APPENDIX 6

Cre Bioaerosols Report

COMPOSTING ASSOCIATION of IRELAND TEO

Bioaerosols and Composting

A Literature Evaluation

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A Literature Evaluation

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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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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 x 10^{-1} -1.2 x 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 x 10^{-1} -2.47 x 10^{2} Respirable dust <2.5 x 10^{-1} – 1.47 x 10^{0} Feedstock Mixing: < 1.8 x 10^{-1} - 1.22 x 10^{0} respirable dust Pile Construction: 1.47 x 10^{0} -1.26 x 10^{0} – respirable dust Pile Breakdown: <2.3 x 10^{-1} -0.75 x 10^{-1} respirable dust Pile Screening: <2.4 x 10^{-1} -<0.3 x 10^{-1} respirable dust	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)
Ontario, Canada	Outdoor Windrow Leaf and Yard Composting 1600 tonne p.a.	0.11 x 10^{-1} -1.15 x 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 x 10^{-1} -1.8 x 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 5×10^3 to 2×10^6 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/m^3)[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 x 10^{2} Site 2: 8.6 x 10^{1}		Reinthaler et al., (1998/1999)
Germany	Literature search of levels.	Delivery: 2.6 x 10^{4} Sorting: 3.9 x 10^{4} Turning: 4.6 x 10^{4} Post Treatment: 1.5 x 10^{4} Background: 3.1 x 10^{3}		Böhm et al., (2002)
Germany	Enclosed system.	Near Rotating Sieve: 2.03 x 10^{3} 75 m up-wind: <0.00 x 10^{0} 150 m down-wind: 2.00 x 10^{2} Exhaust from biofilter: 6. x 10^{2} Control Site: 7.77 x 10^{1}	Composting green waste and biowaste-details of size of site not recorded.	Danneberg et al.,(1997)
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 x 10^{3} 2: 2 x 10^{2} 3: 7.8 x 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 x 10^{3} Site 2: Spreading: 1.4 x 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 x 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 x 10^2		
		Pile Breakdown	1.4 x 10^2 to > 4.4 x 10^2		
		Pile Screening	< 47 to > 4.4 x 10^2		
		No Activity	3 - 7		
Ontario, Canada	Outdoor Windrow Leaf and Yard Composting 1600 tonne p.a.	0.4 x 10^3- 7.8 x 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 x 10^2 (mean) 6 x 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 x 10^2 (mean)			Folmsbee and Strevett (1999)
Maryland	Enclosed Compost Facility	Mean: 22 1.44 x 10^2 max		Details of facility not stated	Millner et al., (1994)/ Millner (1995)
Portland	Not Stated	2x 10^1 at 6 metres		Details of facility not stated	Millner et al., (1994)/ Millner (1995)
New Jersey	Yard Waste	5 x 10^3 during high activity		Details of facility not stated	Millner et al., (1994)/ Millner (1995)
Connecticut	Yard Waste	2.6 x 10^3		Details of facility not stated	Millner et al., (1994)/ Millner (1995)
New York	Yard Waste	6 x 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 x 10^2	
Compost Site (Quiescent)	0-2.4 x 10^1	
Hay barn	5.5 x 10^3	
Poultry House (in spring)	2.1 x 10^3	
Mushroom House (stationary beds)	3.3 x 10^2 (90% non mould spores)	
Timber Processing	1 x 10^2-1 x 10^4	
Debarking	1.27 x 10^4 heartwood	Includes all fungi *Penicillium* and *A. fumigatus* predominate
	5.3 x 10^4 sapwood	
	6.5 x 10^4bark	
Composted Wood Chips	1.4 x 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 x 10^3 – 3.3 x 10^3 Post Composting 1.4 x 10^3 – 1.5 x 10^3 Control Sites 5.9 x 10^2 – 5.4 x 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 x 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 x 10^3 at 3 months 1.9 x 10^4 background concentrations: 1.4 x 10^2 2: at start: 7.5 x 10^3 outdoor concentrations: 3.4 x 10^3		Shredding increases fungi concentrations ten fold (waste volume processed not specified)	Jager et al.,(1994)
Germany	Literature Search	Delivery	4 x 10^4	Literature Review	Böhm et al., (2002)
		Sorting	2.3 x 10^4		
		Turning	4.3 x 10^4		
		Post Treatment	1.7 x 10^4		
		Background	3.8 x 10^3 – 6 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 x 10^4		Kampfer (2002)
		Shredding	8 x 10^2		
		Idle Pile	9 x 10^2 x 1.5 10^3		
	40,000 tonne p.a. Domestic waste	Biofilter	5.4 x 10^5		

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 x 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 x 10^2		
		150 m down-wind	3.9 x 10^2		
		Exhaust from biofilter	9.4 x 10^2		
		Control Site	8 x 10^2		
Canada	Enclosed System Mixed Waste	7 x 10^2 - 7.2 x 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 x 10^3	Site located in wooded area.	Hryhorczuk et al., (2001)
		On site	3.068 x 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.

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.	3.2×10^{-1} – 5.8×10^1		>7 ng/m^3 recorded at seven sites.	Gladding et al., (1999)
Denmark	Source Separated Household Waste.	Maximum concentrations were recorded as: 1.4×10^4		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.	<$1.9 \times 10^0 – 4.7 \times 10^1$	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)	1.2×10^{-1} -6.1×10^0	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 10^3
Household waste composting plant	2.1 x 10^1
Garden-waste composting plant	8 x 10^{-2}
Fur Animal Bedding	6.2 x 10^0 – 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: 4.5×10^3 Site 2: 1.6×10^2			Reinthaler et al., (1998/1999)
Germany	1: Domestic Waste Sludge Drum Piles (plant D) 1m high, aerated.	1: $1.2 \times 10^4 – 8.3 \times 10^4$		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: 2.1×10^4 during shredding 1.3×10^3 outdoor concentrations			
Germany	Literature search of levels	Delivery	1.6×10^4		Böhm et al., (2002)
		Sorting	1.4×10^4		
		Turning	2.8×10^4		
		Post Treatment	5.4×10^4		
		Background	1.3×10^4		
Germany	8, 000 tonne p.a. Pile composting, covered by membrane Open Storage (in sheds) Domestic Waste 70% and Plant waste 30%	Turning	3.5×10^5		Kampfer (2002)
		Shredding	4.3×10^3		
		Idle Pile	1×10^3		
	40,000 tonne p.a. Domestic waste	Biofilter	8.9×10^6		
		Raw air	8.8×10^5		

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

Location	Type of Composting Facility	Recorded (CFU/m^3)	Concentrations	Comments	Reference
Germany	Enclosed System	Near Rotating Sieve	7.67 x 10^4	Greenwaste and Biowaste. Details of quantities not specified.	Danneberg et al., (1997)
		75 m up-wind	4.33 x 10^2		
		150 m down-wind	2.83 x 10^3		
		Exhaust from biofilter	3.30 x 10^1		
		Control Site	3.11 x 10^2		
Denmark	Source Separated Household Waste	1.7 x 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 x 10^4 to 2.1 x 10^4	Site 1: Concentrations vary depending sampling date.	Gilbert et al., (2002)
		Turning	6 x 10^2 to 9 x 10^2		
	Site 2: 12,000 tonne p.a. tonnes of greenwaste.	Turning	6 x 10^2 to 2 x 10^4	Site 2. high background concentrations (Background concentrations: 1.6 x 10^3).	
Canada	Enclosed System Mixed Waste.	8.7 x 10^3 - 5.3 x 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 x 10^2- 7.8 x 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 milti-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 7

Noise Assessments Reports

Dixon.Brosnan
environmental consultants

project title	Noise survey - Dripsey		
client	O'Callaghan Moran		
client ref.	Michael Watson		
project ref.	05025		
report ref.	05025.2		
revision	1	revision date	05.10.06
approved by	Damian Brosnan	issue date	05.10.06
certified only where signed			

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CONTENTS

1. INTRODUCTION

1.1 Dixon.Brosnan Environmental Consultants were commissioned by O'Callaghan Moran to carry out a noise survey at a quarry site at Dripsey, Co. Cork. The site is currently being quarried for sand and gravel.

