage lagoon. The water balance calculations therefore remain unchanged.

In the event that leachate is not generated, as for example in dry periods, water obtained from the on-site groundwater abstraction well will be used to maintain the optimum moisture conditions in the windrows. The water will be applied in the same manner as that removed from the storage lagoon.

5. *Describe how and when (frequency of removal) the finished compost will be removed off-site and how do you propose to use the product?*

The product will be loaded loosely using a front end loader onto trucks for removal off-site to its final destination/end market. KTS anticipates that their existing customers for wood chips, which are generated in the tree services business, will accept finished compost product. KTS also expect to develop new markets including local authorities and possibly to supply the landscaping requirements of road construction projects in the locality. There are no proposals to bag any material as yet, but this option will be kept under review.

In the initial phase it is estimated that approximately 10 tonnes of finished product will be produced daily and one truck will be loaded with compost on average every 2 days. At the projected maximum annual production of 25,000 tonnes of finished product at a maximum of 100 tonnes/day, 5 trucks will be loaded with compost every day.

6. *On Page 8 of the non-technical summary under the heading Leachate, last sentence it is stated:* 'It is therefore considered that further mitigation measures are required'. *Please explain/clarify this statement.*

This sentence should read 'It is therefore considered that further mitigation measures are not required'.

7. *Will any of the Construction & Demolition wood waste contain biocide treated wood?*

It is not proposed to accept biocide treated wood at the facility.

Non-Technical Summary

The information supplied in response to this notice does not impinge on the non-technical summary.

APPENDIX 1

Bioaerosol Risk Assessment

Bioaerosol Risk Assessment

Kings Tree Services Ltd

Co. Wicklow

Waste Licence Application No. 218-1

Prepared For: -

Kings Tree Services Ltd.,
Glaskenny,
Enniskerry,
Co. Wicklow.

Prepared By: -

O' Callaghan Moran & Associates,
Granary House,
Rutland Street,
Cork.

5th July 2005

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1. INTRODUCTION

Kings Tree Services Ltd (KTS) have applied to the Environmental Protection Agency (Agency) for a green waste composting facility at Coolbeg, Co. Wicklow (Application Register No. 218-1). In a Notice issued in accordance with Article 14(2)(b)(ii) of the Waste Management Licensing Regulations, the Agency have requested the submission of a site-specific bioaerosol risk assessment which shows that the operation will not have negative impacts on the nearest sensitive receptors to the site and that bioaerosols can be maintained at appropriate levels.

This document provides an assessment of the risk of bioaerosol impacts of the greenwaste composting facility on nearest sensitive receptors. It includes a bioaerosol control plan that describes how bioaerosol levels will be maintained at appropriate levels at the facility.

The assessment is based on OCM's experience of composting processes with capacities ranging from 2,000 to 50,000 tonnes per annum and a review of national and international literature on composting facilities and specifically greenwaste composting.

2. PROJECT DESCRIPTION

2.1 Overview

The green waste will comprise wood wastes generated by the KTS tree surgery business, garden and park waste produced during improvement and maintenance works by landscape gardeners, grass and shrub trimmings produced by individual householders and timber and wood waste recovered during construction and demolition works. Biocide treated wood wastes will not be accepted at the facility.

The site encompasses approximately 2.5 ha and will be occupied by the compost process area, ancillary buildings including the reception office, workshop and weighbridge and parking areas. The composting process areas will comprise the waste reception area, windrows, maturation area, finished product storage and a leachate storage lagoon.

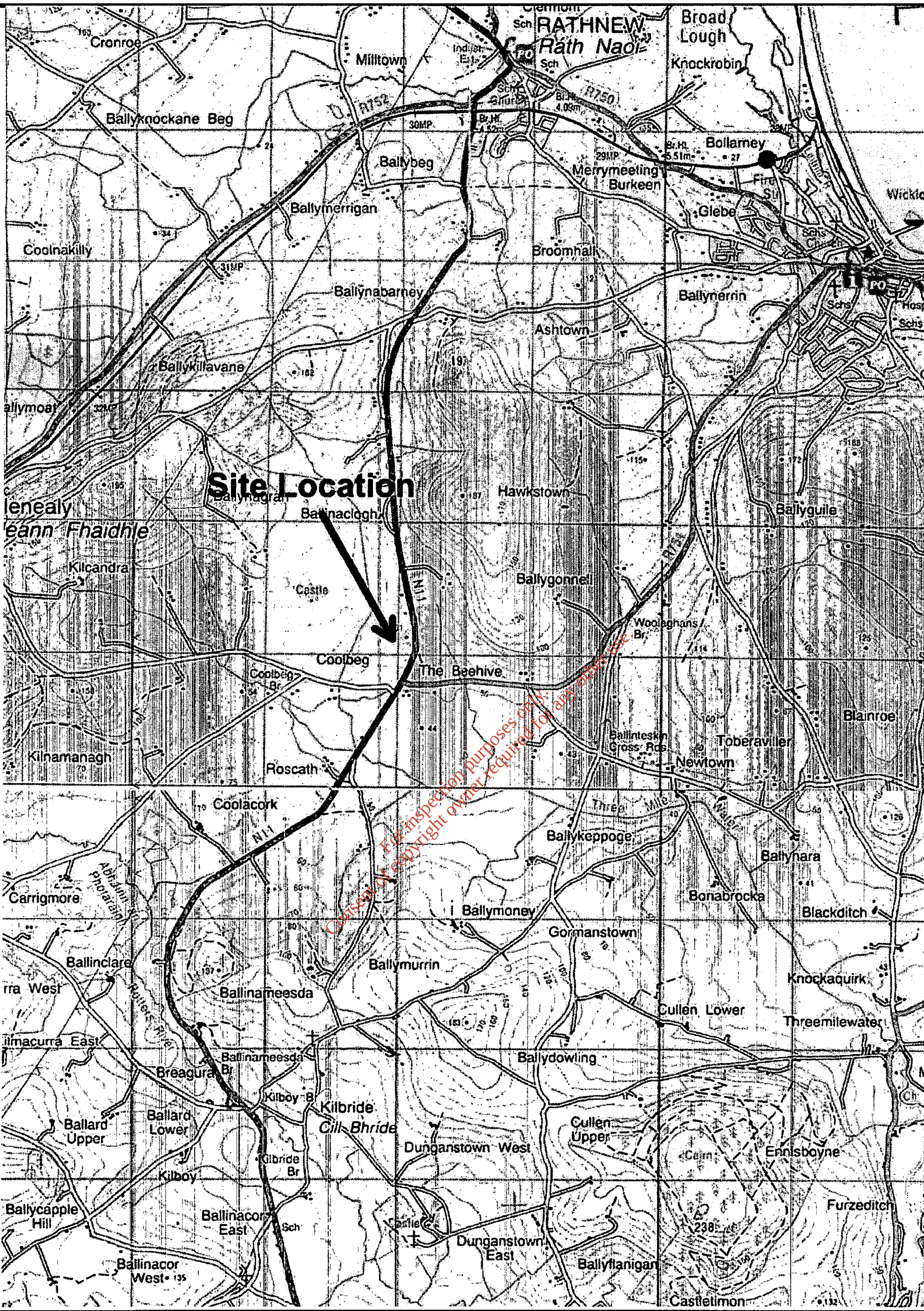
The composting operation will involve pre-treatment to shred and mix the green waste, composting in open windrows, maturation and post treatment screening to remove impurities. The finished product will be suitable for horticultural and agricultural use. When fully operational the facility will accept approximately 40,000 tonnes of green waste annually and produce approximately 25,000 tonne of compost. In the start-up phase it is envisaged that there will be an annual throughput of 4,500 tonnes of green waste.

2.2 Site Location

The site is located in a worked out sand and gravel pit approximately 4 km to the south west of Wicklow Town and 3 km to the south east of Glenealy, as shown on Figure 2.1. It is at an elevation of approximately 60 mOD.

2.3 Site Layout

The facility will be developed in two stages. Stage 1 will include the reception office (240 m^2), workshop (540 m^2) and weighbridge and parking areas, the waste reception area (c. 1250 m^2), windrows (c. 720 m^2), maturation area (700 m^2), finished product storage (c. 2375/2 m^2) and a leachate storage lagoon (1250 m^2). This stage is designed to process up to 4,500 tonnes of waste annually.



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CLIENT

Kings Tree Services

TITLE

Site Location

Details

O.S. Licence Agreement Number AR 0038702

Ordnance Survey Ireland. Government of Ireland.

FIG. No	
2.1	
Scale	Rev.
NTS	A

Stage 2 will involve the extension of the windrow area to ca 9500 m^2 to accommodate the processing of up to 40,000 tonnes of waste annually. The final site layout is shown on Drawing No. 1360-P1. The layout took into consideration the need to minimise the risk from potential sources of bioaerosol generation presented to off-site activities.

2.4 Compost Areas

2.4.1 Waste Reception

The Waste Reception Area will, at full capacity, encompass 1200 m^2. The area is designed to provide storage for up to 5 days intake at maximum production and to accommodate pre-treatment (shredding). It is estimated the peak delivery will be 200 tonnes per day, which is likely to occur in the spring, summer and autumn (April - October). This requires a storage capacity of 1000 tonnes.

2.4.2 Windrow

The Windrow Area, which will encompass 9,500 m^2 and at maximum capacity, will accommodate up to 15 individual windrows. In the initial stage it is envisaged that a single windrow will be operated. The windrow will be approximately 5 m wide, 2.5 m high and 50 m long. As waste inputs increase the length of the windrow will increase to a maximum of 107 m. Additional windrows will be provided, with a space of 1 m between each windrow.

2.4.3 Screening & Maturation

The Screening and Maturation area will encompass 700 m^2 at maximum capacity and is designed to accommodate 8 weeks storage.

2.4.4 Finished Product Storage

The Finished Product Storage area will encompass c 2375 m^2. It is designed to accommodate 8,000 tonnes of product.

2.5 Climate

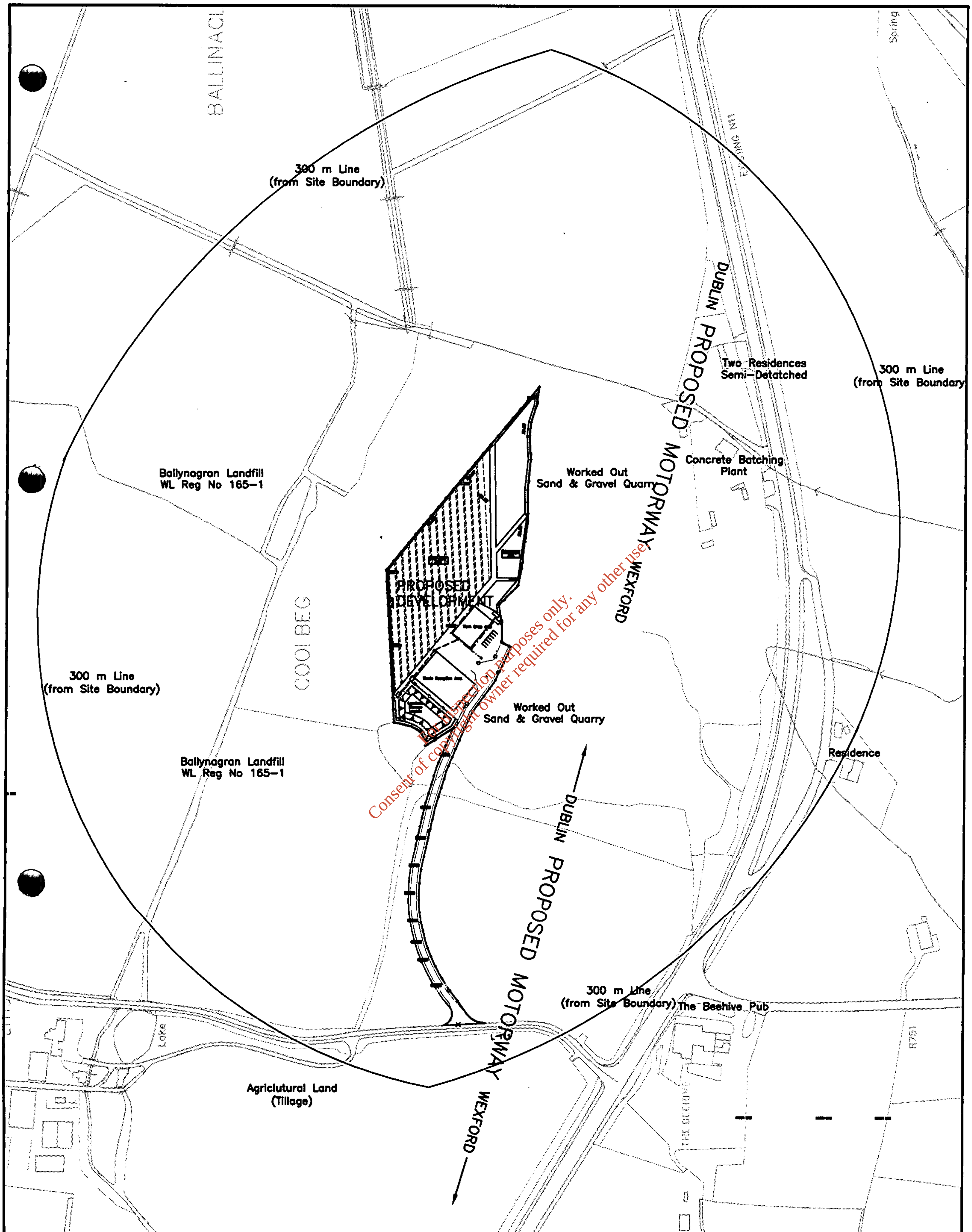
The description of the climatic conditions is based on meteorological data obtained from the Dublin Airport Meteorological Station located approximately 45 km to the north of the site (wind speed and direction, temperature and humidity) and the station at Glenealy County Wicklow (rainfall). Average rainfall, temperature, humidity and wind speed and direction are presented in Table 2.1. The climate is mild and wet, with the prevailing wind direction from the south west which occurs approximately 25% of the year. The wind rose for Dublin Airport is included in Appendix 1.

Table 2.1 Meteorological Data : Dublin

Rainfall –	
Annual average	732.7 mm
Average maximum month (Dec)	75.6 mm
Average minimum month (July)	49.9 mm
Temperature	
Mean Daily	9.6°C
Mean Daily Maximum (July)	18.9°C
Mean Daily Minimum (Feb)	2.5°C
Relative Humidity	
Mean at 0900UTC	82%
Mean at 1500UTC	72%
Wind (Knots)	
Frequency of calms	2.2%
Prevailing direction	South West: Approx. 25% of the Time
Prevailing sector	South West

2.6 Surrounding Land Use & Sensitive Receptors

There are three residential properties within 300 m of the site (Ref. Figure 2.2). The nearest properties (two semi detached houses) are approximately 150 m north east of the northern site boundary but are 350 m from the Shredding area and 220 m from the Screening and Windrow areas. These properties are surrounded by mature trees as can be seen in Photo 1 in Appendix 2. The third property is located across the N11 approximately 300 m to the east. The Beehive Public House is approximately 320 m to the south east of the southern site boundary.



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CLIENT	DETAILS	Fig No
Kings Tree Services Ltd		2.2
TITLE: Surrounding Landuse		SCALE: NTS / REV.: A

The nearest settlement to the site is the village of Glenealy located approximately 3 km to the north west of the site.

There is a concrete batching plant located approximately 180 m east of the site boundary, between the site and the N11. The plant is approximately 300 m from the Shredding area and 200 m from Windrow Area and the Screening and Maturation Area.

The lands to the north and west are currently in agricultural use, primarily tillage. The lands adjoining the western site boundary will be developed in the near future as a non-hazardous residual waste landfill. There will be a buffer of approximately 500 m between the footprint of the landfill cells and the site boundary. The administration offices serving the landfill will be located approximately 420 m from the western site boundary.

The site is currently accessed off the N11. Wicklow County Council proposes to upgrade this section of the N11 to dual carriageway standard as part of the provision of the Rathnew to Arklow Bypass. The upgrade will include the provision of a new access road and a four lane dual carriageway, which will run between the eastern site boundary and the existing route of the N11. The dual carriageway and associated landscape works will be located between the facility and the closest sensitive receptors i.e. the residences located to the north east and the concrete batching plant. The location of the proposed roadways is shown on Drawing No. P8A.

3. LITERATURE REVIEW - BIOAEROSOLS & GREENWASTE COMPOSTING

3.1 Introduction

OCM completed a search of national and international literature on composting, bioaerosol generation and control, and impacts. The search identified a number of recently published assessments of the international research and reports on the evaluation of risks presented by composting facilities, which OCM considers represents the most up to date information available.

These documents include publications by The Composting Association of Ireland (Cre), the UK Health and Safety Executive (HSE), the Department of Environment and Conservation (New South Wales) in partnership with The University of New South Wales as the recycled Organic Unit and UK Environment Agency (EA). In addition OCM reviewed a number of the primary research sources referenced in the above reports.