1.2 The purpose of the survey was to assess noise levels near noise sensitive locations in the vicinity of the site.

2. NOISE

2.1 Noise levels are usually recorded on a logarithmic decibel scale. Table 1 provides an indication of this scale.

Table 1. The decibel scale.

DECIBELS (dB)	NOISE
20	Very quiet room
35	Rural environment at night
65	Conversation
80	Busy pub
100	Nightclub
120	Jet take-off
140	Threshold of pain

2.2 An adjustment or weighting – the 'A' weighting – is normally applied to recorded levels in order to approximate the manner in which the human ear hears noise, the ear being more sensitive to sounds of higher frequency. Measurements which have been subjected to the weighting are denoted by the inclusion of 'A' with the measurement parameter.

2.3 The L_{Aeq} t is the parameter usually used to describe noise levels at a location. The parameter represents the average noise level at that location from all sources when measured over time interval t. The duration of t may be several seconds or will more usually be 5-60 minutes depending on the standard or noise limit under consideration.

2.4 Noise parameters to which reference is made in this report are defined table 2. Throughout this report noise levels are presented as decibels (dB) relative to $2x10^{-5}$Pa.

Table 2. Noise glossary.

TERM	DEFINITION
$L_{Aeq\ t}$	The equivalent continuous sound level during the measurement interval t, effectively representing the average noise level.
L_{An}	The sound level which is exceeded for n% of the measurement interval.
L_{A10}	The sound level which is exceeded for 10% of the measurement interval, usually used to quantify traffic noise.
L_{A90}	The sound level which is exceeded for 90% of the measurement interval, usually used to quantify background noise.
A weighting	The weighting or adjustment applied to sound level recordings to approximate the non-linear frequency response of the human ear. The A-weighting is denoted by the suffix A in the parameters listed above.
1/3 octave band analysis	Frequency analysis of sound such that the frequency spectrum is subdivided into bands of one third of an octave each. An octave is taken to be a frequency interval, the upper limit of which is twice the lower limit in Hertz.
Tone	A character of the noise caused by the dominance of one or more frequencies which may result in increased noise nuisance.
Impulse	A noise which is of short duration (typically less than one second), the sound pressure level of which is significantly higher than the background.

3. LOCATION

3.1 The quarry under consideration is situated at Tulligmore, Dripsey, Co. Cork. The quarry is located 4 km northeast of Coachford on the eastern side of regional route R619. The quarry is accessed from the R619 by an entrance located at the southwest corner of the site.

3.2 There are two dwellings located to the immediate south of the site entrance. A third dwelling lies to the north of the entrance on the opposite side of the road. Further north, two dwellings are positioned adjacent to the quarry boundary near the northwest corner. Several more dwellings are also located in proximity to the northwest corner.

3.3 The northern boundary of the site adjoins a third class road which provides access to one dwelling 100 m north of the boundary. This road also provides access to a single dwelling located 275 m northeast of the site. This residence constitutes the nearest noise sensitive location to the northeast.

3.4 Five noise monitoring stations were selected to represent private residences in the vicinity of the quarry. Four of the stations were located on the quarry boundary, while the fifth was located offsite at the noise sensitive receptor 275 m northeast of the site. The stations, designated N1-N5, are described in table 3. The four onsite stations are also indicated in figure 1.

Table 3. Noise monitoring stations.

Ref.	Location
N1	Near SW corner of site, 10 m from boundary behind private workshop
N2	S of site entrance, 40 m N of dwelling
N3	SE corner of 'peninsula' containing 2 houses S of NW corner
N4	NW corner of site
N5	50 m SE of house 275 m NE of site

4. NOISE SURVEY

4.1 The noise survey was commenced on Tuesday 15.08.06. Noise levels were recorded at stations N1, N2 and N3 while a light northwest air was present measuring 0-1 m/s at ground level. This survey was terminated due to the onset of rain. Measurements were recorded at the remaining stations N4 and N5 on Tuesday 22.08.06. On this occasion a light southwest breeze prevailed during the survey, thereby creating a worst case scenario with respect to station N5.

4.2 Throughout both survey dates noise emissions arose continuously from the Dripsey quarry facility. Emissions arose from a number of sources, chiefly from processing plant located in the main works area. Emissions were audible occasionally from a dumper ascending a ramp to the primary hopper. Emissions also arose from two excavators, a front end loader and trucks accessing the site.

4.3 Extraneous noise sources noted over both survey dates consisted chiefly of traffic, birdsong and processing plant at a quarry operated by Ducon to the west of the study site. At stations N1 and N2, noise levels were dominated by emissions from an offsite workshop near the southwest corner. Emissions here arose from a continuous machine, possibly a sawdust extraction system.

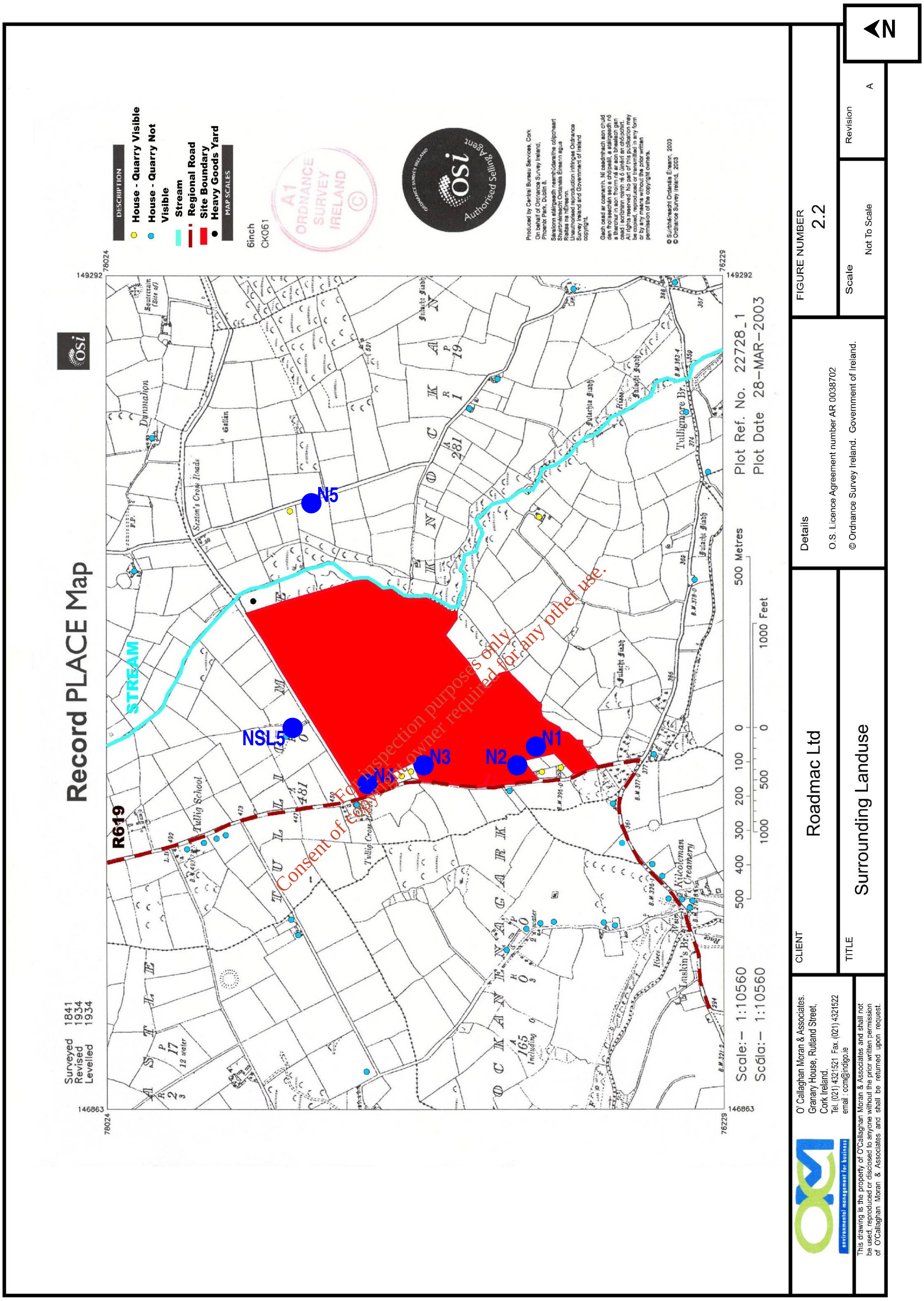

Figure 1. Noise sensitive locations.