3.1.1 Cre

Cre published a literature evaluation of bioaerosol impacts from composting facilities. (Bioaerosols and Composting: A Literature Evaluation, 2004). The report is intended as a reference document for bioaerosol emission management at composting facilities in Ireland. Its conclusions are based on a comprehensive review of international literature on bioaerosol concentrations from composting facilities in Europe, the United States and elsewhere.

The report, which cites extensively from the published literature, includes an assessment of the potential health risks associated with bioaerosols and makes recommendations on measures to minimise bioaerosol generation. A copy of the report is included in Appendix 3 and relevant sections related to green waste composting are summarised below. To avoid confusion, where an extract from the document is cited it is attributed to Cre rather the authors of the particular research paper. The Cre report includes the full bibliography of the sources reviewed.

3.1.2 HSE

The HSE published 'A Critical Review of Published Data on Occupational and Environmental Exposure to Bioaerosols from Composts and Potential Health Effects' (2003).

The objective of the study was to critically review published literature related to studies of airborne micro-organisms or their constituent parts (bioaerosols) associated with organic waste composting facilities, and to establish whether there is a risk to worker health, neighboring facilities or residents, leading to health concerns. The review also looked at evidence of bioaerosol dissemination from sites, potential exposures and reported ill health.

3.1.3 ROU

The Department of Environment and Conservation (New South Wales) in partnership with The University of New South Wales as the Recycled Organics Unit (ROU) have prepared a report on Occupational Health and Safety and Commercial Composting including A Review of Potential Risks of Infection and Risk Management Strategies, March 2003. The report provides an overview of infection risks due to bioaerosols and organics dusts and recommendations of the appropriate training for facility staff on mechanisms to minimise impacts.

3.1.4 EA

OCM reviewed the position statement published by the Environment Agency in 2001 outlining its position in relation to health effects from composting. The statement is based on an research conducted by the Agency and the UK Department of the Environment Transport and the Regions and includes recommendations on buffer zones between composting facilities and workplaces and dwellings.

3.2 Types of Bioaerosol Exposure & Health effects

Bioaerosols are organisms or biological agents that can be dispersed through the air and affect human health. They can contain living organisms including bacteria, fungi, actinomycetes, arthropods and protozoa as well as biological products such as endotoxin, microbial enzymes, β-1,3 glucans and Mycotoxins (ROU 2003).

Composting is a natural process that involves the action of micro-organisms (fungi and bacteria) to breakdown the organic substrate. There is the potential for these bacteria and fungi to become airborne as bioaerosols. The average human inhales about 10 m^3 of air per day, consequently inhalation is the predominant route of human exposure and adverse health effects from bioaerosols.

A normal individual will inhale millions of bioaerosol or organic dust particles daily with many of these being potentially pathogenic. However, the vast majority of these inhaled particles will be deposited on airway surfaces, lodge in mucus and ultimately be cleared by the lungs. Only a small proportion of these particles will enter the deep lung where gas exchange takes place. The bodies defence system typically responds and generally combat any infection. However, the bioaerosols can cause inflammatory and allergic responses in certain individuals (ROU, 2003). The most common types of bioaerosols are discussed below.

3.2.1 Fungi and Aspergillus Fumigatus

During the handling of fresh green waste the micro-organisms present are predominantly the saprophytic "field" fungi such as Aspergillus fumigatus, which is a highly ubiquitous fungus. It has been associated with soil, crop plants, bird droppings, chicken roosts, cattle dung, horse dung, hay, fodder, corn, straw, grass and compost. It is also found on refrigeration and bathroom walls and building vent systems where moulds have had a chance to grow (Cre 2004).

Aspergillus fumigatus is an allergenic fungus and is an opportunistic pathogen which can cause aspergillosis (fungal growth in the lungs) in immunocompromised subjects. Healthy individuals are at minimal risk of infection from Aspergillus fumigatus whereas individuals with damaged lungs or compromised immune systems are more at risk (H&SE, 2003).

3.2.2 Actinomycetes

Actinomycetes are filamentous gram-positive bacteria that are commonly found associated with soil and plant materials. Thermophilic actinomycetes, with a growth temperature range of 30 to 60°c, thrive in wet compost that has begun the self heating process. Therefore, they can be used as indicator organisms for self heating of organic material and as indicator organisms for the presence of bioaerosols generated from compost (Cre 2004).

Thermophilic actinomycete species are recognised respiratory allergens. Actinomycetes produce thousands of very small spores (1 - 3 um diameter) which easily become airborne in large numbers when heavily colonised material is disturbed. Their small size means that they are potentially capable of penetrating deep into the human lung. They are primarily responsible for occupational allergic lung diseases such as Farmers Lung Disease and Mushroom Workers Lung Disease, which are forms of extrinsic allergic alveolitis (H&SE 2003).

3.2.3 Endotoxin

Endotoxins are constituents of gram-negative bacteria. Endotoxin is a macromolecule with a lipopolysaccharide core, which is found in the cell walls of all gram-negative bacteria. Gram-negative bacteria are present in the oral cavities and intestinal tracts of humans and animals; they also live on the surfaces of animals and plants. Consequently, the general population is exposed to low levels of environmental endotoxin and it is found in house dust (H&SE 2003).

Inhalation of endotoxin in large quantity can cause short term illness, with flu-like symptoms, fever, myalgia, and malaise. This is often termed inhalation fever or organic dust toxic syndrome (ODTS). This acute clinical symptom response occurs between 6 - 12 hours after exposure and lasts about 4 hours. Chronic exposure to endotoxin has been linked to work related symptoms such as inflammation leading to chronic bronchitis, chronic obstructive pulmonary disease and reduced lung function (H&SE 2003).

Endotoxin concentrations drop considerably when certain measures were taken (e.g. if the compost is moistened). There is also a good correlation between total respirable dust and endotoxin concentrations, indicating any measures taken to reduce dust would effectively reduce endotoxin concentrations (Cre 2004).

3.2.4 Glucans

Glucan is a polyglucose compound in the cell walls of fungi, some bacteria and plants. It is a potent inflammatory agent that induces non-specific inflammatory reactions and may also be a respiratory immunomodulatory agent. Glucans may be involved in contributing to the inflammatory responses resulting in respiratory symptoms and adverse lung function effects in response to the inhalation of bioaerosols. As it is present as a component of fungi, it will be present in compost and potentially therefore airborne dust associated with compost (H&SE, 2003).

3.2.5 Mycotoxins

Mycotoxins are non volatile low molecular weight toxic secondary metabolites produced by some species of fungi during their growth in organic materials. The most common route of exposure is by ingestion of fungally contaminated food. Aspergillus fumigatus produce mycotoxins which is usually present in the dust generated during the handling of compost. It has been suggested that mycotoxin exposure may contribute to occupational lung disease in workers exposed to organic dusts. It is considered that compost handling, like other industries such as grain and animal feed handling, could represent a theoretical hazard of mycotoxin exposure (H&SE 2003).

3.3 Levels of Bioaerosols in Ambient Environment

Bioaerosols are naturally present in the environment, and may occur naturally at levels similar to those found in waste facilities (EA 2002). A 1983 study found that in the absence of any significant bioaerosol sources, natural atmospheric conditions in a typical suburban gave rise to 0 - 7.2 x 103 (mean 273) cfu/m^3 mesophilic fungi, 0 - 193 (mean 2.1) cfu/m^3 thermophilic fungi, 0 - 71 (mean 1) cfu/m^3 Aspergillus. fumigatus, 42 - 1.6 x 10^3 (mean 79) cfu/m^3 bacteria. The highest concentrations occurred during summer and autumn (Cre 2004).

A 1998 found concentrations of viable airborne micro-organisms outdoors to be: 500 cfu/m^3 total bacteria, 10 cfu/m^3 Gram-negative bacteria, 1,200 cfu/m^3 total mesophilic fungi, 300 cfu/m^3 thermophilic fungi and 60 cfu/m^3 thermophilic bacteria and actinomycetes.

A 1978 study reported ambient levels of viable airborne bacteria in an agricultural area were as being, 2 - 3.4 x 10^3 (mean 99) cfu/m^3, and in a city 100 - 4.0 x 103 cfu/m^3 (mean 850) (HSE 2003).

3.4 Levels of Bioaerosols from Greenwaste Composting

A 2001 study of microbial emissions from a green waste composting site in the UK. Found that handling of green waste compost in the open generated levels of airborne bacteria which exceeded 106 colony forming units (cfu; a measure of culturable microbial cells) /m^3 air sampled on occasions. Levels of Gram-negative bacteria, fungi and actinomycetes each at times exceeded 105 cfu/m^3 air sampled. Levels of airborne bacteria were highest during shredding and turning, airborne fungi during screening and airborne actinomycetes during screening and shredding.

The HSE includes data from an investigation conducted by Hryhorczuk et al (1996; 2001) and Curtis et al (1999) who measured bioaerosol emissions from a green waste composting facility in Chicago. Concentrations of airborne bacteria, total fungal spores, endotoxin and beta glucans were significantly higher on-site than off-site, i.e., beyond the boundary fence 75 metres away from the nearest windrows. Levels of bacteria next to the compost windrows reached 7.9 x 104 cfu/m^3 and averaged 11,879 on-site, compared to 3,204 off-site. Total fungal spores reached 26,067 spores/m^3 (average 13,451 spores/m^3 on-site 8,772 spores/m^3 off-site), levels of viable fungi reached 1.8 x104 cfu/m^3. Mean total viable fungi were higher off-site than on-site (average 3,068 on-site, 8,651 off-site). Endotoxin levels on-site reached 6.06 ng/m^3 (60 EU/m^3) (average 1.94 ng/m^3 on-site, 0.14 off-site) and beta Glucans reached 14.45 ng/m^3 (average 2.17 ng/m3 on-site, 0.24 off-site).

3.5 Bioaerosol Dispersion

Bioaerosols are formed when the composting materials are agitated. Concentrations decrease to background when waste processing activities stop, indicating that windblown aerosolisation is insignificant (HSE 2003). As bioaerosols are small with low settling velocities they can be carried long distances by wind and thermal currents.

The pattern of dispersal from a composting facility is determined by a number of factors including the rate of emission, prevailing atmospheric conditions (e.g. wind speed and direction, temperature gradients, relative humidity) and local topography that determines the air flow around the site (HSE 2003).

The optimisation of bioaerosol (including dust and Aspergillus fumigatus) dispersal can be achieved through increasing the height of release and increasing the turbulence in the air flow thereby increasing the spread of the bioaerosols. Air turbulence can be increased by providing structures that impede the airflow. These can be walls or fences, or natural structures such as tree screens (Cre 2004).

A study carried out for the EA 2001 found that spore (fungi especially Aspergillus fumigatus) concentrations decreased by 80% to 90% from 20 m to 40 m from the source (composting facility) (Cre 2004). A 2002 study in the UK which monitored bioaerosols emissions from two composting facilities, one of which was an open green waste windrow process, found that levels decreased to background levels 200m from the site (HSE 2003).

3.6 Buffers

While there are a number of studies that investigated the fate of bioaerosols and dispersal patterns from the source there is limited information on minimum buffer distances that should be maintained between composting facilities and potentially sensitive receptors.

The EA's position on siting composting facilities is *"There will be a presumption against permitting [and to object to any planning application] of any new composting process [or any modification to an existing process] where the boundary of the facility is within 250 metres of a workplace or the boundary of a dwelling, unless the application is accompanied by a site-specific risk assessment, based on clear, independent scientific evidence which shows that the bioaerosol levels are and can be maintained at appropriate levels at the dwelling or workplace:"* (EA, 2001).

This approach is based on the findings of a study completed in 2001, which included a modelling exercise that assumed the bioaerosols had gaseous properties. The author of the study acknowledged that many of the bioaerosols formed aggregates large enough to demonstrate non-gaseous behaviours and it was suggested that the concentrations would decline at a greater rate with distance than the model predicted. However, the 250 m was taken to provide an additional factor of safety to the 200 m distance less suggested in other studies (HSE 2003).

Cre suggest that a 200 m distance would be particularly applicable to 'benign' feedstocks, e.g. greenwaste composting, but that this could be further reduced depending on control measures.

3.7 Mitigation Measures

There is international consensus that operational controls can effectively mitigate bioaerosol generation. These controls include: -

- Maintaining a proper composting environment. Regular and thorough mixing of windrows (2 - 3 times per week) to minimise the presence of *Aspergillus fumigatus*.
- Maintaining optimal moisture content in the windrows (50 - 60%.) Dust levels can be greatly reduced if moisture levels are maintained at optimal concentrations.
- Maintaining a clean site including access roads and storage areas and provision of a damping system to reduce dust generation from dry surfaces.
- Proper training of all facility operators in methods of dust and bioaerosol control.
- Arranging work rosters to ensure facility exposure to potentially high bioaerosol generating activities is minimized.
- Construction of windrows as high as possible, but not so as to reduce the efficacy of the composting process. The increased height of release of bioaerosols enhances dispersion. The windrows can also be used to create an effective barrier and to increase turbulence.

3.8 Conclusions

The literature review indicates that the potential health risks associated with bioaerosol generation at composting facilities to the general public are minimal and can be managed if the proper operational controls are applied. The risks to facility personnel can be minimised by the provision of appropriate training, personnel protective equipment and operational control measures.

There is limited consensus on buffers distances that must be maintained between green waste composting facilities and sensitive receptors. The literature review indicates that bioaerosols are reduced to background levels within 200 metres of composting facilities where source operational controls and the influence of barriers to air flow are not taken into account. Cre suggest that a 200 m distance would be particularly applicable to 'benign' feedstocks, e.g. greenwaste composting, but that this could be further reduced depending on control measures. The EA recommends a 250 m buffer.

Both Cre and the EA allow for a reduction the buffers based on evidence that bioaerosols can be maintained at appropriate levels at the sensitive receptors. Cre suggests that this can be achieved by the application of appropriate operational control measures and site specific factors such as impediments to air flow which can improve dispersion.

4. BIOAEROSOL CONTROL PLAN - COOLBEG

4.1 Introduction

A Bioaerosol Control Plan has been developed for the facility based on the source-pathway-receptor risk assessment model. The effective mitigation of the impacts on sensitive receptors requires the application of operational controls at the source that minimises the release to the pathway which is the air. The proposed measures for controlling emissions from the site and the factors affecting the movement of the bioaerosols along the pathway to the potential receptors are discussed below.

4.2 Location and Site Layout

4.2.1 Site Location

The site is located in a worked out sand and gravel quarry, which extends to the east and south of the property boundary. There are three residential properties within 300 m of the site. The nearest properties are approximately 150 m north east of the northern site boundary. The third property is located across the N11 approximately 300 m away to the east. The Beehive Public House is approximately 320 m to the south east of the southern site boundary. There is a concrete batching plant located approximately 180 m east of the eastern site boundary, between the site and the N11.

The lands adjoining the western site boundary will be developed in the near future as a non-hazardous residual waste landfill. There are mature hedgerows and small areas of woodland along the western site boundary. It is intended to maintain these hedgerows and woodland. There will be a buffer of approximately 500 m between the footprint of the landfill cells and the site boundary and the administration offices serving the landfill will be located approximately 420 m from the western site boundary.

4.2.2 Site Layout

The site layout was designed to maximise the distance between the potential sources of bioaerosols and potential receptors. The eastern side of the site will be used for finished product storage, maturation, car park and quarantine area, site buildings. There is the potential for bioaerosol generation during screening activities in the maturation area.

The southern and western portion of the site will be used for green waste reception and shredding, windrows and leachate storage. Of these areas there is the potential for bioaerosol generation from the shredding and the windrows turning.

4.3 Operational Controls

The following operational control measures will be employed at the facility: -

- Regular and thorough mixing of the Windrows (2 - 3 times a week) will be carried out to aid proper composting and minimise the presence of *Aspergillus fumigatus*. Temperature sensors will be placed at different locations and depths in each windrow. These will be monitored on a daily basis by KTS personnel to ensure that optimum temperatures are maintained.

- The optimal moisture content for windrows is 50 - 60%. Dust concentrations can be greatly reduced if moisture levels are maintained within the optimal levels. The windrows will be visually inspected on a daily basis to confirm the moisture level is in the optimum range. Leachate/contaminated run-off from the on-site leachate storage lagoon will be added to the windrow using the windrow turning machine as required to maintain optimum moisture levels.

- Maintaining a clean site to reduce dust generation. A flexible hose will be provided for use in damping down the site during dry weather conditions.

- All facility operators and compost workers will be trained in the appropriate methods of dust and bioaerosol control.

- The windrows will be as high as possible to, but not so as to reduce the efficacy of the composting process. The average height will be 2.5 m.

4.4 Abatement Measures

Apart from the operational measures described above the dust mitigation measures which will be employed at the facility have been shown to reduce bioaerosol dispersion. The measures include dust suppression systems on the shredder and screening machine and regular cleaning of the site. The specific shredder/screeners that will be used at the facility have not yet been purchased, but will include a sprinkler system.

4.5 Monitoring

Baseline dust monitoring has already been conducted at the facility and it is proposed to conduct monitoring at three locations on the property boundary biannually. It is proposed to conduct baseline bioaerosol monitoring prior to waste acceptance. The monitoring locations will, subject to the agreement to the owners, be at the site boundary and the nearest sensitive receptor i.e. the residential properties located to the north east of the facility boundary and the batching plant. It is also proposed to conduct bioaerosol monitoring once the facility is operational on an annual basis.

5. RISK ASSESSMENT

5.1 Introduction

The risk assessment is based on the likely emissions from facility, the proposed composting processes, site specific characteristics and the locations of the nearest potentially sensitive receptors i.e. the residential property to the north east, the concrete batching plant to the east and the proposed landfill development to the west.

5.2 Bioaerosol Impact Criteria & Potential

The concentration of bioaerosols declines with distance from the source due to atmospheric dispersion and dilution. Most published data indicate that bioaerosols are reduced to background levels within 250 metres of composting facilities. Studies have also shown that spore concentrations were reduced by 80% to 90% at a distance of 20 m to 40 m from the bioaerosol (spore) source.

In assessing the impact criteria therefore it is necessary to analyse the source-pathway-receptor process that will apply at the KTS facility. At maximum capacity the facility will process 40,000 tonnes of waste per annum and produce approximately 25,000 tonnes of compost. Dispersion of bioaerosols will occur through the air dependant on wind speed and direction and any obstacles which will impede air flow. The potential receptors site are the residential properties to the north east and east, the concrete batching plant to the east and the landfill to the west.

5.3 Site Location

The site is located in a worked out sand and gravel quarry, which extends to the east and south of the property boundary. There are three residential properties within 300 m of the site. The nearest properties are approximately 150 m north east of the northern site boundary but are 350 m from the Shredding area and 220 m from the Screening and Windrow Areas. These properties are surrounded by mature trees. The third property is located across the N11 approximately 300 m away to the east. The Beehive Public House is approximately 320 m to the south east of the southern site boundary.

There is a concrete batching plant located approximately 180 m east of the eastern site boundary, between the site and the N11. The plant is approximately 300 m from the Shredding area and 200 m from the Screening and Windrow Areas. The lands to the north and west are currently in agricultural use, primarily tillage.

The lands adjoining the western site boundary will be developed in the near future as a non-hazardous residual waste landfill. There are mature hedgerows and small areas of woodland along the western site boundary and it is intended that these will be maintained There will be a buffer of approximately 500 m between the footprint of the landfill cells and the site boundary and the administration offices serving the landfill will be located approximately 420 m from the western site boundary.

The site is currently accessed off the N11. Wicklow County Council proposes to upgrade this section of the N11. The upgrade will include the provision of a new access road and a four lane dual carriageway will be located between the facility and the closest sensitive receptors i.e. the residence located to the north east and the concrete batching plant.

5.4 Site Layout

The site layout was designed to maximise the distance between the potential sources of bioaerosols and potential receptors. The eastern side of the site will be used for finished product storage, maturation, car park and quarantine area, site buildings. There is the potential for bioaerosol generation during screening activities in the maturation area. The maturation area is approximately 220 m from the residential properties and approximately 200 m from the concrete batching plant.

The nearest residences are to the north east of the site and down prevailing wind. However, these are surrounded by trees which will aid the dispersal of any bioaerosols as a result of wind turbulence. The upgrade of the N11, which will result in the construction of a four lane dual carriage way and access road between the site and the residences, is also likely to result in air turbulence associated with landscape measures and vehicle movements.

The southern and western portion of the site will be used for green waste reception and shredding, windrows and leachate storage. Of these areas there is the potential for bioaerosol generation from the shredding and the windrows turning. The greenwaste reception and shredding area is located approximately 350 m from the residential properties and approximately 300 m from the concrete batching plant. The closest windrow to the receptors will be approximately 220 m from the residential properties and approximately 200 m from the concrete batching plant.

All of the potential sources of bioaerosol generation will be more that 400 m from the administration and operational areas of the landfill which will be developed on the lands to the west.

5.5 Site Activities

5.5.1 Waste Reception

Proper mixing of the material is important to allow for both a proper composting process and the production of compost with a consistent quality. Some green waste streams may contain relatively high or low concentrations of certain elements, e.g. nitrogen, sulphur. To prevent process disturbances (e.g. high C/N ratio), excessive emissions (e.g. ammonia, H_2S) and bad quality compost, proper mixing is essential. To achieve proper mixing certain waste streams (e.g. branches, timber, stumps) will be chipped/shredded.

There is a risk of bioaerosol generation during shredding. The shredder machine will be located in the southern portion of the site, approximately 350 m from the nearest residence. The shredder will be fitted with a dust suppression system to control dust emissions.

5.5.2 Windrow

The green waste will be placed on the ground at the front of the windrow using an industrial front-end loader. In the early stages of the process the windrow will be turned two to three times a week using a hydraulic excavator. The excavator will work through the composting section from the back-end to the front-end. It starts by removing the mature compost (at the back-end) to the compost refinement area, and subsequently move (turn) the material along the windrow. Once it has turned the whole composting section, the area at the front-end will be empty and ready for the intake of fresh green waste. The height of each windrow (approximately 2.5 m) will be kept constant over the total composting period.

It is considered unlikely that significant volumes of bioaerosols will be generated from the static windrows. There is however a risk of generation from the agitation of the windrow during turning. In order to minimise this, the moisture content will be maintained at the appropriate level. The windrow turning machine will be fitted with water sprinkler nozzles which will be used to add water during the mixing process as required.

The nearest windrow to receptors will be approximately 220 m from the residential properties, approximately 200 m from the concrete batching plant and greater than 400 m from operational areas of the landfill.

5.5.3 Screening & Maturation

Following the composting process, the material will be transferred to the maturation area, where it will be screened to remove impurities. The equipment used will comprise a mobile hopper/trommel system, with adjustable sieving plates in the trommel and dust suppression water sprinklers. The screening will be carried out 3 to 4 times a week. The screening area is approximately 220 m from the residential properties, approximately 200 m from the concrete batching plant and more than 400 m from operational and administration areas of the proposed landfill.

5.5.4 Finished Product Storage

The finished product will be stored on-site in the dedicated product storage area. The product will be loaded onto trucks for removal off-site to its final destination/end market. This activity will not be a source of bioaerosols.

5.6 Meteorological Data

The description of the climatic conditions is included in Section 2.5 and is based on meteorological data obtained from the Dublin Airport Meteorological Station located approximately 45 km to the north of the site (wind speed and direction, temperature and humidity) and the station at Glenealy County Wicklow (rainfall). The climate in the area of Coolbeg can be described as mild and wet, with the prevailing wind direction from the south west approximately 25% of the year.

5.7 Risk to Sensitive Locations

5.7.1 Residential Properties & Concrete Batching Plant

The nearest private residences are located generally down prevailing wind of the facility. The literature review indicates that bioaerosols are reduced to background levels within 200 metres of composting facilities where source operational controls and the influence of barriers to air flow are not taken into account. Cre recommend a buffer of 200 m between composting facilities and sensitive receptors and the UK Environment Agency recommends a 250 m buffer. However, it is recognised that site specific factors, including on-site bioaerosol control measures and local topographical and man made features will reduce bioaerosol emission rates and increase dispersion to atmosphere allowing for a buffer lower than 200 m.

The activity with the potential to cause the greatest bioaerosol generation, shredding, will be at least 350 m from the residential properties and 300 m from the concrete batching plant. The other activities with the potential to generate bioaerosols (windrow turning and screening) will be located at least 220 m from the residential properties and at least 200 m from the concrete batching plant.

The operational control procedures and abatement measures proposed for the facility which are described in the Bioaerosol Control Plan will minimise the rate of generation and emission if bioaerosols from the facility.

The prevailing wind is from the south west. The mature hedgerows and woodland along the western site boundary will induce turbulence in the air flow across the site. The perimeter fence and that surround the residences nearest the site will also contribute to air turbulence and enhance the bioaerosol dispersal rate. The proposed access road and dual carriageway, which will run between the site and the nearest receptors will also influence air flow patterns and dispersal rates.

5.7.2 Greenstar Landfill

The Greenstar landfill is located up prevailing wind of the KTS facility. The areas where Greenstar staff will be based i.e. the landfill footprint and the site administration offices are both greater than 400 m away form the site boundary.

5.8 Monitoring

Baseline dust monitoring has already been conducted at the facility and it is proposed to conduct monitoring at three locations on the property boundary biannually. It is proposed to conduct baseline bioaerosol monitoring prior to waste acceptance. It is also proposed to conduct bioaerosol monitoring once the facility is operational on an annual basis.

The monitoring locations will, subject to the agreement to the owners, be at the site boundary and the nearest potential receptors i.e. the residential properties located to the north east of the facility boundary and the batching plant. The monitoring data will be used to assess the efficacy of the facility's operational control measures in maintaining bioaerosols concentrations at ambient levels at the nearest potential receptors.

5.9 Conclusions and Recommendations

Cre concludes that a 200 m buffer between composting facilities and potential sensitive receptors is suitable to 'benign' feedstocks, e.g. greenwaste composting but that this could be further reduced depending on control measures and site specific features. The nearest residential properties are located at least 220 m from the potential bioaerosol generating areas. The concrete batching plant is located at least 200 m from the bioaerosol generating areas and the operational and administrations areas of the proposed landfill are greater than 400 m away.

The mature hedgerows and woodland along the western site boundary, the proposed perimeter fence and the trees surrounding the nearest receptors will all contribute to creating turbulence in the air flow across the site, which will enhance the dispersal rate of bioaerosols generated by the active.

A Bioaerosol Control Plan has been prepared for the facility which includes operational controls to minimise bioaerosol emissions levels and further reduce the bioaerosols to a level that presents negligible risk to the receptors. The influence of future works in the area, including landscape measures at the facility and particularly the construction of the dual carriageway between the facility and the nearest receptors will further reduce the risk. Routine dust and bioaerosol monitoring will be carried out at the nearest sensitive receptors to confirm that bioaerosols are at ambient levels.

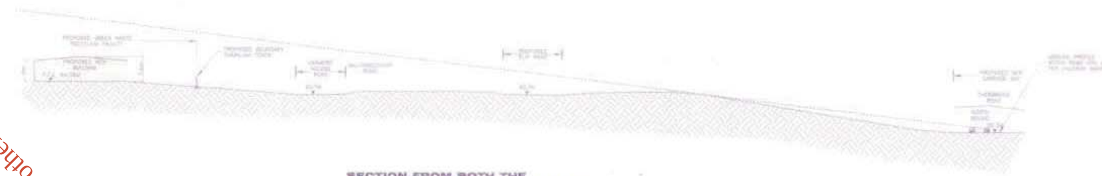
It is considered that, in the context of the site conditions, proposed composting activities and operational controls, the distances between the potential sources of bioaerosols and the potential receptors are adequate to achieve the necessary dispersion and dilution of bioaerosols to ambient levels at the receptors.

DRAWINGS

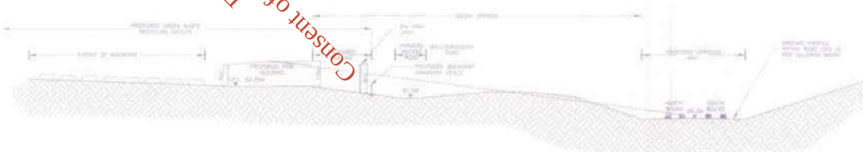
Drawing No. 1360-P1 - Site Layout

Drawing No. P8A - Proposed N11 Upgrade

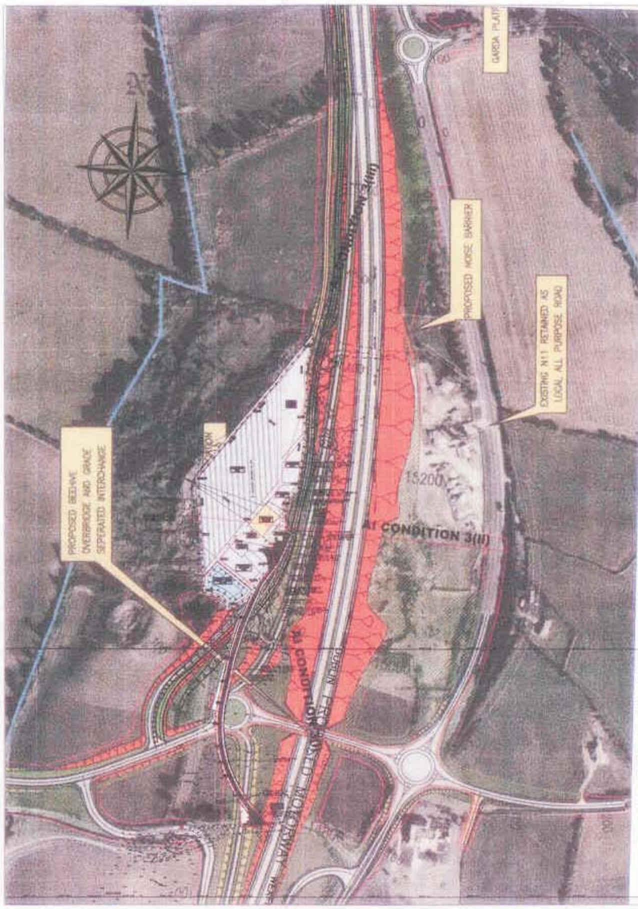
LONGITUDINAL SECTION FROM CHAINAGE 15 500m ON PROPOSED N11 TO PROPOSED GREEN WASTE RECYCLING FACILITY (AI CONDITION 3(III))



SECTION FROM BOTH THE PROPOSED CARRIAGEWAY AND THE OVERBRIDGE TO THE DEVELOPMENT (AI CONDITION 3(I))



CROSS SECTION THRU SITE OF PROPOSED N11 LOOKING NORTHWARDS (AI CONDITION 3(II))



PROPOSED SITE PLAN WITH PROPOSED NEW CARRIAGEWAY

A	ISSUED FOR ADDITIONAL INFORMATION	14-09-04
	AMENDMENT DETAILS	DATE

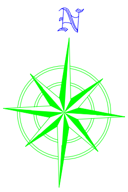
T.J.O'CONNOR & ASSOCIATES
CONSULTING ENGINEERS
CORRIG HOUSE, CORRIG ROAD, SANDYFORD, DUBLIN 18.
Tel: 295 2321 Fax: 295 4541

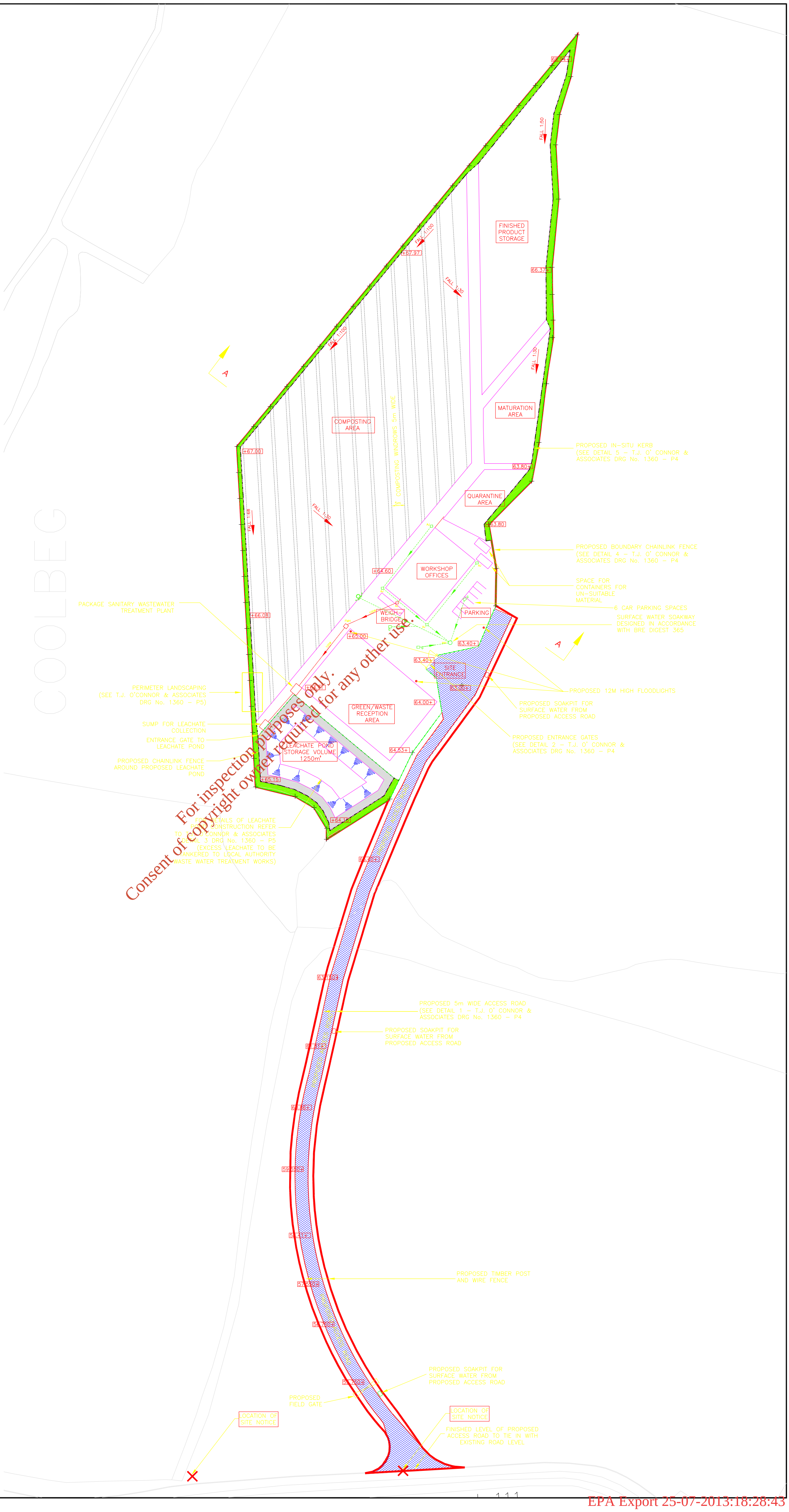
PROJECT: GREEN WASTE COMPOSTING CENTRE, COOLEBG, Co WICKLOW

CLIENT: AIKG TREE SERVICES LTD

DRAWING TITLE: VIEWS FROM PROPOSED N11 ROAD IMPROVEMENT SCHEME TO THE PROPOSED GREEN WASTE DEVELOPMENT

SCALE: 1:000 | JOB NO: 1360 | DRAWING NO: P8 A
DATE: | DRAWN BY: D.D.