4.4 Measurements were recorded using a Bruel & Kjaer Type 2260 integrating sound level meter which was calibrated before and after both survey events. Measurements were recorded using the 'fast' network. The surveys were conducted by Damian Brosnan on behalf of Dixon.Brosnan. Following survey completion recorded data were uploaded to PC for subsequent analysis using task specific software. Measurements were recorded in accordance with *International Standard ISO 1996 Acoustics: Description and measurement of environmental noise Parts 1-3 1982-1987*.

4.5 Monitoring intervals of one hour were used as recommended by the Environmental Protection Agency draft document *Environmental management in the extractive industry (non-scheduled minerals) – Environmental management guidelines* (2004). The measurement interval was shortened to 50 minutes at station N5 due to the onset of rain.

5. NOISE SURVEY RESULTS

5.1 Noise levels recorded at the stations noted above are presented in table 4. A description of measurement parameters is provided in table 2. Noise profiles and frequency spectra as one third octave bands are presented in section 7.

Table 4. Noise levels recorded 15.08.06 and 22.08.06.

STATION	TIME	L_{Aeq} (dB)	L_{A10} (dB)	L_{A90} (dB)	COMMENT
N1	1327-1427 15.08.06	55 See 5.2 below	58	44	Noise dominated by sawdust extraction system at adjacent premises. No noise audible over this apart from trucks on quarry access road and processing plant slightly audible. Extraction system shut down at 1400. Thereafter quarry traffic and processing plant audible at low level. Road traffic, birdsong and Ducon processing plant also audible at low level.
N2	1139-1239 15.08.06	49	52	44	Quarry processing plant, mobile plant and access road traffic slightly audible. Not significant. However squeaking conveyor roller on sand plant near site office annoying and tonal near 1000 Hz. Repair recommended. Dominant noise source here: sawdust extraction system at premises to SE. Ducon processing plant becoming more prominent during interval. Birdsong. Intermittent road traffic significant here.
N3	1028-1128 15.08.06	45	47	38	Quarry processing plant audible at low level (downwind and screened by site topography). Dumper climbing ramp clearly audible occasionally. Ducon plant slightly audible. Birdsong.
N4	1324-1424 22.08.06	50	53	45	Processing plant at study site and Ducon site codominant but not significant. Occasional climbing dumper audible. Intermittent road traffic through nearby junction significant. Rustling vegetation and birdsong not significant.
N5	1158-1248 22.08.06	45	47	39	Quarry audible at low level, chiefly processing plant but also dumper on occasion. Emissions generally sound steady and continuous. Loading of primary hopper audible but not impulsive (>1s). Unclear if Ducon contribute to noise. Crows significant and intrusive for first 10 min. Local car x2.

5.2 The L_{Aeq} recorded at station N1 over the measurement interval was 55 dB. Noise levels here were dominated until 1400 hours by emissions from a nearby offsite workshop. The termination of these emissions is clearly visible in the profile in section 7. A more accurate review of noise levels at N1 is possible by separately assessing emissions recorded before and after 1400 hours. The results of the separate assessment are presented in table 5.

Table 5. Noise levels recorded at N1 before and after 1400 hours.

TIME	L_{Aeq} (dB)	L_{A10} (dB)	L_{A90} (dB)	COMMENT
1327-1401	57	59	54	Noise dominated by sawdust extraction system at adjacent premises. No noise audible over this apart from trucks on quarry access road and processing plant slightly audible. Extraction system shut down at 1400.
1401-1427	51	50	43	Extraction system shut down at 1400. Thereafter quarry traffic and processing plant audible at low level. Road traffic, birdsong and Ducon processing plant also audible at low level.

5.3 Table 5 indicates that the noise level at N1 was dominated by activities at the offsite workshop, resulting in a significant L_{Aeq} of 57 dB. The L_{Aeq} decreased to 51 dB following cessation of the emissions. Operations at the study site were audible at a low level thereafter, and contributed to this 51 dB. Processing plant emissions, more accurately represented by the L_{A90} parameter, gave rise to a relatively low noise level of 43 dB.

5.4 At station N2 a satisfactory L_{Aeq} level of 49 dB was recorded with an L_{A90} level of 44 dB. These levels were significantly influenced by noise emissions from the offsite workshop noted above. The increasing audibility of processing plant emissions from the Ducon site, as noted in table 4, is evident in the profile in section 7. Emissions from the study site were slightly audible here.

5.5 The only onsite tonal noise source noted during the survey was detected at station N2. A squeaking conveyor roller in the sand plant near the site office gave rise to a cyclic tonal component near the 1000 Hz one third octave band. This component was not continuous enough to be detected by frequency analysis. Nonetheless, the tone was deemed subjectively annoying and worthy of immediate attention.

5.6 Emissions from the study site were audible at a low level at station N3, due chiefly to the presence of an onsite mound to the northwest of the main site works area. The L_{Aeq} recorded was 45 dB with an L_{A90} of 38 dB. These levels are satisfactory. The impact of occasional emissions arising from the dumper, ascending the ramp to the primary hopper, may be seen in the profile in section 7.

5.7 The noise environment at station N4 was influenced equally by emissions from the study site and from the nearby Ducon facility. Despite processing plant at both sites being audible, emissions were not deemed significant and the L_{Aeq} and L_{A90} levels recorded were satisfactory at 50 and 45 dB respectively.

5.8 At station N5, the only offsite measurement position, processing plant emissions from the study site were audible at a low level due to their propagation on a southwest breeze. The L_{Aeq} level recorded was 45 dB. As the emissions from the processing plant were continuous and unfluctuating, the L_{A90} parameter may be considered to provide a more accurate assessment of noise impacts from the quarry here. The relatively low 39 dB L_{A90} level recorded indicates that minimal noise impacts arose at N5 during the survey.

5.9 Noise levels recorded at all stations were below the 55 dB limit noted in the Environmental Protection Agency document *Integrated Pollution Control Licensing – Guidance note for noise in relation to scheduled activities* (1995) and which is normally specified by local authorities in planning permission for quarry developments. In all cases the L_{Aeq} attributable to quarry emissions was significantly below the 55 dB limit.

5.10 No impulsive components were noted in noise emissions over both survey dates. One tonal component was identified as outlined in 5.5 above.

6. CONCLUSIONS

6.1 Noise levels recorded at all five stations were satisfactory. Noise emissions from the quarry were generally audible at low levels only. In all cases, quarry emissions were significantly below the 55 dB normally applied to quarry developments.

6.2 The dominant noise source near the southwest corner of the site was a machine, possibly a sawdust extraction system, located in a private workshop immediately outside the site boundary.

6.3 One source of tonal noise emissions was noted on the study site: a squeaking conveyor roller on the sand plant near the site office. It is recommended that this component is repaired or replaced immediately.

Instrument:	2260	
Application:	BZ7202 version 2.0	
Bandwidth:	1/3 Octave	
Peaks Over:	140.0 dB	
Range:	20.7-100.7 dB	
	Time	Frequency
Broad-band measurements:	S F I	A L
Broad-band statistics:	F	A
Octave measurements:	F	L
Instrument Serial Number:	2217608	
Microphone Serial Number:	2174854	
Input:	Microphone	
Pol. Voltage:	0 V	
S. I. Correction:	Frontal	
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Calibration Level:	93.9 dB	
Sensitivity:	-26.9 dB	
ZF0023:	Not used	

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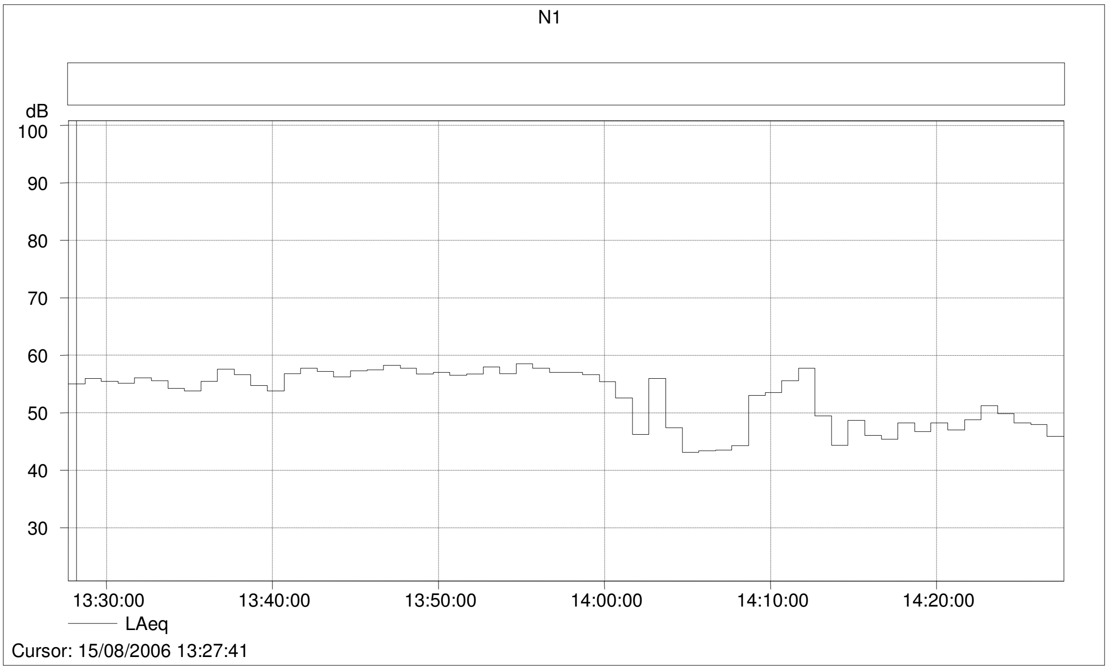