LEGEND:

EXISTING SITE LEVEL	+67.00
PROPOSED FINISHED GROUND LEVEL	+67.00
PROPOSED WORKSHOP/OFFICES	
PROPOSED ASPHALT SURFACING (see detail 1 drg. no. 1360–p1)	
PROPOSED LANDSCAPING	
PROPOSED IN–SITU KERB	
PROPOSED CHAINLINK FENCE	
SITE BOUNDARY	
PROPOSED ACCESS ROAD	
BACK INLET GULLY TRAP	BIGT
ACCESS JUNCTION	AJ
PROPOSED FOUL SEWER	
PROPOSED SURFACE WATER SEWER	

NOTES:

1.) ALL LEVELS ARE IN METRES ABOVE ORDNANCE DATUM MALIN HEAD.

2.) FOR SECTION A–A REFER TO T.J. O'CONNOR & ASSOCIATES DRAWING No. 1360 – P2.

3.) FOR CONSTRUCTION DETAILS REFER TO T.J. O'CONNOR & ASSOCIATES DRAWING No. 1360 – P4.

	AMENDMENT DETAILS	DATE
	PLANNING ISSUE	18–06–04

T.J.O'CONNOR & ASSOCIATES
CONSULTING ENGINEERS
CORRIG HOUSE, CORRIG ROAD, SANDYFORD, DUBLIN 18.
Tel: 295 2321 Fax: 295 4541

PROJECT: GREEN WASTE COMPOSTING CENTRE, COOLBEG, Co.WICKLOW

CLIENT: KING TREE SERVICES LTD.

DRAWING TITLE: PROPOSED SITE PLAN

SCALE: 1:500 | **JOB NO:** 1360 | **DRAWING NO:** P1

DATE: JUNE'04 | **DRAWN BY:** D.D

APPENDIX 1

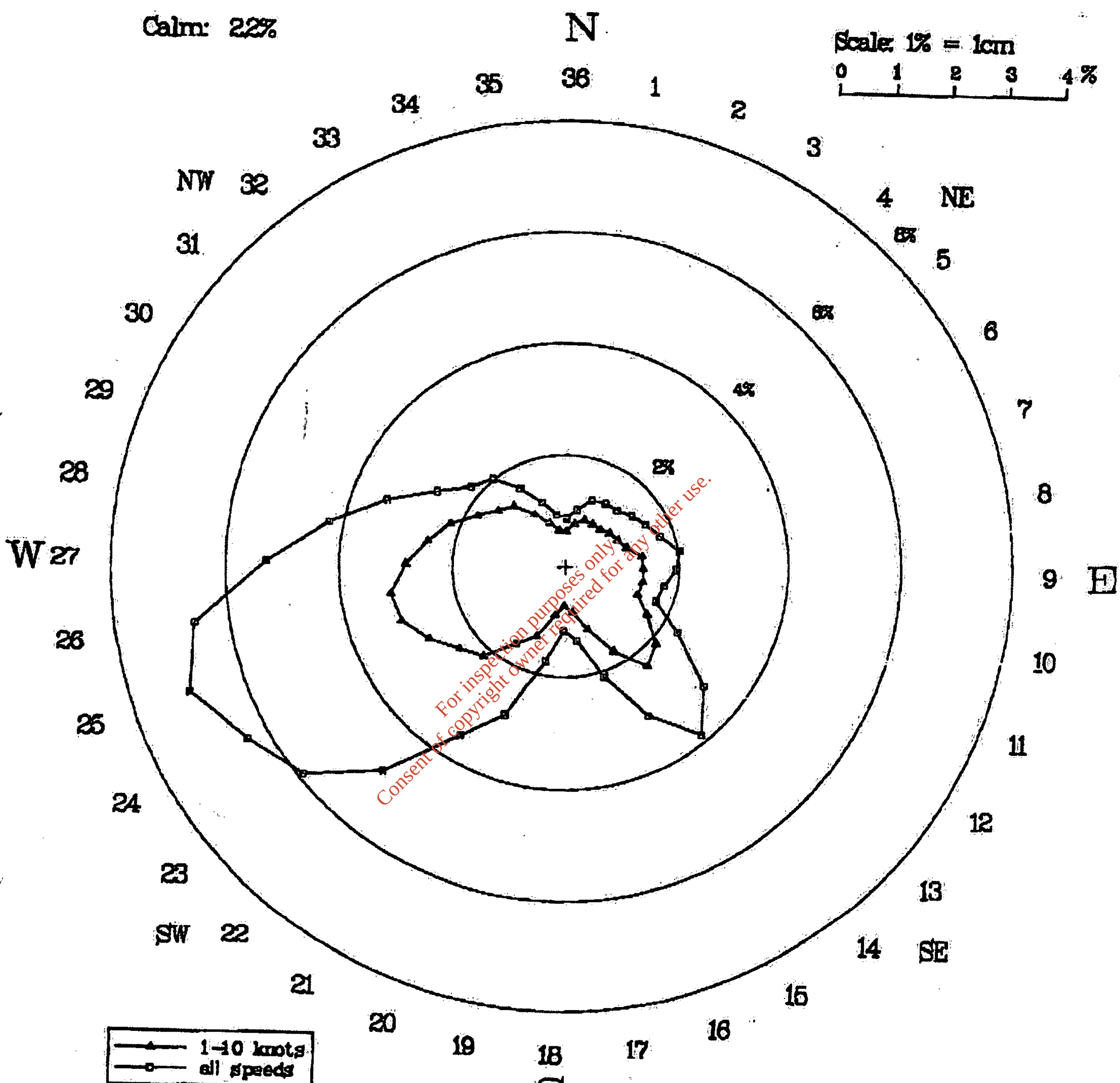
30 Year Dublin Wind Rose

6919712001

Percentage Frequency of Occurrence of Wind Directions

Calm: 2.2%

Scale: 1% = 1cm



Percentage Frequency of Occurrence of Wind Speeds

+ less than 0.1

0	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	over 48	knots
2.2	10.2	18.0	27.4	28.4	9.7	3.5	0.6	+	+	0.0	%

mean wind speed: 10.0 knots

anemometer height: 12m

standard deviation: 5.9 knots

Met Eireann, Glasnevin Hill, Dublin 9.

APPENDIX 2

Photograph

O' Callaghan Moran & Associates.
Granary House, Rutland Street,
Cork Ireland.
Tel. (021) 4321521 Fax. (021) 4321522
email : ocm@indigo.ie

CLIENT	Kings Tree Services Ltd
TITLE	Residential Properties
Details	© Ordnance Survey Ireland. Government of Ireland.
FIGURE NUMBER	Appendix 2
Scale	Not To Scale
Revision	A

APPENDIX 3

Bioaerosols and Composting: A Literature Evaluation, Cre 2004

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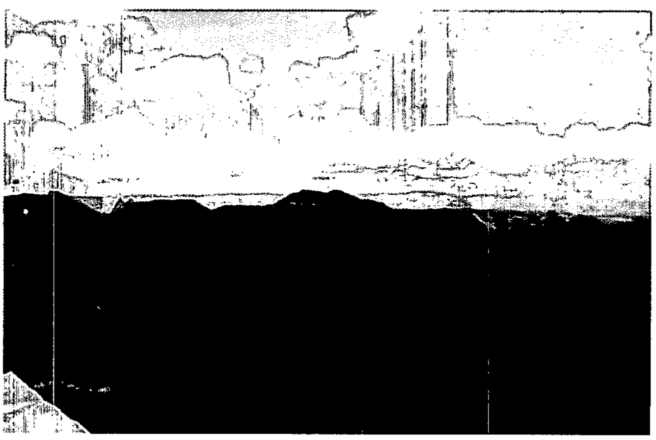
of IRELAND TEO

Bioaerosols and Composting

A Literature Evaluation



August 2004

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of IRELAND TEO

Bioaerosols and Composting

A Literature Evaluation

This report was part funded by the EPA

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Table of Contents

Recommended Reading

1. The Composting Association. Standardised Protocol for the Sampling and Enumeration of Airborne Micro-organisms at Composting Facilities. 1999.

2. Gilbert J.E. 1998. Health and Safety at Composting Sites. A Guidance Note for Site Managers. The Composting Association (UK) Pp 1-32.

3. Jensen, P. A., Schafer, M. P., 1998 Sampling and Characterization of Bioaerosols. NIOSH Manual of Analytical Methods. 82-112.

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List of Tables

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Chapter 1

Introduction

Composting is a microbiological process and during mechanical agitation of composting material, biological agents are aerosolised (i.e. become airborne), giving rise to the term 'bioaerosol'. Most of the composting done in Europe is done by open air windrow system, for instance in the UK and Denmark around 90% of composting is done by open air windrow. (Slater et al., 2001)

Bioaerosols are an issue in composting because of their potential negative impact on public or worker health. Occupational health and safety concerns and public health issues are varied. They include exposure to aerosols, primarily worker inhalation and also the potential for bioaerosols to migrate to areas beyond a facility perimeter and affect the nearby inhabitants. The predicted increase in large scale composting across Ireland over the next five years will result in increasing pressures being placed on the industry to identify new sites for composting facilities.

Bioaerosols of concern during composting consist of a range of micro-organisms (*Actinomycetes*, bacteria, fungi) and organic constituents of microbial and plant origin (Millner et al., 1994, Millner 1995). Focus to date has been on *Aspergillus fumigatus* (AF), fungus and bacteria. Fine dust is also very important as it is respirable and can affect the lung function of workers.

The responses to bioaerosols are host and dose dependent; that is some individuals may respond to a dose that does not affect others (Millner et al., 1994, Millner 1995).

Most reported cases of aspergillosis (the condition caused by *Aspergillus fumigatus*) have occurred in immuno-compromised individuals. Instances of aspergillosis in healthy individuals are rare, even when involved in occupations associated with exposures to high concentrations of airborne *Aspergillus fumigatus* (Millner et al., 1994, Millner 1995).

Other responses to bioaerosols can range from mild cases of inflammation and allergy to serious tissue or systemic infection by secondary pathogens (Millner et al., 1994, Millner 1995). Inflammation responses can include Mucous Membrane Irritation (MMI), Organic Dust Toxic Syndrome (ODTS) or Hypersensitive Pneumonitis (HP). Allergenic responses may stimulate inflammatory responses as well as a broad range of typical allergenic responses (e.g. mild itching, watery eyes/nose or asthma) (Millner et al., 1994, Millner 1995).

Endotoxins are the part of the outer layer of the cell wall of gram-negative bacteria. The primary concern with endotoxins is for workers. It was reported that there is little evidence to suggest that exposure to airborne endotoxins cause toxic conditions. (Millner et al., 1994, Millner 1995).

It is also important to note that bioaerosols are not exclusive to composting facilities. Bioaerosols may be found in non-occupational environments (e.g. home lawns, wooded areas, attics) and occupational environs (e.g. farms, mushroom production, timber processing and cotton processing) (Millner et al., 1994, Millner 1995).

Millner et al., 1994, Millner (1995), Poulsen et. al., (1995) and Ault and Schott, (1993) provide reviews on bioaerosols and composting.

In Ireland, the Environmental Protection Agency considers bioaerosol emissions as one of the potential negative impacts of composting facilities. It has recently requested some waste license applicants to submit a Bioaerosol Monitoring Plan as part of the information to be supplied with the application.

The objective of this study is to provide a comprehensive reference document for bioaerosol emission management in composting facilities in Ireland. This is based on exhaustive evaluation of international literature on bioaerosol concentrations from composting facilities, in Europe and elsewhere. An assessment is made of the potential health risks associated with bioaerosols at composting facilities. Sampling methodologies are presented. Recommendations are made on how to minimise bioaerosol generation through compost facility siting/design and site operation.

The scope of this paper does not extend to compost site odour.

Chapter 2

Bioaerosol Concentrations

2.1 Dust

The International Standardization Organization (ISO 4225-ISO, 1995), define dust as: 'small solid particles, conventionally taken as those particles below 75 μm in diameter, which settle out under their own weight but which may remain suspended for some time'. The Council Directive 1999/30/EC have defined PM_{10} as: 'particulate matter which passes though a size selective inlet with a 50% efficiency cut-off at 10μm aerodynamic diameter. There is very little information available on PM_{10} levels at composting sites in Europe.

Dust produced during composting is technically not a bioaerosol, but, it may carry microbial constituents. The dust at a composting facility can include bacteria, fungi, dry plant particles or insects, depending on the feedstock.

Dust at composting facilities can be produced during transportation, mixing, sieving, processing and storing of feedstock or finished product. The majority of dust generation at a composting facility is due to insufficient moisture in the composting material. Table 1 presents an overview of dust concentrations from a variety of activities at a number of composting facilities.

Dust concentrations have been reported between 0.1 to 12.0 mg/m^3 (Table 1) at composting sites reviewed, but are generally less than 2 mg/m^3. Dust concentrations may vary with various composting activities (e.g. grinding, turning, screening etc.). It has been shown that there is significant reduction in dust concentrations when there is sufficient moisture in the composting system. (Epstein et al., 2001).

At a large scale industrial and domestic waste plant in Germany, fine dust concentrations of greater than 6mg /m^3 were recorded for short periods when the waste was being delivered to the plant (Streib et al., 1996).

In a composting site in Colorado, it was reported that when the moisture level of the compost was increased the dust concentration dropped dramatically (Epstein et al., 2001). The concentrations of dust were highest during pile construction but surprisingly the concentrations were low during pile screening. However, results from Sweden have shown high concentrations of dust recorded in the pile screening area. (Millner 1995).

In a study conducted by one of the authors of the report, (van der Werf et al.,1996) dust concentrations were low 10 metres upwind and downwind of composting activities.

The National Authority for Occupational Safety and Health (Ireland) have set a 8 hour exposure limit of 10 mg/m^3 for non specific total inhalable dust and 4 mg/m^3 for total respirable dust. A 6 mg/m^3 over short periods fine dust concentration threshold has been suggested in Germany (Streib et al., 1996).