Sensitivity:	-26.9 dB
ZF0023:	Not used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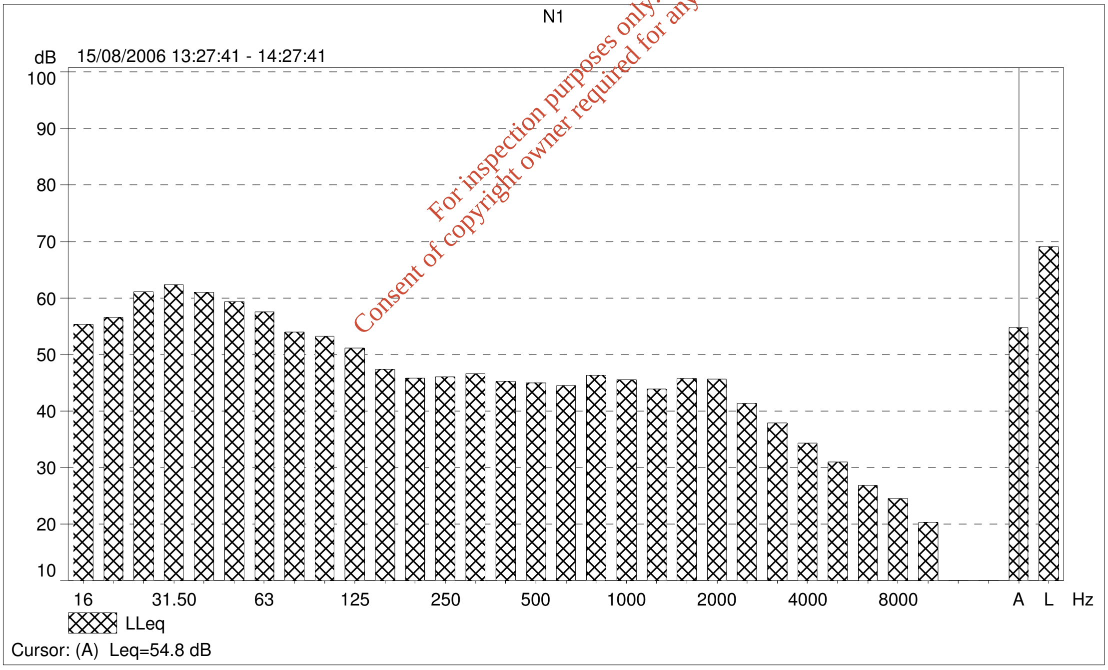
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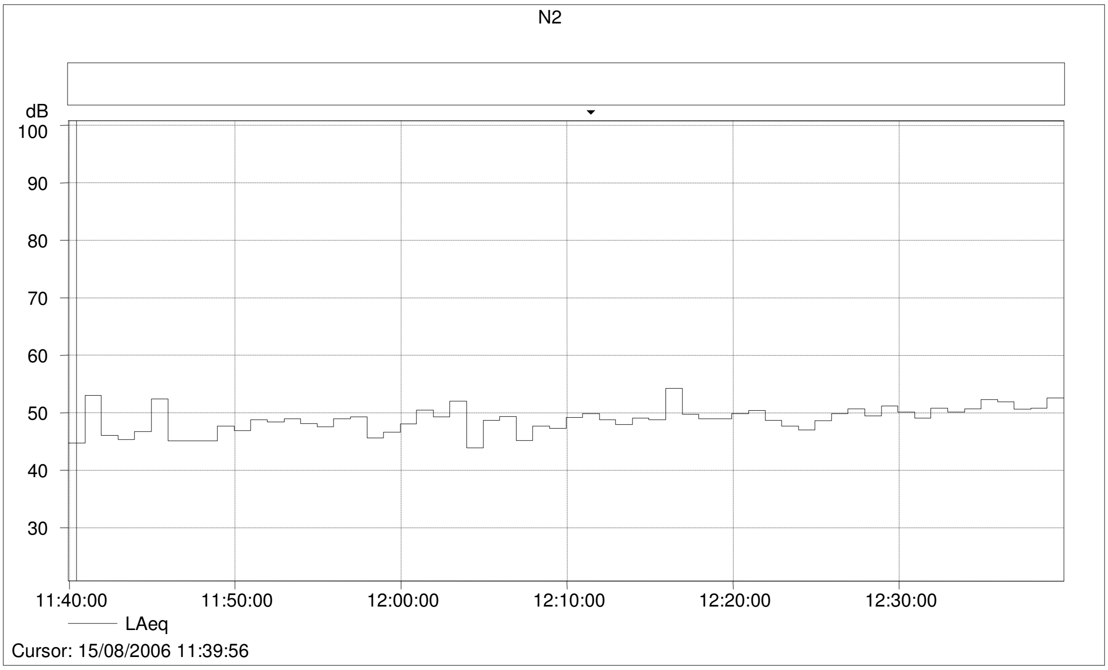
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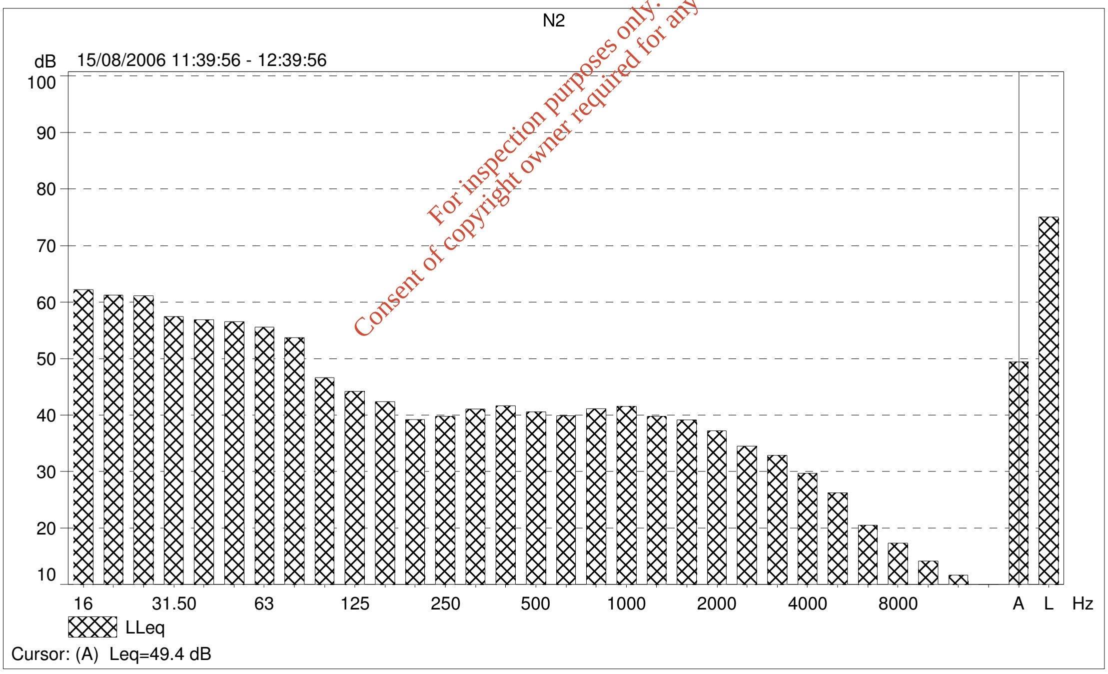
N2
dB 15/08/2006 11:39:56 - 12:39:56
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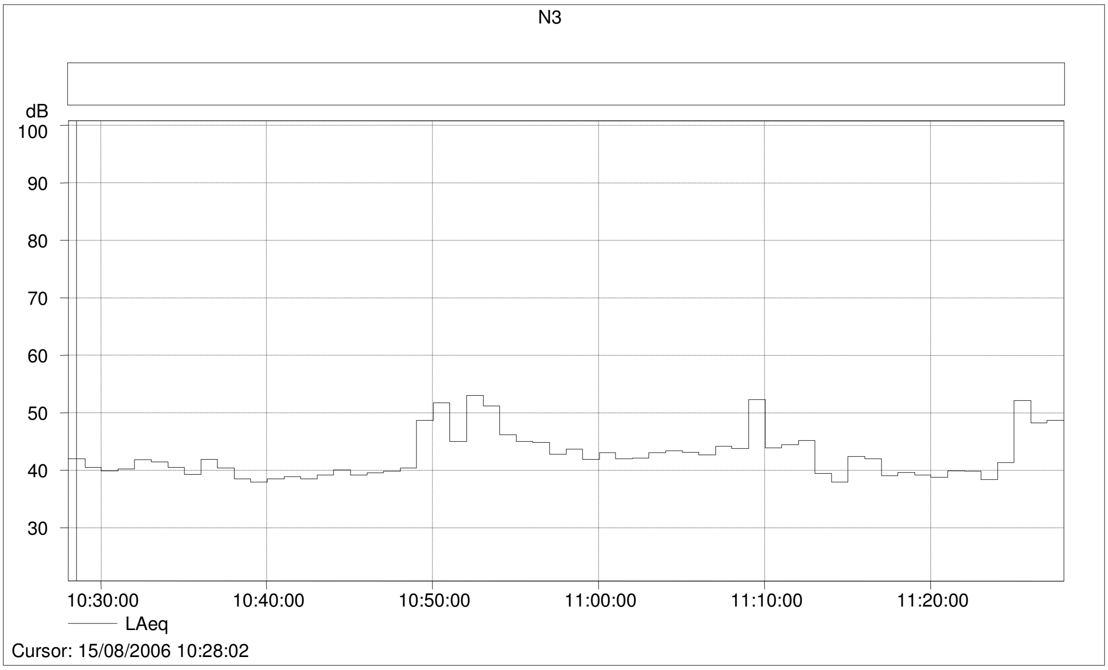
LLeq