Table 1: Dust Concentrations Recorded at Various Composting Sites

Location	Type of Composting Facility	Recorded Concentrations(mg/m^3)	Comments	Reference
Sweden	Solid Waste Composting Facility (indoor and outdoor sites).	1×10^{-1} - 1.2×10^{1} airborne dust in screening area.	Median value 10.6 mg/m^3 in screening area. Not stated if enclosed facility or otherwise.	Millner (1995)
Netherlands	Source separated organic waste, food and yard waste. Indoor Composting Plant. Aerated Tunnels.	0.4-3.1 personal dust exposures.	Further details of site not specified.	Douwes et al., (1997)
Germany	285 tonne p.a. domestic waste. 1800.000 tonne p.a. domestic/industrial. Unsorted.	>6 x 10^{0} fine dust for short periods Generally much lower.	Threshold Concentrations 6 mg / m^3. Highest concentrations found in waste delivery.	Streib et al., (1996)
Colorado, USA.	Aerated Static Pile, Biosolid composting Enclosed Building 2800 tonne p.a.	Total Dust 5×10^{-1} - 2.47×10^{2} Respirable dust <2.5×10^{-1} – 1.47×10^{0}	Depends on process, season, and composting activity. There is a 90% reduction in concentrations if certain measures are undertaken i.e. increase moisture. Highest during pile construction.	Epstein et al., (2001)
		Feedstock Mixing: < 1.8×10^{-1} - 1.22×10^{0} respirable dust		
		Pile Construction: 1.47×10^{0} - 1.26×10^{0} – respirable dust		
		Pile Breakdown: <2.3×10^{-1} - 0.75×10^{-1} respirable dust		
		Pile Screening: <2.4×10^{-1} - <0.3×10^{-1} respirable dust		
Ontario, Canada	Outdoor Windrow Leaf and Yard Composting 1600 tonne p.a.	0.11×10^{-1} - 1.15×10^{0} total dust	Measured over a two day period snap shot, 10m upwind and downwind.	van der Werf 1996; van der Werf and van Opstal (1996)
Illinois USA	Yard Waste (outdoor) 14624 m^3 landscape waste (grass clippings, leaves, tree branches).	3.9×10^{-1} - 1.8×10^{0} total dust	10 sampling days at various sites in and around composting facilities.	Hryhorczuk et al., (2001)

2.2 *Aspergillus fumigatus*

Aspergillus fumigatus is a highly ubiquitous fungus. It has been associated with soil, crop plants, bird droppings, chicken roosts, cattle dung, horse dung, hay, fodder, corn, straw, grass and compost. It is also found on refrigeration and bathroom walls and building vent systems where moulds have had a chance to grow (Millner et al., 1994).

Table 2 depicts *Aspergillus fumigatus* data from various composting facilities.

Aspergillus fumigatus concentrations were in the range of 10^2 to 10^3 CFU/m^3 with several concentrations of 10^4 recorded in German literature (Böhm et al., 2002). Highest concentrations were recorded whenever the piles were disturbed (i.e. during pile construction or screening). In one case in Denmark the concentrations were almost below detection and similar to background concentrations (Neilson et. al., 1997). Concentrations dropped considerably at a distance of 150 m downwind and 75 m upwind (Nielson et al., 1997).

In a study carried out for the UK Environmental Agency by Casella et al., 2001 it was found that spore (fungi especially *Aspergillus fumigatus)* concentrations decreased by 80% to 90% from 20m to 40 m from the source.

The optimisation of bioaerosol (including dust and *Aspergillus fumigatus*) dispersal can be achieved through increasing the height of release or through increasing the turbulence and thereby increasing the spread of the plume. Turbulence around the plant can be increased by providing structures that impede the airflow. These can be walls or fences, or can be more natural structures such as earth mounds (bunds) or tree screens. (Wheeler et al., 2001). Britter et al., (1998) has assessed the effect of these structures on turbulence and has found that they have increased dispersion characteristics. The impacts of these structures for increasing turbulence will have to be measured as they are likely to be site specific.

In a study carried out in New York, off-site concentrations ranged from 5.6 x 10^2 CFU/m^3 with a maximum of 6.4 x 10^3 CFU/m^3 (Recer et. al., 2001). In a companion study undertaken by Browne et al., (2001) in order to provide data about daily changes in symptom occurrence, a variety of health symptoms were recorded by participants in a diary. Data was analysed in relation to spore concentrations observed during the study period. Other data collected included temperature, ozone level, nitrogen oxide level, sulphur dioxide concentrations and ragweed pollen grains. Ozone, ragweed and temperature were significantly associated with allergy and asthma incidence ($p<0.05$). For both daily mean and maximum *Aspergillus fumigatus* concentrations there was no positive association with allergy and asthma symptom incidence. The results of the study suggested that if increased concentrations of *Aspergillus fumigatus* spores generated during operations at the composting facility are leading to increases in allergy and asthma symptoms these increases were too small to detect, given the limitations of the study (Browne et al., 2001).

Fischer et al., 1998 investigated the effect of turning frequency on the concentrations of *Aspergillus fumigatus* during windrow composting of garden and kitchen waste. *Aspergillus fumigatus* concentrations in the centre of the windrows were reduced after two weeks of composting from $>10^3$ dry weight of compost to 10^2. Surface concentrations of *Aspergillus fumigatus* remained high in the least frequently turned windrows. The more frequently the compost pile was turned the faster the temperature increased to a level which can eliminate *Aspergillus fumigatus*. Fischer et al., 1998 concluded that health risks to compost plant workers could be lowered by frequent turning of the windrows, reducing the *Aspergillus fumigatus* concentrations on the surface on the compost. This study also showed that 10 metres downwind from the turning process *Aspergillus fumigatus* levels had decreased by 2 to 3 magnitudes.

Data depicting *Aspergillus fumigatus* concentrations in other industries are included in Table 3. Concentrations found in composting sites are in the lower range of concentrations found in other industries and agricultural activities.

Aspergillus fumigatus concentrations of 5 x 10^3 to 2 x 10^6 CFU/m^3 were found in hay silos during hay turning and in stables (Lacey et., al 1992, Millner et., al 1994).

Table 2: Bioaerosol *Aspergillus fumigatus* Concentrations recorded at various composting sites

Location	Type of Composting Facility	Recorded Concentrations(CFU/m³)[a]		Comments	Reference
Germany	Site 1: Landfill Site enclosed composting facility, 4000 tonne p.a., open air curing for 12 weeks Site 2: 300 tonne p.a. biowaste and greenwaste, open windrow.	Site 1: 1.2×10^2 Site 2: 8.6×10^1			Reinthaler et al., (1998/1999)
Germany	Literature search of levels.	Delivery	2.6×10^4		Böhm et al., (2002)
		Sorting	3.9×10^4		
		Turning	4.6×10^4		
		Post Treatment	1.5×10^4		
		Background	3.1×10^3		
Germany	Enclosed system.	Near Rotating Sieve	2.03×10^3	Composting green waste and biowaste-details of size of site not recorded.	Danneberg et al.,(1997)
		75 m up-wind	$<0.00 \times 10^0$		
		150 m down-wind	2.00×10^2		
		Exhaust from biofilter	$6. \times 10^2$		
		Control Site	7.77×10^1		
Denmark	Source Separated Household Waste.	Very low concentrations-equivalent to background concentrations.			Nielson et al., (1997)
Italy	3 municipal waste composting sites.	1: 4.9×10^3 2: 2×10^2 3: 7.8×10^3 (Maximum concentrations).			Varese et al., (2002)
UK	Site 1: 5000 tonne p.a. botanic and kitchen waste. Site 2: 12,000 p.a. tonnes of greenwaste	Site 1:Turning: 9×10^3 Site 2: Spreading: 1.4×10^2			Gilbert et al., (2002)

[a] Details of sampling site (i.e. upwind or downwind) stated where available.

Table 2 (continued): Bioaerosol *Aspergillus fumigatus* Concentrations recorded at various composting sites

Location	Type of Composting Facility	Recorded Concentrations (CFU/m^3)		Comments	Reference
Colorado, USA	Aerated Static Pile, Biosolid Composting. Enclosed Building. 2800 tonne p.a.	Mixing	1.1×10^3	Measured in summer. 90% reduction with certain measures. Very low concentrations were measured in winter.	Epstein et al., (2001)
		Pile construction	<74 – 77 $\times 10^2$		
		Pile Breakdown	1.4×10^2 to > 4.4 $\times 10^2$		
		Pile Screening	< 47 to > 4.4×10^2		
		No Activity	3 - 7		
Ontario, Canada	Outdoor Windrow Leaf and Yard Composting 1600 tonne p.a.	0.4×10^3- 7.8×10^3		Measured over a two day period snap shot, 10m upwind and downwind	van der Werf (1996); van der Werf and van Opstal (1996)
Long Island, New York	Residential neighbourhood, near yard waste composting site	5.6×10^2 (mean) 6×10^3 (max)		Processing 25,000 tonnes p.a. 1 year study period. Samples taken 2 upwind, 1 downwind.	Recer et. al., (2001)
Norman, Oklahoma, USA	Outdoor Municipal Waste Composting Facility	9.72×10^2 (mean)			Folmsbee and Strevett (1999)
Maryland	Enclosed Compost Facility	Mean: 22 1.44×10^2 max		Details of facility not stated	Millner et al., (1994)/ Millner (1995)
Portland	Not Stated	2×10^1 at 6 metres		Details of facility not stated	Millner et al., (1994)/ Millner (1995)
New Jersey	Yard Waste	5×10^3 during high activity		Details of facility not stated	Millner et al., (1994)/ Millner (1995)
Connecticut	Yard Waste	2.6×10^3		Details of facility not stated	Millner et al., (1994)/ Millner (1995)
New York	Yard Waste	6×10^2		Details of facility not stated	Millner et al., (1994)/ Millner (1995)

Table 3: Bioaerosol *Aspergillus fumigatus* Concentrations for other Industries/Activities (Adapted from Ault and Schott 1993)

Activity	Recorded Concentrations (CFU/m^3)	
Mulched Lawn	6.9×10^2	
Compost Site (Quiescent)	$0\text{-}2.4 \times 10^1$	
Hay barn	5.5×10^3	
Poultry House (in spring)	2.1×10^3	
Mushroom House (stationary beds)	3.3×10^2 (90% non mould spores)	
Timber Processing	$1 \times 10^2\text{-}1 \times 10^4$	
Debarking	1.27×10^4 heartwood	Includes all fungi *Penicillium* and *A. fumigatus* predominate
	5.3×10^4 sapwood	
	6.5×10^4 bark	
Composted Wood Chips	1.4×10^6 (Includes all fungi)	

2.3 Total Fungi

Table 4 depicts total fungi from various composting facilities.

Total fungi concentrations ranged from 10^2 for an idle pile in Germany to 10^5 at the biofilter, at the same plant (Kampfer 2002). Concentrations were also higher closer to the point of activity than further downwind from the site. Activity in the composting site resulted in elevated fungi counts, in one case the concentrations were elevated ten fold during shredding, (Jager et al., 1994).

Hass et al., (1999) reported that there were seasonal differences in fungi concentrations. It was found that fungi concentrations were higher during the summer than the winter. This is probably due to the fall in ambient temperatures in winter as colder temperatures may curb the growth of micro-organisms. In another case, in Germany. Böhm et. al., (2002) the highest concentrations of fungi were recorded during delivery of wastes. Marchand et al., (1995) reported fungi concentrations were highest during waste storage and sorting activities through to the discharge of compost from a tunnel composting system. Hryhorczuk et al., (2001) found that fungi concentrations were higher off site than on site although this was attributed to the site's location in a wooded area.

Fungi concentrations in other industries are depicted in Table 5. Concentrations of various activities including agricultural, sawmill, range from $10^2 – 10^9$ CFU/m^3 Stetzenbach., (1997).
Bioaerosol fungi concentrations at composting facilities are similar to concentrations found in other industries and environments.

Table 4: Total Bioaerosol Fungi Concentrations recorded at various composting sites

Location	Type of Composting Facility	Recorded Concentrations(CFU/m^3)	Comments	Reference
Germany	300 tonne p.a. open windrow 4,000 tonne p.a. enclosed system	Highest near bio-filter. $3.9 \times 10^3 - 3.3 \times 10^3$ Post Composting $1.4 \times 10^3 - 1.5 \times 10^3$ Control Sites $5.9 \times 10^2 - 5.4 \times 10^2$	Mould concentrations higher during the summer than the winter	Hass et al., (1999)
Germany	285 tonne p.a. domestic waste 1800,000 tonne p.a. domestic/industrial	8.4×10^5 in composting area	Measured during winter	Streib et al., (1996)
Germany	1: Domestic Waste Sludge (drum piles) 2: Biowaste and garden waste, Indoor Hall Composting, no forced aeration	1: at start 9.4×10^3 at 3 months 1.9×10^4 background concentrations: 1.4×10^2 2: at start: 7.5×10^3 outdoor concentrations: 3.4×10^3	Shredding increases fungi concentrations ten fold (waste volume processed not specified)	Jager et al.,(1994)
Germany	Literature Search	Delivery: 4×10^4 Sorting: 2.3×10^4 Turning: 4.3×10^4 Post Treatment: 1.7×10^4 Background: $3.8 \times 10^3 - 6 \times 10^4$	Literature Review	Böhm et al., (2002)
Germany	8,000 tonne p.a. Pile composting, covered by membrane Open storage (in sheds) Domestic waste 70% and plant waste 30% 40,000 tonne p.a. Domestic waste	Turning: 3×10^4 Shredding: 8×10^2 Idle Pile: 9×10^2 x 1.5 10 ^{3} Biofilter: 5.4×10^5		Kampfer (2002)

Table 4 (continued): Total Bioaerosol Fungi Concentrations recorded at various composting sites

Location	Type of Composting Facility	Recorded Concentrations (CFU/m^3)		Comments	Reference
Germany	Closed System	Near Rotating Sieve	2.48×10^3	Total fungi at 22°C and 30 °C. Composting green waste and Biowaste. Further details of site not recorded	Danneberg et al., (1997)
		75 m up-wind	1×10^2		
		150 m down-wind	3.9×10^2		
		Exhaust from biofilter	9.4×10^2		
		Control Site	8×10^2		
Canada	Enclosed System Mixed Waste	7×10^2 - 7.2×10^3			Marchand et. al., (1995)
Illinois, USA	Yard Waste (outdoor). 14624 m^3 landscape waste (grass clippings, leaves, tree branches)	Off site	8.651×10^3	Site located in wooded area.	Hryhorczuk et al., (2001)
		On site	3.068×10^3		

Table 5: Bioaerosol Fungi Concentrations for other Industries/Activities

Adapted from Stetzenbach, L. 1997

Activity / Industry	Fungi (CFU/m^3)
Animal Facilities	$10^2 - 10^8$
Composting	$10^2 - 10^7$
Agricultural Harvesting and Storage	$10^3 - 10^9$
Sawmill	$10^4 - 10^8$
Manufacturing Technology	$10^2 - 10^6$
Water Treatment (Activated Sludge)	$10 - 10^3$

2.4 Bioaerosol Endotoxin

Endotoxins are constituents of gram-negative bacteria. Table 6 depicts endotoxin data from various composting facilities.

There was a lot of variation in the recorded endotoxin levels, from <1 to 640 ng/m^3. In Denmark when bioaerosols were artificially generated, concentrations[b] of 14,000 ng/m^3 were found. Concentrations of this magnitude do not reflect any other concentrations recorded in other sites mentioned during normal composting activity. In the other sites, maximum concentrations were found at pile construction and screening, that is whenever the piles are disturbed. Concentrations are higher in summer than in winter (Epstein et al., 2001).

Epstein et al., (2001) reported that endotoxin concentrations dropped considerably when certain measures were taken (e.g. if the compost is moistened). The concentrations of endotoxins also dropped considerably some distance from the plant, for example concentrations dropped by 80 times at 150 metres downwind, indicating minimal health problems for the general public if their homes are at least 150 metres away. There was a good correlation between total respirable dust and endotoxin concentrations, indicating any measures taken to reduce dust would effectively reduce endotoxin concentrations (Epstein et al., 2001).

General threshold levels are given by the International Committee of Occupational Health but these are only guidelines and no data is available on dose-response relationships. These are depicted below.

Potential Health Effect	ng/m^3
Mucous Membrane Irritation	20-50
Acute Bronchial Constriction	100-200
Organic Dust Toxic Syndrome	100-2000

As reported by Epstein et al., 2002

Rylander suggested that up to 100 ng/m^3 should be considered as safe until additional information is available (Rylander 1993). The Dutch Expert Committee on Occupational Standards of the National Health Council (Heedrik, et. al., 1997) proposes a value of 4.5ng/m^3 over an 8 hour exposure period.

Endotoxin concentrations from other industries/activities are depicted in Table 7. The data reported in Table 6 typically falls within the low to mid range of data depicted in Table 7.

[b] This figure is not particularly relevant as (i):it is artificially generated and (ii): concentrations of this magnitude have not been recorded in other sites reviewed in Table 6.

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Table 6: Bioaerosol Endotoxin Concentrations recorded at various composting sites

Location	Type of Composting Facility[c]	Recorded Concentrations (ng/m^3)		Comments	Reference
Sweden	Solid Waste Composting Facility	$1 - 4.2 \times 10^{1}$. (Indoor and outdoor sites)		Stated safe concentrations of: 100 ng/m^3	Millner (1995)
Netherlands	Source separated organic waste, food and Yard Waste. Indoor Composting Plant. Aerated Tunnels.	3.6×10^{-1} - 2.12×10^{0} initially. After certain measures (i.e. general site management) were taken concentrations dropped to a maximum of 7.8×10^{1}.		Links were made to enhanced inflammatory reactions of upper airways. Further details of site not reported.	Douwes et al., (2002)
UK	12 Material Recovery Plants Surveyed Processing Industrial, Household, Commercial Waste.	$3.2 \times 10^{-1} - 5.8 \times 10^{1}$		>7 ng/m^3 recorded at seven sites.	Gladding et al., (1999)
Denmark	Source Separated Household Waste.	Maximum concentrations were recorded as: 1.4 x 10[illegible]		Bioaerosols artificially generated in rotating drum.	Nielson et al., (1997)
Germany	Enclosed System.	Near Rotating Sieve	2.07×10^{1}	Composting green waste and biowaste- further details of site not recorded.	Danneberg et al., (1997)
		75 m upwind	1.6×10^{-1}		
		150 m downwind	2.36×10^{-1}		
		Exhaust from biofilter	8×10^{-3}		
		Control Site	7×10^{-2}		
Colorado, USA	Aerated Static Pile, Biosolid Composting. Enclosed Building. 2800 tonne p.a.	Feedstock Mixing	5×10^{-1} – 7.7×10^{1}	Depends on process, season. There is a 90% reduction in concentrations if certain measures are undertaken i.e. increase moisture.	Epstein et al., (2001)
		Pile Construction	5×10^{-1} – 2.51×10^{2}		
		Pile Breakdown	2.2×10^{1} - 6.4×10^{2}		
		Pile Screening	1.68×10^{2} – 4.88×10^{2}		
		Compost Building	7×10^{1} – 2.29×10^{2}		

[c] Details of compost site shown if available

Table 6: (Continued) Bioaerosol Endotoxin concentrations recorded at various composting sites

Location	Type of Composting Facility	Recorded Concentrations (CFU/m^3)	Comments	Reference
Ontario, Canada	Outdoor Windrow Leaf and Yard Composting 1600 tonne p.a.	<1.9 x 10^0 – 4.7 x 10^1	Measured over a two day period snap shot, 10m upwind and downwind.	van der Werf 1996; van der Werf and van Opstal 1996
Illinois USA	Yard Waste (outdoor) 14624 m^3 landscape waste (grass clippings, leaves, tree branches)	1.2 x 10^{-1} -6.1 x 10^0	10 sampling days at various sites in and around composting facilities.	Hryhorczuk et al., 2001

Table 7: Bioaerosol Endotoxin Concentrations in other industries

Adapted from California Department of Health Services Environmental Health Investigations Branch Oakland, California 1999 (Mc Neel et al., 1999)

Industry	Endotoxin Concentration ng/m^3
Livestock Industry	5. x 10^1 -1. x 10^2
Animal Feed Production	1.61 x 10^4
Glasshouse	6 x 10^0 -7.79 x 10^2
Household waste composting plant	2.1 x 10^1
Garden-waste composting plant	8 x 10^{-2}
Fur Animal Bedding	6.2 x 10^1 – 1.950 x 10^3

2.5 Total Bioaerosol Bacteria

Bacteria are prevalent in the composting process. Table 8 depicts total bacteria from various composting facilities.

The total bacterial concentrations varied from 10^2 to 10^5 CFU/m^3 with most levels around 10^2 CFU/m^3. In one case when bioaerosols were artificially generated using a rotating drum, the levels were recorded at 10^7 CFU/m^3. Turning and shredding resulted in higher airborne bacterial concentrations in general, as with other bioaerosols.

In one case, the bacterial concentrations in the air increased as the composting proceeded (higher levels after three months) (Jager et al., 1994). Concentrations dropped considerably at some distance from the plant (75 metres upwind 4.3 x 10^2 CFU/m^3 and 150 metres downwind 2.83 x 10^3 CFU/m^3) and the drop was, as expected, more pronounced upwind than downwind. It was also found that biofilters decreased concentrations considerably (3.3 x 10^1 CFU/m^3) (Danneberg et al., 1997).

In the case of a plant in Germany (biowaste, hall composting, 3-4 meter high non-aerated piles), the concentrations were so high that the author recommended special protection for plant personnel working directly beneath the shredding process. (Jager et al., 1994). In contrast with another plant in Germany where windrow composting was being undertaken, the concentrations in and near the plant were the same as naturally occurring concentrations. (Reinthaler et al., 1998/1999). However, the impact of nearby farms in affecting the neighbourhood air cannot be excluded.

Bacterial concentrations from other industries/activities are depicted in Table 9. Total bacteria concentrations reported in Table 8 are within the range of those reported in Table 9.

Table 8: Total Bioaerosol Bacteria Concentrations recorded at various composting sites

Location	Type of Composting Facility	Recorded Concentrations (CFU/m^3)		Comments	Reference
Germany	Site 1: Landfill Site Composting Facility, closed 4000 tonne p.a., open air curing for 12 weeks Site 2: 300 tonne p.a. Biowaste and greenwaste, open windrow.	Site 1: 4.5 x 10^3 Site 2: 1.6 x 10^2			Reinthaler et al., (1998/1999)
Germany	1: Domestic Waste Sludge Drum Piles (plant D) 1m high, aerated.	1: 1.2 x 10^4 – 8.3 x 10^4		Highest concentrations during shredding. 10 fold above without shredding (tonnage processed not specified)	Jager et al., (1994)
	2: Biowaste and Garden Waste (Plant E) Indoor Hall Composting, no forced aeration 3-4 m high	2: 2.1 x 10^4 during shredding 1.3 x 10^3 outdoor concentrations			
Germany	Literature search of levels	Delivery	1.6 x 10^4		Böhm et al., (2002)
		Sorting	1.4 x 10^4		
		Turning	2.8 x 10^4		
		Post Treatment	5.4 x 10^4		
		Background	1.3 x 10^4		
Germany	8, 000 tonne p.a. Pile composting, covered by membrane Open Storage (in sheds) Domestic Waste 70% and Plant waste 30%	Turning	3.5 x 10^5		Kampfer (2002)
		Shredding	4.3 x 10^3		
		Idle Pile	1 x 10^3		
	40,000 tonne p.a. Domestic waste	Biofilter	8.9 x 10^6		
		Raw air	8.8 x 10^5		

Table 8: (Continued) Total Bioaerosol Bacteria Concentrations recorded at various composting sites

Location	Type of Composting Facility	Recorded Concentrations (CFU/m^3)		Comments	Reference
Germany	Enclosed System	Near Rotating Sieve	7.67×10^4	Greenwaste and Biowaste. Details of quantities not specified.	Danneberg et al., (1997)
		75 m up-wind	4.33×10^2		
		150 m down-wind	2.83×10^3		
		Exhaust from biofilter	3.30×10^1		
		Control Site	3.11×10^2		
Denmark	Source Separated Household Waste	1.7×10^7	Bioaerosols generated experimentally via rotating drum		Nielson et al., (1997)
UK	Site 1: 5000 tonne p.a. botanic and kitchen waste	Shredding	1.17×10^4 to 2.1×10^4	Site 1: Concentrations vary depending sampling date.	Gilbert et al., (2002)
		Turning	6×10^2 to 9×10^2		
	Site 2: 12,000 tonne p.a. tonnes of greenwaste.		6×10^2 to 2×10^4	Site 2. high background concentrations (Background concentrations: 1.6×10^3).	
Canada	Enclosed System Mixed Waste.	8.7×10^3 - 5.3×10^5		Particularly high during turning and sorting. Further details of site not recorded.	Marchand et al., (1995)
Illinois, USA	Yard Waste (outdoor). 15000 m3 landscape waste (grass clippings, leaves, tree branches)	4.8×10^2- 7.8×10^4		10 sampling days at various sites in and around composting facilities.	Hryhorczuk et al., (2001)

Table 9: Bacteria Bioaerosol Concentrations for other Industries/Activities

Adapted from Stetzenbach, L. 1997

Activity / Industry	**Bacteria Concentrations(CFU/m^3)**
Animal Facilities	$10^3 – 10^5$
Composting	$10^3 – 10^6$
Agricultural Harvesting and Storage	$10^2 – 10^3$
Sawmill	$10 - 10^3$
Manufacturing Technology	$10^2 – 10^6$
Water Treatment (Activated Sludge)	$10^2 – 10^6$

2.6 Conclusions on Concentration Data

The data presented are indicative (i.e. general comparison) rather than absolute. Given slightly different methodologies used for data collection and other variables, the data reported by different authors can only be compared on this basis.

The quantitative differences observed by different authors are caused by different types of facilities, sampling locations and especially by air sampling instruments with their various advantages and disadvantages. The concentrations can vary greatly with different measuring systems used (Griffiths and De Cosemo 1994, Reinthaler et., al 1998/99). See also Chapter 5 Sampling.

The bioaerosol concentration data reviewed generally fell into the ranges of other industries/activities.

Various authors have also found high microbial loads in the air of sorting facilities and have shown that these high loads depend on input material, facility, specific factors such as transporting technology and frequency of cleaning procedures (Danneberg et., al 1998, Deininger 1998, Jager et., al 1995, Missel 1997).

In general, it is reasonable to assume that workers may be exposed to potentially higher bioaerosol concentrations at closed composting facilities, where the ability of ambient air to dilute bioaerosol concentrations is reduced, as compared to an outdoor windrow facility. The installation of appropriate air handling equipment may abate this potential greater impact at an enclosed facility. Given appropriate air handling and other abatement systems, the potential for off-site migration of bioaerosols may be less from an enclosed facility than an open windrow facility.

To obtain indicative data in Ireland, air sampling using standardised methods could be used at new or existing composting facilities.

Given the very dynamic nature of air sampling, extremely targeted experiments would have to be carried out simultaneously with different composting units, and different feedstocks, to obtain more reliable data regarding the effects of the compost process or feedstocks on various parameters. Sampling methods would have to be standardised as well as analytical methods, as these also have an effect on recorded levels (see Chapter 5 Bioaerosol Sampling).

Chapter 3

Background Bioaerosol Concentrations

Table 10 depicts data outlining the distance, from various composting activities, at which background bioaerosol concentrations are attained. These distances vary considerably (61 - 2,614 metres), although generally background concentrations are achieved within a few hundred metres.

The impact of a composting operation on background concentrations of bioaerosols can be variable and is a function of wind direction/speed, weather, concentration of various bioaerosols at source and type of composting activity at site. (Reinthaler et, al. 1998/1999)

In the case of bio-solid (sewage sludge) composting background concentrations are reached at 2,614 metres and 806 metres. In most cases background concentrations are reached at a distance of less than 200 - 300 metres. In three cases, the background concentrations are reached at a distance of 500 metres.

According to Reinthaler et., al (1998/1999), Austrian law, in relation to potential hazard to neighbouring residents, requires a distance of 300 meters for large scale composting facilities (> 4,000 tonne per annum). In Germany, various regulations in different German states require between 200 meters and 500 metres (Ruf 1994), but these legal regulations target odour, which according to Reinthaler may often be a more significant problem than bacteria or fungi in the ambient air.

Bioaerosol concentrations and dispersion of bioaerosols depend on a number of site specific factors, these include feedstock, method of composting, configuration of composting site, method used for and frequency of pile turning, prevailing atmospheric conditions, moisture of composting piles, landscaping i.e. trees, bunds, fences, background concentrations. Background concentrations can depend on proximity to agricultural activity, wooded area, landfill, or other industry which produces bioaerosols. Therefore it can be seen that bioaerosol concentrations in a composting site are site specific.

Milner et al. 1994 after reviewing published data has concluded that 'the data have indicated that at distances of 76-152 m from the compost facility perimeters the airborne concentrations of *Aspergillus fumigatus* were at or below background concentrations.

Gilbert and Ward 1999 have found that *Aspergillus fumigatus* and mesophilic bacteria were found to reach background concentrations within 200m have suggested a set back distance on this basis, providing that routine sampling should be carried out at a facility if a 'sensitive receptor' lies within 200 metres of the site boundary .

A distance of 250 metres was recommended by the U.K Environment Agency, this distance provides an additional 'safety factor' over the 200 metres suggested by Gilbert and Ward 1999 and is considerably greater than the distance recommended by Millner et al., 1994. The U.K Environment Agency has also stated that this distance can be reviewed on a case by case basis. The UK Environmental Agency have chosen the 250 metres distance in spite of the fact that background levels of bioaerosols are reached within 200 metres of the source and that spore concentrations decreased by 80%-90% at a distance of 20-40metres from source. (Casella et al., 2001) Dust concentrations reached 'safe levels' levels at a distance of less than 100 metres. (Wheeler et al., 2001)

In view of these conflicting recommendations, in the absence of any clear cut data and the absence of a dose response relationship it is recommended that there be a guideline set-back distance or buffer zone of 200 metres from the site boundary composting facilities to the nearest dwelling, to facilitate abatement of bioaerosols from a composting facility. This buffer distance is arbitrary and the minimum distance where bioaerosols reach background levels can vary a great deal, due to the factors discussed above. The 200 metre distance would be particularly applicable to 'benign' feedstocks, e.g. greenwaste composting. Also where there are trees or bunds, this buffer distance could be slightly relaxed. This set back distance could also be relaxed if the composting carried out on an enclosed site utilising biofilters with appropriate site management practices.

It should also be noted that as far as the authors are aware, no other European country have a national regulation on set back distance to a sensitive receptor.

Table 10: Buffer distances where measured concentrations reach background concentrations

Reference/Site Details (Volume processed not detailed in reviewed papers)		**Parameter Measured**	**Distance to where conc. reach Background conc.(metres)**
McNeel et al., 1999	Greenwaste	*Aspergillus fumigatus*	152 - 502
	Biosolids		149 - 806
Reinthaler et al., 1998/1999	Waste Sorting Open Windrow	Bacteria and *Aspergillus fumigatus*	At 200 concentrations are significantly reduced
Heller et al., 2000	Partly Indoor	Fungi and *Aspergillus fumigatus*	200
	Indoor		500
Millner et al., 1995	General Recommendation	*Aspergillus fumigatus*	61- 152
Oregon Department of Environmental Quality 2001 (Tetratach 2001)		*Aspergillus fumigatus*	1: 76-304 2: at 182 no effect on public health
Danneberg et al., 1997	Herhof System	Endotoxin	150
		Total microbial concentrations	No increase > 500
California Integrated Waste Management Board, (Ault et al., 1993)	Sewage Sludge-enclosed system.	*Aspergillus fumigatus*	610 upwind 304-2614 downwind

Chapter 4

4.1 Bioaerosols and Health Risks

The health risks posed by bioaerosols come under the jurisdiction of the Health and Safety Authority. A study carried out by 25 scientists and engineers in the U.S.A., drawn largely from regulatory and research agencies came to the following conclusions after examining the full spectrum of potential bioaerosol agents of composting and their health impacts (Millner 1995).

- The general population is not at risk to systemic or tissue infections from composts associated bioaerosol emissions
- Immuno-compromised individuals are at increased risk of infection by various opportunistic antigens such as *Aspergillus fumigatus*, occurrence is not only in composts but also in other self heated organic materials present in the natural environment.
- Asthmatics and other "allergic" individuals are at increased risk to responses to bioaerosols from a variety of environmental sources and organic dust sources, including composts.
- Some types of bioaerosols can cause occupational allergy and diseases. Some types of bioaerosols are present in the air at facilities that compost organic materials. Available epidemiological evidence does not support the suggestion of allergic, asthmatic, acute or chronic respiratory diseases in the general public around the sites evaluated. The conclusion was drawn that "composting facilities do not pose any unique endangerment to the health and welfare of the general public". The basis for this conclusion is the fact that workers were regarded as most exposed part of the community, and where worker health was studied, for periods up to ten years on a composting sites, no significant adverse health impact were found.
- Occupational exposure to bioaerosols on composting sites may be significant, depending on the circumstances on the site, operational characteristics, and worker proximity. Compost site workers are clearly more exposed to compost bioaerosols than the surrounding population. However, as already stated, worker populations at such facilities thus far have not shown any significant difference in overall body or respiratory fitness as compared to non exposed persons.
- Dose and effect responses for concentrations of dust, microorganisms, and toxins for people working in plants could not be determined.
- Because of continuing public concern and because of the wide range of potential respiratory responses to organic dust, additional study would be helpful to further verify this apparent lack of adverse health impacts from composting facilities. Two kinds of studies (epidemiological and annoyance studies) would be helpful for defining potential impact of bioaerosols from any source, composting or otherwise. Annoyance studies are much easier to conduct; they can and have yielded useful information at much less cost.

Conclusions between dose, effects in regard to frequency of exposure, worker symptoms and dust, microorganism and toxin concentrations could not be determined.

Only few published studies exist where the health of residents near to composting facilities has been investigated, but where this has been done there is no evidence of significant ill health compared to unexposed controls. (Swan et al., 2003). The precise risk of bioaerosols is impossible to quantify due to the lack of defined dose-response relationships. (Wheeler et al., 2001)

Investigations in Scandinavia (Nersting 1993) showed that exposure to airborne microorganisms (type not specified) higher than 10^5 CFU/m^3 was the cause of different serious health problems of workers in a plant. Technical change at the plant reducing the exposure concentrations of the microbial air pollution, lead to a decrease in the health problems.