Cursor: (A) Leq=49.4 dB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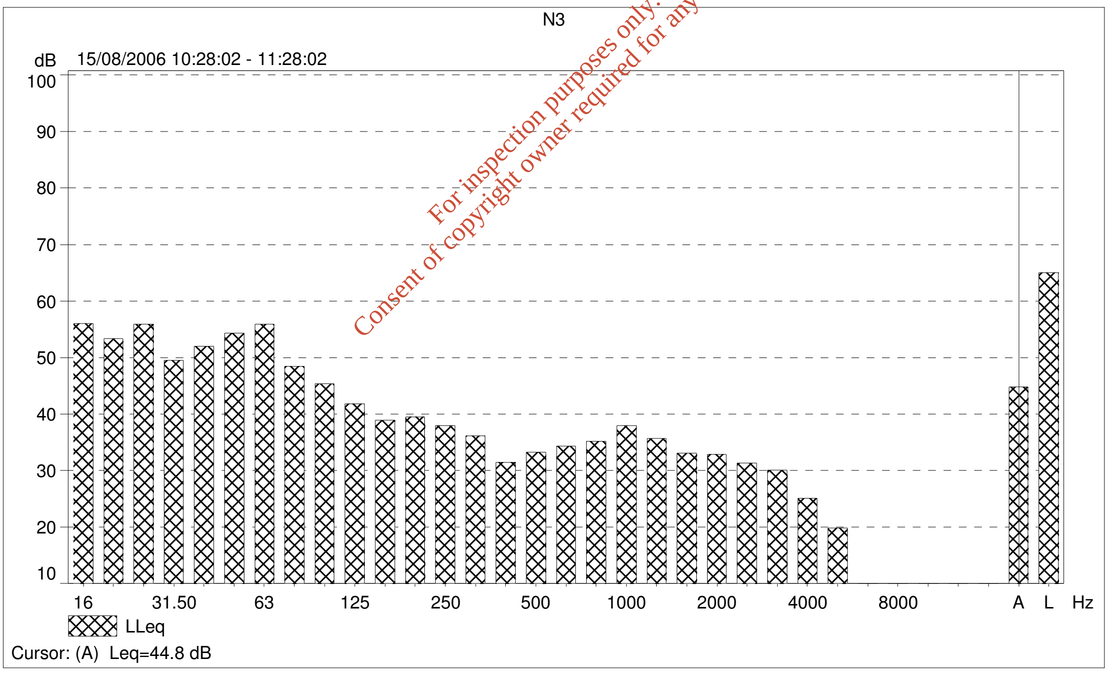
N3
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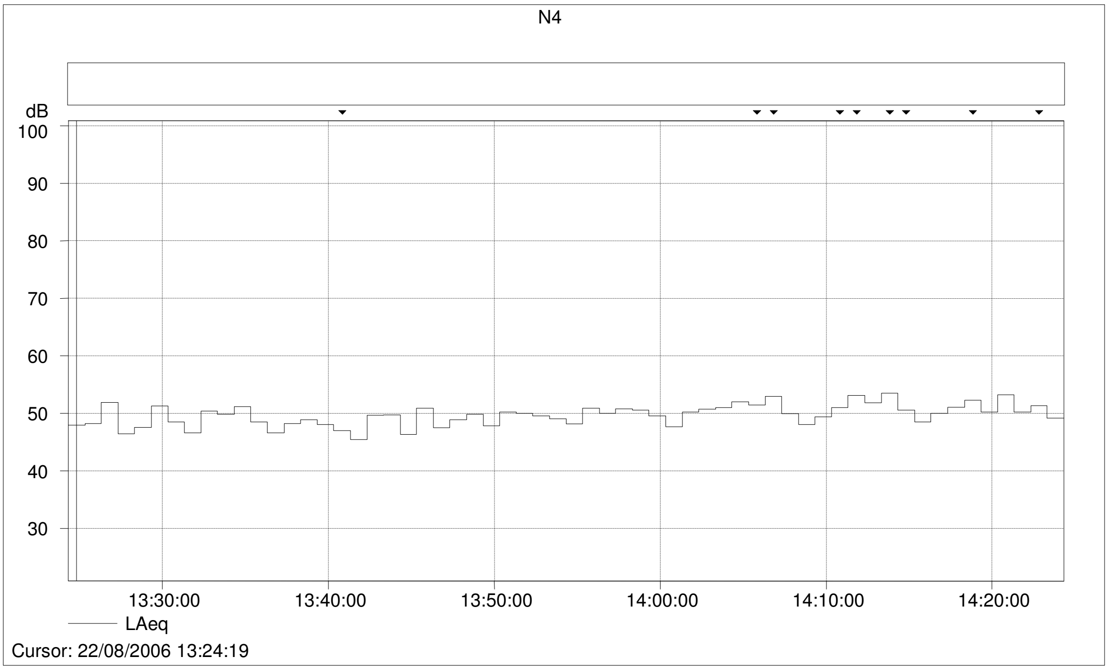
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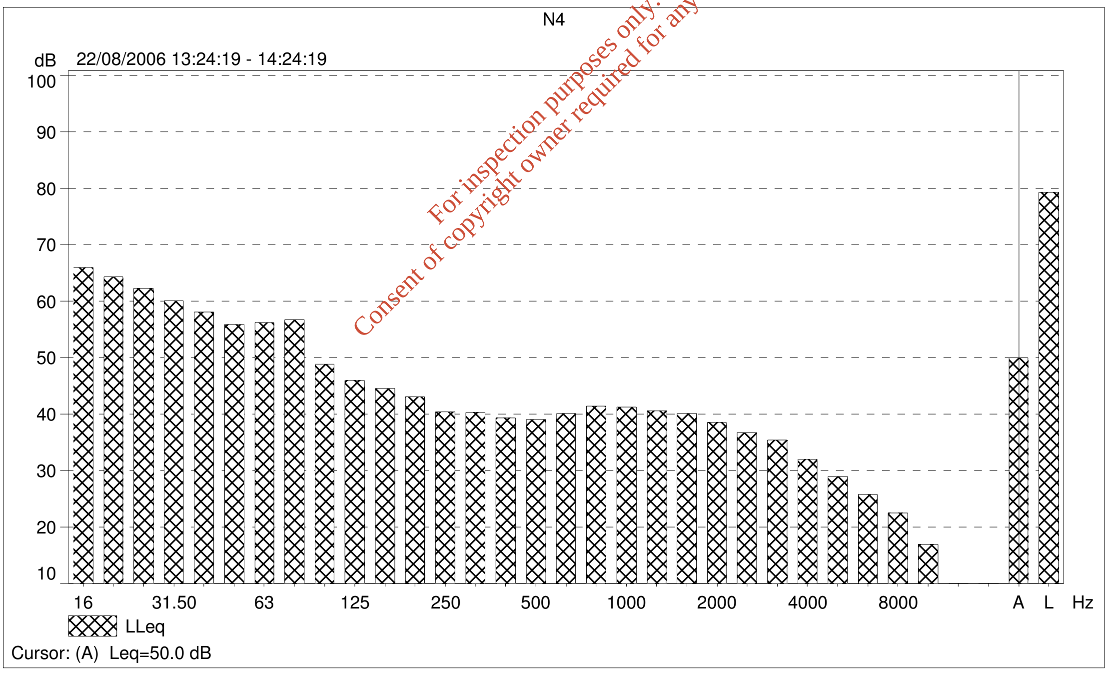
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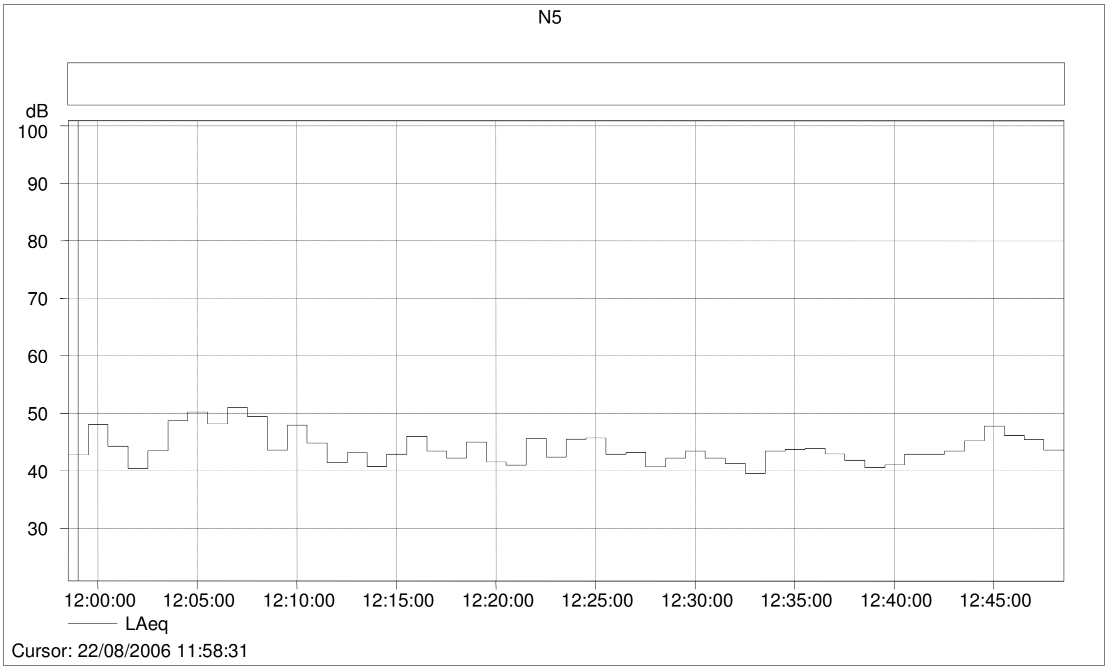
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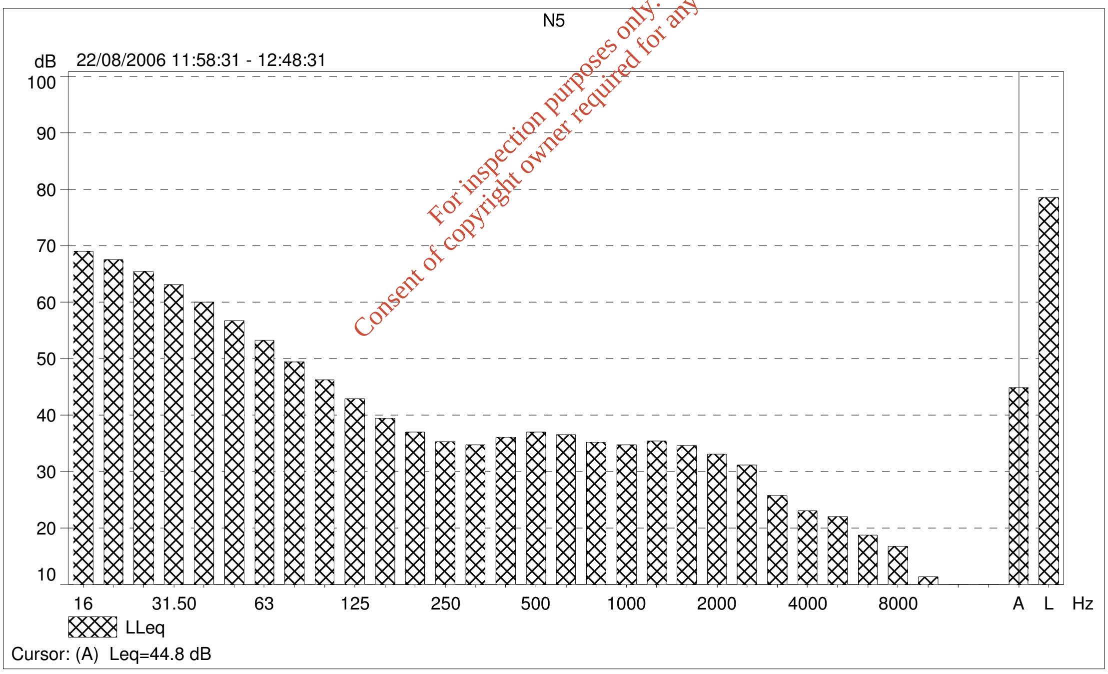
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Dixon.Brosnan
environmental consultants

project title	Noise impact assessment at Dripsey		
client	O'Callaghan Moran		
client ref.	Michael Watson		
project ref.	05025		
report ref.	05025.3		
revision	1	revision date	05.10.06
approved by	Damian Brosnan	issue date	05.10.06
certified only where signed			

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CONTENTS

1. INTRODUCTION

1.1 Dixon.Brosnan Environmental Consultants were commissioned by O'Callaghan Moran to carry out a noise impact assessment in relation to a proposed waste management facility at Tulligmore, Dripsey, Co. Cork. The site is currently being quarried for sand and gravel.

1.2 This report documents the noise prediction undertaken. The report will be included as an appendix to the noise section of an EIS currently in preparation by O'Callaghan Moran.

2. SENSITIVE RECEPTORS

2.1 Seven noise sensitive receptors were identified in the vicinity of the study site. The receptors are indicated in table 1 and figure 1.

Table 1. Noise sensitive locations.

Ref.	Location
NSL1	2 dwellings S of site entrance, SW corner of site
NSL2	Dwelling near site entrance, opposite site of road
NSL3	2 dwellings on 'peninsula' near NW corner
NSL4	Single dwellings near crossroads at NW corner of site
NSL5	Single house north of site boundary
NSL6	Single house 250 m NE of site boundary
NSL7	Single house 500 m SE of proposed waste apron

2.2 While a number of other sensitive receptors are located with 1 km of the site boundary, potential impacts at such receptors will be indirectly assessed by examining impacts arising at the properties listed in table 1 ie. compliance with noise criteria at the above receptors will guarantee compliance at all other receptors.

2.3 The proposed waste management facility will be located near the southeast corner of the quarry site. The location is indicated elsewhere in the EIS document.

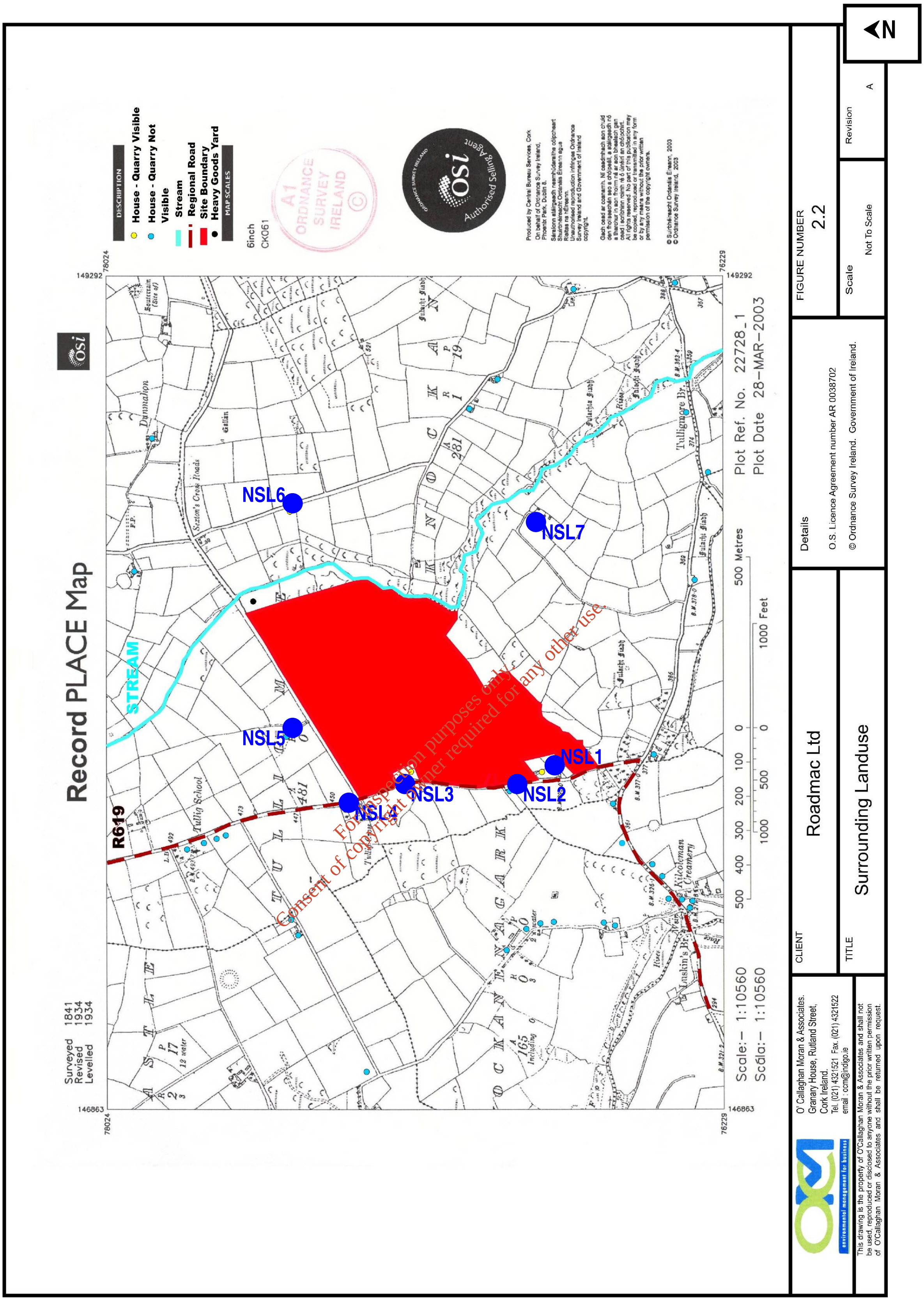

Figure 1. Noise sensitive locations.

3. INPUT DATA

3.1 Typical plant which may be used at the proposed facility in addition to the existing plant is indicated in table 2. Noise output data presented in the table were obtained from plant suppliers and/or from similar facilities. Crushing of C&D rubble at the facility will be undertaken using the existing crusher. Some plant items listed below may not be required but are included in order to provide a worst case scenario. The impact of the existing plant on sensitive receptors has been assessed in the accompanying noise baseline assessment.