The health risks depend not only on the conditions of the environment, but also on the individual conditions, especially the disposition and susceptibility of a person. (Emmerling 1995). This is the reason for the difficulties in establishing threshold levels for airborne microorganisms in an occupational setting. Castellan et al., found a level of approx 10 ng/m^3 as the maximum (endotoxin) exposure limit without significant response.

No legal occupational exposure limits are available for exposure to microorganisms and their decomposition products. As the relationship between exposure to biological agents in organic waste and health effects is not clear, it is not possible yet to draw qualitative conclusions on the health risks due to biological agents. The amount of data is limited, and in some cases the quality of the studies is poor. Furthermore, as stated by the experts, differences in methodology do not allow comparison of the results between studies (van Yperen et al., 1997).

Rylander (1983) has stated that spore concentration for sensitization must be at least 10^8 CFU/m^3. Other authors have identified the relevant concentration of fungal spores to be between 10^6-10^{10} CFU/m^3 (Lacey et al., 1972). Malmros (1993) has suggested, the limits and recommended levels for employment in composting plants are 10,000 CFU/m^3 for total bacteria. The author adds, however, that these figures require further research.

As there was no data to show health risks due to exposure to biological agents during recovery of organic waste in groups with an increased risk, no conclusion can be drawn (van Yperen et al., 1997).

Similarly, Reinthaler (1998/1999) could not demonstrate a correlation between micro-organism concentrations and adverse effects for human health at the work place and sorting facility.

Some studies suggest that there may be a link between occupational exposure to compost workers and non-immuno-specific or allergic inflammation. However they conclude that the findings need to be confirmed in a larger study (Dowves et al., 2000).

There are currently no occupational exposure standards for bioaerosols either in the UK or throughout Europe (Gladding et al., 1999). Telephone calls made to the Austrian EPA and scientists working on composting in Italy and Norway confirmed that no standards on bioaerosol concentrations are available. (Personal communication, Prasad 2002).

It should also be kept in mind that to date despite 3,400 yard waste composting facilities, over 300 bio-solid composting facilities and numerous other food, animal manure and municipal solid waste composting facilities in the U.S., to date there is no (clear cut) evidence that either the public or workers have been affected by bioaerosol concentrations. (Epstein 2002).

Chapter 5

Bioaerosol Sampling

5.1 Determining Bioaerosol Sampling Requirements

5.1.1 Baseline Bioaerosol Monitoring

It is recommended that some baseline bioaerosol research is undertaken as it pertains to composting, since no data from Ireland is available. It is important that bioaerosol concentrations be measured at composting and non-composting locations. Data collection should focus at least on *Aspergillus fumigatus*, dust and possibly total bacteria. It needs to be recognised that bioaerosols are constantly present in the ambient atmosphere as a consequence of dust and soil and the natural breakdown of vegetation. (Swan et al., 2003)

Sampling should be considered prior to constructing and/or during the compost facility commissioning phase to ensure that bioaerosol concentrations fall within expected ranges.

5.1.2 Active Facility Bioaerosol Monitoring

As in other jurisdictions, it is recommended that bioaerosol monitoring should only be carried out if there is a definite requirement. (Gilbert et al., 1999) It may be prudent to collect bioaerosol samples periodically. The Standardised Protocol for the Sampling and Enumeration of Airborne Microorganisms at Composting Facilities - The Composting Association (1999) recommend 'that sampling should only be carried out at sites that meet certain criteria'. These are 'the proximity to the site of neighbouring homes, businesses or other installations; whether any complaints about emissions from the site have been received, or if local factors indicate that sampling would be prudent'.

Oregon Department of Environmental Quality (Tetra-tech 2001) similarly suggest that bioaerosol monitoring 'is not usually done routinely but is done if there is concern for worker health'.

Sampling should also be considered if workers are exhibiting adverse effects that may be attributable to bioaerosols.

First of all, any visible signs of mould growth should be addressed; growth on walls, floors, ceilings, in air conditioning system etc. If workers or surrounding inhabitants are still exhibiting adverse reactions, air monitoring may need to be considered. Interpretation of results needs to be carefully undertaken as false positives may lead to unnecessary concern.

One must play special attention to the sampling method used due to the heterogeneous microbial composition of air at composting plants. The sampling method has to generate reproducible results and also the method must be able to collect a wide range of microbial concentrations and different groups of organisms which require special environmental consideration for their survival.

5.1.2.1 Bioaerosol Monitoring Considerations

If air monitoring is being considered there are a number of factors to be taken into account.

- **Why Sample:** Before a sampling method is chosen it is important to define the reason for monitoring i.e. are workers/surrounding neighbourhoods exposed to higher concentrations than background concentrations/non-exposed workers or communities, or are they exhibiting any adverse reactions to possible bioaerosol concentrations?

- **What to sample for:** The specific parameters to be monitored need to be defined i.e. specific organisms, dust. These may need to be monitored during specific stages in the composting process i.e. feedstock delivery, shredding, turning etc.

- **When and where to sample:** The samples taken should be representative of the bioaerosol concentrations over area and time. Ideally, a study should be undertaken over a 12 month period to take into consideration seasonal and weather variation. Selection of monitoring sites will also need to be agreed on, i.e. areas of activity, sites of worker exposure, prevailing winds and surrounding populations. Sampling locations are chosen depending on the parameters to be monitored and the reason for monitoring. Background samples need to be measured at the same time - there is extreme variation in bioaerosol concentrations over a short period of time. Background concentrations may vary considerably and depend on nearby activity i.e. farming, passing traffic etc.

- **Cost:** Sampling, analysis and interpretation of data involve a team of highly trained individuals. Due to the high number of samples to be taken, intensive hands-on attention is needed. These factors can contribute to the high costs of the studies. Costs of between €5,000 - €100,000 or more are required to study a compost site for one parameter (*Aspergillus fumigatus*). The smaller figure would only provide for intermittent sampling at a couple of locations for a couple of months and is not very good evidence for a regulatory body. (Haines1995). It seems appropriate that the Irish Government, which aims to implement at least 300,000 tpa composting capacity in the country because of its international obligations, should contribute significantly to the funding of bio-aerosol monitoring at Irish sites once they are operational.

- **Research:** Research on the effect of compost bioaerosol on human health will need a multi-disciplinary approach and may require a pan European dimension.

5.2 Sampling Methods

When it is decided what parameters are to be monitored, a sampling method can be chosen. There are a few basic methods that can be considered:

- Collection of microorganisms onto a membrane filter or impinger, filter pore size will need to be discussed, depending on the size of microorganisms to be monitored.
- Collection of microorganisms directly onto growth media, i.e. using an Anderson Sampler, this is the most common method of evaluation.
- Collection of microorganisms into an adhesive surface for microscopic examination.
- Collection of airborne material into a coated glass slide for measuring optical density.
- Organic dust is measured by collecting dust and measuring total and respirable dust.

(adapted from McNeel et al., 1999)

The Composting Association (UK) has produced a document detailing sampling and enumeration of airborne microorganisms. (Standardised Protocol for the Sampling and Enumeration of Airborne Microorganisms at Composting Facilities, 1999). This is a very comprehensive document, detailing when and where to carry out sampling for detection of *Aspergillus fumigatus* and mesophilic airborne bacteria. The scope of the protocol, enumeration of colonies, as well as methods of sampling and equipment used are given. There are other factors that need to be taken into consideration, that are also covered in this protocol; these include meaningful and accurate data recording, interpretation and reporting.

Comparison of various samplers is discussed by Jensen et al., (2002). The concentrations of bioaerosols recorded will vary depending on the sampler used. (Jensen et al., 1998) Wheeler et al., (2001) found poor correlations between a filter and Anderson sampler for the measurement of fungi and bacteria.

The NIOSH Manual of Analytical Methods provides general guidelines when choosing the appropriate sampler for the bioaerosol of interest. Temperature and relative humidity may need to be noted as these can have an effect on the numbers of bioaerosols collected. Full monitoring guidelines can be found in the NIOSH Manual of Analytical Methods, Sampling and Characterization of Bioaerosols (Jensen et al., 1998).

Chapter 6

Addressing bioaerosols at Irish composting facilities

As has been noted throughout this document, the potential health effects of bioaerosols on workers and the general public tends towards there being no negative impacts. However, this is not conclusive. Like any other potential risk, steps can be taken to reduce the risks posed by bioaerosols.

6.1 Bioaerosol Control Plan

Bioaerosols represent a worker health and safety issue, as well as potential off-site receptor health and safety issue, although the emphasis should be strongly placed on compost facility workers.

It is recommended that a bioaerosol control plan be developed during the waste licensing/permitting process for composting facilities. It should include considerations for facility siting, and design, site operation.

A bioaerosol control plan, which would become an integral part of site procedures, could consist of the following parts:

6.1.1 Facility Siting and Design

In general, the siting requirements to address bioaerosols can be included within the context of requirements to address other potential compost facility nuisances such as dust, noise and odour. However, the proximity to potentially sensitive sub-populations needs to be considered. Those most sensitive to bioaerosols are immuno-compromised or immuno-deficient individuals. In particular, additional care should be taken when siting a facility in proximity to hospitals or health care centres.

There are in some cases buffer zones delineated between a compost facility and a potential receptor but these zones have been put into place to mitigate nuisance odours and for aesthetic reasons. (See Chapter 3)

A facility should be designed to minimize the impact of bioaerosols on worker health and safety and off-site receptor health and safety. (See section 6.1.2.)

Enclosed facilities should have adequate ventilation and air exchanges. This type of design consideration is similar to those used to ensure that odorous process air is removed from the facility.

As pointed out in Chapter 3, it is recommended that there be a guideline set back distance or buffer zone of 200m from the boundary of a composting facilities to the sensitive receptor, to facilitate abatement of all potential nuisances emanating from a composting facility, including bioaerosols. This set back distance could be further reduced, depending on the efficiency of biofilters, whether the site is enclosed, efficient site management and the use of landscaping e.g. trees or bunds, fences.

Bunds, trees or fences will enhance turbulence and hence dispersion and reduce the exposure concentrations of bioaerosols the public and workers.

6.1.2 Site Operation

A plan should be formulated which addresses steps taken to minimise bioaerosol generation and how to protect workers at the site. The plan should also consider the potential for off-site migration of bioaerosols. This plan should consist of the following generic recommendations:

6.1.2.1 Operational controls

This relates to compost facility operations.

a. It is important to maintain a proper composting environment. Regular and thorough mixing of compost piles will aid proper composting and minimise the presence of *Aspergillus fumigatus*.
b. Optimal moisture content for windrows is 50-60%. Dust concentrations can be greatly reduced if moisture levels are maintained at optimal concentrations.
c. Maintain a clean site to reduce dust generation. Have a means of wetting down dry and dusty surfaces.
d. All facility operators and compost workers should be trained in methods of dust and bioaerosol control.
e. Schedule worker rotations to ensure that exposure to potentially high bioaerosol generating activities is minimized.
f. Construction of windrows to be as high as possible, but not so as to reduce the efficacy of the composting process. This increases the height of release of bioaerosols enhances dispersion. Windrows can also be used to create an effective barrier and to increase turbulence.
g. Very frequent turning (i.e. daily to 2-3 times a week) to decrease the concentrations of *Aspergillus fumigatus* in the windrows.

6.1.2.2 Engineering controls

a. Consider installing a High Efficiency Particulate Abatement (HEPA) filtration unit in wheeled loader or JCB cabs. These filters are designed to provide flow-through ventilation, from the ceiling, past the operators breathing zone, and exiting through the floor of the cab
b. Ensure that the door seals and structure of wheeled loader or JCB cabs are sufficiently airtight.
c. The cab interior is subjected to a thorough and regular surface cleaning.

6.1.2.3 Protective equipment

a. Mechanical Agitation or Manual Handling: Workers mechanically agitating the active compost or curing compost in an unfiltered wheeled loader or JCB should consider using dust-mist class (NIOSH Class N-95) mask.
b. Normal work clothes and/or coveralls are suitable for site activities.
c. Workers should wear work gloves.

(Additional details can be found in "Health and Safety at Composting Sites: A Guidance Note for Site Managers", The Composting Association 1999)

6.1.2.4 Worker hygiene

a. Hands should be washed prior to drinking, eating or smoking.
b. There should be no eating, drinking or smoking while working.
c. Consider providing and laundering worker overalls.
d. For very large facilities consider installing a changing room with showers.

6.1.2.5 Medical consideration

a. Potential workers for the compost site should be screened to identify predisposed (to the potential effects of bioaerosols) individuals.
b. Workers should receive medical reviews on a biannual basis or when clinically indicated.
c. Workers should ensure that immunizations (i.e. tetanus) are up-to-date

6.1.2.6 Sampling

Sampling is typically undertaken when there is a definite requirement.

Chapter 7

Conclusions and Recommendations

Composting is a microbiological process. When a composting mass is disturbed via activities such as shredding, turning, forced aeration and screening, microorganisms as well as microbial fragments are aerosolised. Dust, although technically not a bioaerosol may have microorganisms or microbial fragments adhered to its surface and therefore should be included in the consideration of bioaerosols. Indeed, the control of conditions that result in dust generation can play a significant role in minimizing bioaerosol generation.

This literature review indicates that the potential health risk associated with composting to workers and especially the general public are minimal and can be managed if certain procedures, as described in this report, are developed.

It is also recommended that research on bioaerosols from composting should be conducted to develop baselines in Ireland as no such information is presently available. Bioaerosols can be generated by other non-waste treatment activities.

In order to develop a firm guideline regarding the set back distance guideline, research needs to be carried out on a pan-European level by a multi-disciplinary team to define to a dose response relationship between bioaerosol exposure and public health (including industry workers) at composting sites. The Irish EPA and the Irish Health and Safety Authority amongst others should be actively involved.

Then, as a result of this study, a rational guideline can be given on a set back distance from source to a sensitive receptor on a rational basis.

Table 11 summarises recommendations made throughout this document.

Table 11: Summary of Recommendations of the Authors

Future Research	There is an urgent need for milti-disciplinary research which includes health professionals should be carried out and may require a pan European dimension.
Baseline Bioaerosol Sampling	It is recommended that some baseline bioaerosol research be undertaken as it pertains to composting. It is important that bioaerosol concentrations be measured at composting and non-composting locations. Data collection should focus at least on *Aspergillus fumigatus*, dust and possibly total bacteria.
Facility Siting	It is recommended that there be a guideline set-back distance or buffer zone of 200m from composting facilities to a sensitive receptor for the abatement of all potential nuisances emanating from a composting facility, including bioaerosols.
Bioaerosol Sampling	As in other jurisdictions it is recommended that bioaerosol monitoring is only carried out when there is a definite requirement.
Development of Educational Material	It is recommended that educational material be developed for site managers, workers and general public regarding bioaerosols.

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APPENDIX 2

Noise Prediction Modelling Report

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DK/05/2489NL01

31 January 2005

Michael Wastson
O'Callaghan Moran & Associates
Granary House
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Dear Michael,

RE: KINGS TREE SERVICES – NOISE ASSESSMENT OF PROPOSED GREEN WASTE COMPOSTING FACILITY

We are pleased to forward the following comments in relation to noise due to the proposed King Tree Services (KTS) Green Waste Compositing (GWC) Facility at Coolbeg, Co. Wicklow.

1.0 INTRODUCTION

AWN Consulting Limited has previously issued a report reviewing a baseline noise survey carried out in the vicinity of the proposed development (Ref: BF/04/2169NR02). This document details noise predictions that have been prepared in relation to the site at nearby noise sensitive locations.

The proposed development involves the construction of a green waste composting facility at a worked out sand and gravel quarry in the townland of Coolbeg, County Wicklow. The green waste will comprise wood wastes generated by the KTS tree surgery business, garden and park waste produced during improvement and maintenance works by landscape gardeners, grass and shrub trimmings produced by individual householders and timber and wood waste recovered during construction and demolition works.

The site encompasses approximately 2.5 ha and will be occupied by the waste acceptance and composting areas, ancillary buildings including the reception office, workshop and weighbridge and parking areas . The majority of the site will, when the facility is operating at maximum capacity, be occupied by the composting process areas which will comprise the waste reception area, windrows, maturation area, finished product storage and a leachate storage lagoon.

The composting operation will involve pre-treatment to shred and mix the green waste, composting in open windrows, maturation and post treatment to remove impurities. The finished product will be suitable for horticultural and agricultural use.

There are three residential properties within 300m of the site. The nearest properties (two semi detached houses) to the site are approximately 150m north east of the northern site boundary. The third house is located across the N11 approximately 300m away to the east. The Beehive Public House is approximately 320m to the south east of the southern site boundary. There is a concrete batching plant located approximately 180m east of the eastern site boundary, between the site and the N11.

The proposed normal operational hours are 06:00 to 20:00hrs Monday to Friday and 06:00 to 18:00hrs on Saturday. The facility will not normally open on Sundays. However, due to the nature of the tree surgery business it may, on occasion, be necessary to operate outside these hours (for example to accommodate call outs to remove storm damaged trees and timber debris). Waste will normally be accepted at the facility between the hours of 08:00 and 18:00hrs.

2.0 NOISE CRITERIA

Given the nature of the development under consideration, appropriate guidance is taken from the EPA publication "*Guidance Note for Noise in Relation to Scheduled Activities*" as follows.

... the noise level at sensitive locations should be kept below an L_{ArT} value of 55dB(A) by daytime. At night, to avoid disturbance, the noise level at noise sensitive locations should not exceed an L_{AeqT} value of 45dB(A).

In summary, the following criteria apply at the façades of those noise sensitive properties closest to the development:

- Daytime (08:00hrs to 22:00hrs) 55dB $L_{Aeq,30min}$
- Night-time (22:00hrs to 08:00hrs) 45dB $L_{Aeq,30min}$

3.0 PREPARATION OF THE NOISE MODEL

As part of the assessment carried out in relation to this project a site noise model has been developed in order to predict noise levels associated with plant items. Details of the noise model software and the noise prediction calculation have be reproduced in the following sections for clarity and information purposes.

3.1 Noise Propagation Calculation

Brüel & Kjær *Predictor* Type 7810 is a proprietary noise calculation package for computing noise levels in the vicinity of industrial sites. Calculations are based on ISO9613-2:1996 *Acoustics - Attenuation of sound outdoors - Part 2: General method of calculation.*

This method has the scope to take into account a range of factors affecting the attenuation of sound, including:

- the magnitude of the noise source in terms of sound power;
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;

- attenuation due to atmospheric absorption;
- meteorological effects such as wind gradient, temperature gradient, humidity (these have significant impact at distances greater than approximately 400m).

Calculations have been performed in octave bands from 63Hz to 8kHz as well as in overall dB(A) terms.

3.2 Brief Description of ISO9613-2: 1996

ISO9613-2:1996 calculates the noise level based on each of the factors discussed previously in Section 3.1. However, the effect of meteorological conditions is significantly simplified by calculating the average downwind sound pressure level, L_{AT}(DW), for the following conditions:

- wind direction at an angle of ±45° to the direction connecting the centre of the dominant sound source and the centre of the specified receiver region with the wind blowing from source to receiver, and;
- wind speed between approximately 1ms^{-1} and 5ms^{-1}, measured at a height of 3m to 11m above the ground.

The equations and calculations also hold for average propagation under a well developed moderate ground based temperature inversion, such as commonly occurs on clear calm nights.

The basic formula for calculating L_{AT}(DW) from any point source at any receiver location is given by:

$$L_{fT}(DW) = L_W + D_c - A \qquad \textit{(Eqn. 3.2.1)}$$

Where:

L_{fT}(DW) is an octave band centre frequency component of L_{AT}(DW) in dB relative to 20×10^{-5} Pa;
L_W is the octave band sound power of the point source
D_c is the directivity correction for the point source;
A is the octave band attenuation that occurs during propagation, namely attenuation due to geometric divergence, atmospheric absorption, ground effect, barriers and miscellaneous other effects.

The agreement between calculated and measured values of L_{AT}(DW) support the estimated accuracy shown in Table 1.

Height, h*	Distance, d†	
	0 < d < 100m	100m < d < 1,000m
0<h<5m	±3dB	±3dB
5m<h<30m	±1dB	±3dB

* h is the mean height of the source and receiver.
† d is the mean distance between the source and receiver.

N.B. These estimates have been made from situations where there are no effects due to reflections or attenuation due to screening.

Table 1 Estimated accuracy for broadband noise of L_{AT}(DW)

3.3 Configuration of the Noise Model

The input to the noise model was an overall site plan, a set of buildings, ground contours and noise sources.

The buildings in the model encompass those on the KTS site and nearby noise sensitive locations and facilities. These were input to the model using drawings supplied by O'Callaghan Moran & Associates as a background and superimposing the buildings.

Each noise source was input as sound power in octave bands. *Predictor* accepts sound power levels in octave bands from 63Hz to 8kHz.

Each source also has its own position, height and directivity.

3.4 Output of the Noise Model

Predicted noise levels are calculated for a grid of receiver points, and coloured iso-contours of the noise levels can be displayed, to give an overall picture of the spatial distribution of noise levels within the grid. Furthermore specific noise levels are predicted at noise sensitive buildings in the vicinity of the site.

4.0 IMPACT ASSESSMENT

In order to assess the impact of the proposed site internal layout changes the following information was used in order to develop the noise model further.

4.1 Building Information

Building extents and elevations based on drawings supplied by O'Callaghan Moran and Associates[1].

4.2 Noise Sources

The following items of plant are proposed for use on site.

Loading Shovel	A loading shovel will be used to transfer materials around the site and to load the finished product onto transport vehicles
Shredder	Waste may be sent through a coarse shredder in advance of the composting to enhance the composting process.
Hydraulic Excavator	An hydraulic excavator will be used to turn the windrows
Mobile Trommel	Compost will be sent through the trommel as part of the refinement process remove unsuitable materials.

[1] 0311701Surrounding Landuse.dwg

The pre-treatment and post treatment screening stages are potential significant sources of noise. To minimise impacts pre-treatment shredding and post treatment screening will be carried out on average 1 to 2 days a week. The waste reception area is designed to accommodate up to 5 days storage of fresh green waste at maximum capacity and the shredder will be of sufficient capacity to ensure that all of the stored material will be shredded in the 1 - 2 day period. Similarly, the screening plant will be of adequate size to ensure that the treatment is limited to 1 to 2 days a week.

Table 2 details the A weighted L_w spectra utilised in the noise model.

Identification	Octave Band Centre Frequency (Hz)								dB(A)
	63	125	250	500	1k	2k	4k	8k	
Front Loading Trommel	84	98	101	104	103	101	94	86	109
Screen Trommel	46	51	57	71	76	75	71	64	80
Wood Shredder	75	89	92	95	94	92	85	77	100
Front End Loader	76	82	80	94	91	91	87	77	98

Table 2 L_w dB(A) Levels utilised in assessment

Sound data that was inputted into the reconfigured model was based upon the following documentation.

- Information supplied by O'Callaghan Moran & Associates;
- Bies and Hansen, Engineering Noise Control.

4.3 Noise Predictions

4.3.1 Assessment Locations

Noise predictions for the revised layout have been carried out to the following locations detailed in Table 3. Figure 1 details the approximate positions of the assessment locations.

Location	Co Ordinates		Comment
	N	E	
1	328,065	191,338	Semi detached private residences 150m north east of site
2	328,065	191,257	Concrete batching plant 180m east of site
3	328,164	191,017	Private residence 300m east of site
4	328,030	190,761	Beehive Pub 320m south east of site
5	327,506	190,766	Coolbeg House south of site
6	327,201	190,753	Private residence south west of site
7	326,680	191,053	Private residence west of site
8	326,866	191,466	Private residence west of site
9	326,908	191,755	Private residence west of site
10	327,863	192,017	Private residence north of site

Table 3 Noise Assessment Locations

4.3.3 Predicted Noise Levels

Table 4 details the predicted noise levels at Locations 1 through 10.

Location	Octave Band Centre Frequency (Hz)								dB(A)
	63	125	250	500	1000	2000	4000	8000	
1	25	32	34	37	35	31	19	--	42
2	26	34	35	39	37	34	24	--	43
3	28	33	34	38	40	38	24	--	44
4	21	32	34	37	36	32	18	--	42
5	26	32	31	35	39	36	20	--	42
6	23	24	25	29	32	28	8	--	36
7	18	18	20	24	26	20	--	--	30
8	19	19	22	25	28	22	--	--	32
9	18	19	21	25	27	21	--	--	31
10	20	25	30	34	31	25	--	--	37

Table 4 L_p dB(A) Noise Levels at Sensitive Locations

Predicted noise levels from plant items are in the range of 30 to 44dB L_{Aeq}. All predicted levels are within the relevant day and night time criteria detailed in Section 2.0.

4.4 Car Parking On Site

In this instance the car-parking facilities for the development will be provided by means of a surface car park area located on the eastern corner of the proposed site between. Noise level measurements have previously been conducted in the vicinity of car parks in support of other planning applications. The typical noise level 10m beyond the boundary of these car parks during busy daytime periods has been found to be of the order 48dB $L_{Aeq,30min}$

Taking into account the attenuation due to distance and screening, the predicted noise level at the nearest noise sensitive locations (i.e. Location 1) beyond car parking areas is 24dB $L_{Aeq,30min}$.

These levels are within the daytime criterion of 55dB $L_{Aeq,30min}$. It is not anticipated that there will be significant activity within car park areas during night time periods.

In summary, the likely noise impact of car parking on the local environment is not significant.

4.5 Noise Contours

Appendix A details noise contours in relation to the site. Predictions indicate that the proposed site will not result in noise levels at sensitive properties that exceed the relevant criteria.

5.0 SUMMARY

Noise predictions have been prepared for a number of sensitive locations in the vicinity of the site. Predicted noise levels at these locations are within the relevant noise criteria associated with the site.

Noise contours based on noise levels associated with plant items bays have been presented in Appendix A for information purposes.

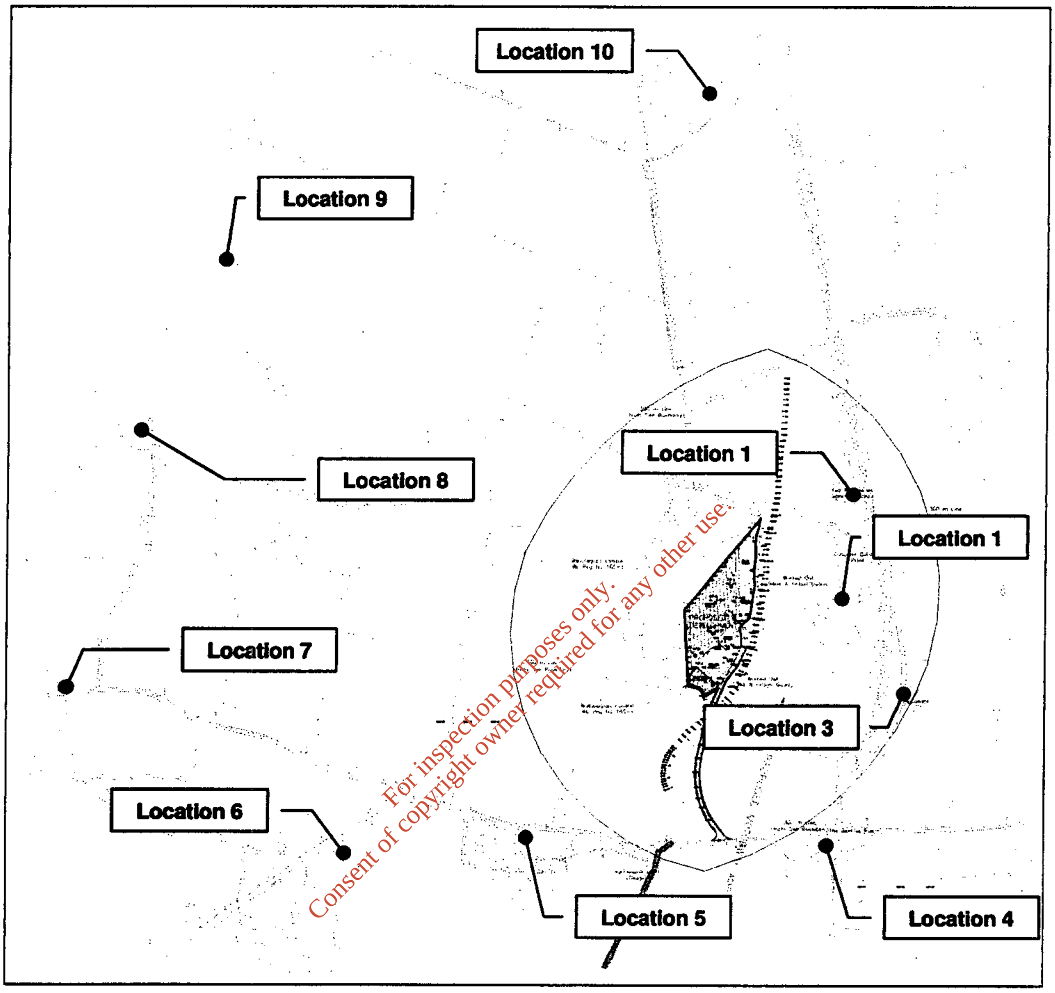
Please do not hesitate to contact this office if you have any further queries in relation to issues highlighted in this document.

Yours sincerely,

DAMIAN KELLY
Senior Acoustic Consultant

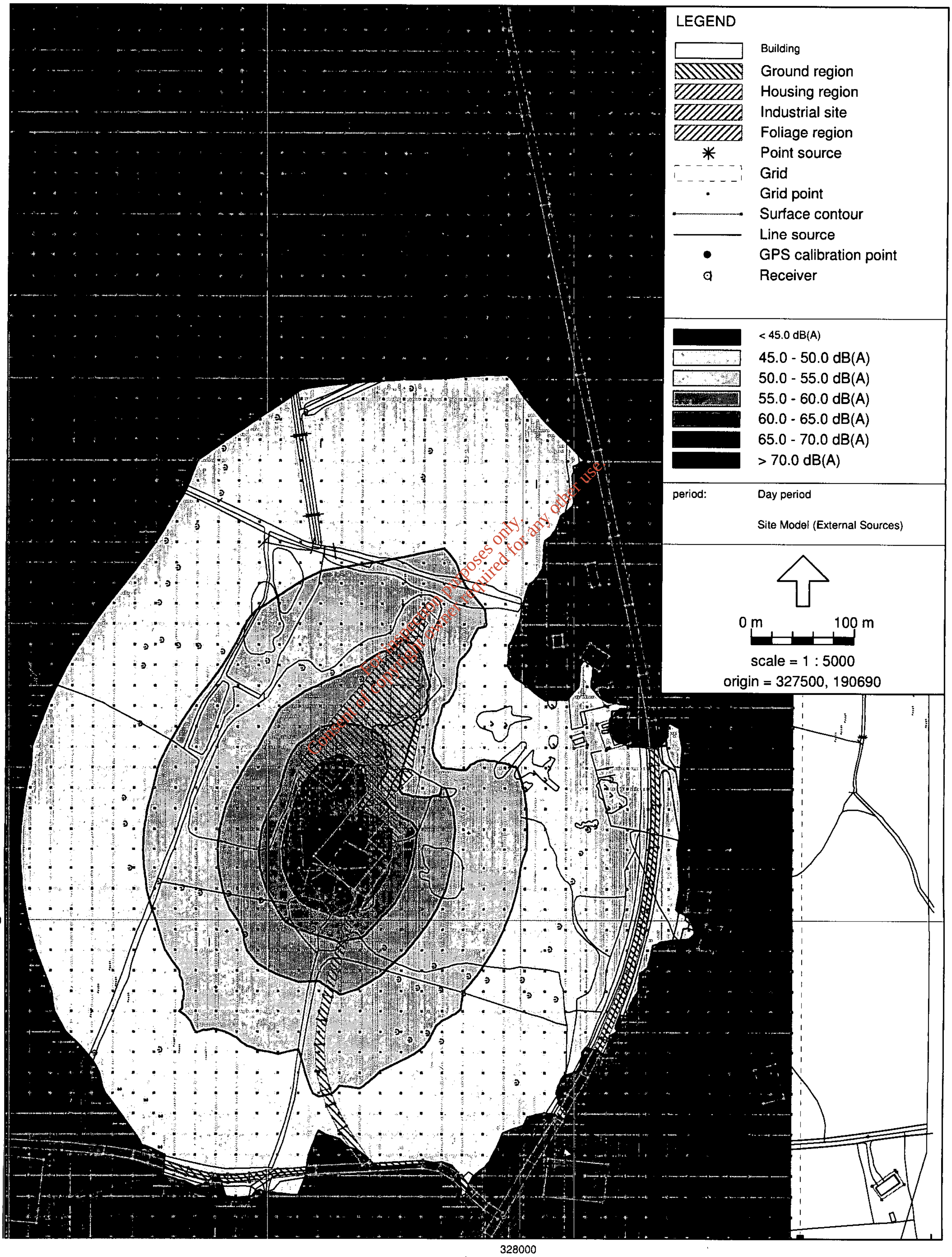
TERRY DONNELLY
Senior Acoustic Consultant

FIGURE 1
ASSESSMENT LOCATIONS



APPENDIX A
SITE NOISE CONTOURS

KTS Green Waste Compsoting Development



Industrial Noise - ISO 9613.1/2, KTS Noise Model - KTS Noise Model - Site Model (External Sources) [C:\DOCUME~1\dkelly\Desktop\DKACTI~1\05_248~1\Model] , Predictor Type 7810 V4.10