Table 2. Additional plant which may be required at proposed waste facility.

Plant	Noise output L_{WA}
Backhoe loader	108 dB
Wood shredder	100 dB
Trommel screen	80 dB
Grab machine	108 dB

3.2 Noise data provided in respect of the shredder and screen indicate that emissions will not be tonal. While emissions from the loader and grab machines may contain tonal characteristics in the 50-200 Hz frequency range, these will not be of aural significance.

3.3 It is assumed in the prediction that emissions will arise continuously during working hours. In practice however it is likely that operation of plant will vary depending on demand.

3.4 The prediction model assumes that mounds will be constructed around the north, east and south sides of the proposed waste management apron. The model also assumes that a mound will be constructed on reinstated ground near the northwest corner of the site, effectively screening locations NSL3 and NSL4. Combinations of natural and artificial screening are also afforded with respect to certain other properties.

4. METHODOLOGY

4.1 The prediction model was undertaken in accordance with *British Standard BS 5228: 1997 Noise and vibration control on construction and open sites Part 1: Code of practice for basic information and procedures for noise and vibration control.*

5. PREDICTED LEVELS

DixonBrosnan Project: 05025

BS 5228 prediction method (stationary sources)

Location	Distance	Noise source	L_{WA}	To L_{Aeq}	L_{Aeq}	Ground type (if mixed see BS 5228)			Screening	Adjustment				Façade	Adjusted	Time correction		Activity LAeq			Cumulative L_{Aeq}
	m		dB	m	L_{WA}-(20logD-8)	Hard/Soft	Kh=20logR/10	Ks=25(logR/10)-2	0,5,10	Kh+Screening	Ks+Screen	Ks only	Applied	0,3	L_{Aeq}	% on	Kt (BS 5228 figD5)	dB	minutes	$10^{L/10}$	$10logS10^{L/10}$
NSL1	500	Waste apron	112	10	84	Soft	33.97940009	40.47425011	0	34.0	40.5	40.5	41	0	43	100	0	43	30	19952.623	N/A
NSL2	500	Waste apron	112	10	84	Soft	33.97940009	40.47425011	5	39.0	45.5	40.5	41	0	43	100	0	43	30	19952.623	N/A
NSL3	350	Waste apron	112	10	84	Soft	30.88136089	36.60170111	10	40.9	46.6	36.6	41	0	43	100	0	43	30	19952.623	N/A
NSL4	470	Waste apron	112	10	84	Soft	33.44195716	39.80244645	10	43.4	49.8	39.8	43	0	41	100	0	41	30	12589.254	N/A
NSL5	370	Waste apron	112	10	84	Soft	31.36403448	37.2050431	10	41.4	47.2	37.2	41	0	43	100	0	43	30	19952.623	N/A
NSL6	360	Waste apron	112	10	84	Soft	31.12605002	36.90756252	10	41.1	46.9	36.9	41	0	43	100	0	43	30	19952.623	N/A
NSL7	500	Waste apron	112	10	84	Soft	33.97940009	40.47425011	10	44.0	50.5	40.5	44	0	40	100	0	40	30	10000	N/A

Table 3. Prediction model output.

6. IMPACTS

6.1 Noise levels directly attributable to the proposed waste management facility are predicted to be as follows:

Table 4. Predicted noise levels arising from proposed facility.

Location	Predicted levels
NSL1	43 dB
NSL2	43 dB
NSL3	43 dB
NSL4	41 dB
NSL5	43 dB
NSL6	43 dB
NSL7	40 dB

6.2 A baseline survey was undertaken at the study site in August 2006. During the survey, noise emissions arose from the existing quarry facility at the site, from quarry operations at the nearby Ducon site, from a private workshop located near the southwest corner of the site, and from traffic. $L_{Aeq\ 1hour}$ levels recorded ranged from 45 to 55 dB at offsite sensitive receptors. The baseline noise survey report is included in the EIS.

6.3 In all cases, levels recorded in August 2006 were higher than emissions predicted from the proposed facility. It follows that noise emissions predicted to arise will be less that existing noise levels at sensitive locations in the vicinity of the site. At most receptors, noise emissions will be significantly lower than existing levels. It is therefore concluded that no noise impacts will arise as a result of the proposed development.

7. CONCLUSIONS

7.1 Noise levels predicted to arise directly from the proposed waste management facility will be 40-43 dB. Emissions will arise from the use of a backhoe loader, grab machine, wood shredder and trommel screen. Crushing of C&D rubble will be undertaken using an existing crusher at the quarry operation onsite. Traffic movements associated with the facility will be negligible in the context of movements at the existing quarry.

7.2 Existing noise levels in the vicinity of the study site range from 45 to 55 dB ($L_{Aeq\ 1hour}$) as recorded during August 2006. These levels are higher than levels predicted to arise from the proposed facility. At most locations, existing noise levels are significantly higher than predicted levels, and it follows that emissions will not be audible. At NSL6 (single house 250 northeast of site) noise emissions from the proposed facility will raise the existing noise levels by 2 dB to 47 dB. This increase will not be significant. It should be noted that an increase of 3 dB is the smallest increase perceptible to the human ear.

7.3 From the foregoing, it is concluded that noise impacts arising from the proposed development will be negligible. Noise emissions will generally not be audible offsite.

7.4 The prediction model was carried out using certain input data. The model will be invalidated where alternative plant equipment is used, or where mounds identified are not constructed. It is therefore recommended that the model is rerun where any such changes arise.

7.5 Despite the absence of noise impacts as predicted, a number of mitigation measures are recommended to ensure that offsite nuisance does not arise:

A. It is recommended that plant ultimately installed onsite does not emit tonal emissions. Manufacturer noise data should be assessed prior to purchase.

B. It is recommended that all plant installed onsite is maintained in accordance with manufacturer requirements. Defective or worn parts should be repaired or replaced immediately.

C. It is recommended that all site mounds are planted and grass seeded on completion in order to stabilise mounds and to reduce visual impacts.

D. It is recommended that external phone bells and tannoy systems are avoided onsite.

E. It is recommended that site personnel are instructed to minimise certain potentially noisy activities such as banging of the backhoe bucket on the concrete apron, etc.

F. It is recommended that noise levels are assessed in the vicinity of the site following commissioning of plant.

APPENDIX 8

Visual Impact Photographs

Viewpoint 1: 350m NW of the site

Viewpoint 2: Northern Site Boundary

Viewpoint 3: Northwest Corner

Viewpoint 4: Residence on Western Boundary

APPENDIX 9

Traffic Impact Assessment

Contents

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Consulting Engineers
Road Design & Traffic Engineering Section
Carrig Mor House
10 High Street, Douglas Road, Cork.

Tel 021- 4840214
Fax. 021- 4840215
E-Mail: info@mhl.ie

1.0 NON-TECHNICAL SUMMARY

M.H.L. & Associates Ltd. Consulting Engineers have been engaged by O'Callaghan Moran Consulting Engineers to prepare a Traffic Impact Assessment report as part of an overall EIS required as part of a planning application on an existing quarry operation in Dripsey, Co. Cork. Following a notice from Cork County Council Roadmac Ltd, the quarry operators are obliged to lodge an application for the continued operation of the quarry in Dripsey. In addition they are seeking permission for the acceptance and processing of inert wastes for recovery including the restoration of certain areas of the site and for the acceptance and composting of green waste. The site is located in the townland of Tulligmore approximately 3 kilometers north east of Coachford. It is bound to the west by the R619 Regional Road, which splits the site in two. (See Site Location Map Drawing No. TR-TIA-01 in Appendix A). The existing site entrances are off the R619, the main Coachford Mallow road. The R619 junctions with the R618 at Coachford, approximately 3km south of the site and with the R579 3 km north of the site.

Existing Operations:

The existing operation involves the quarrying of sands and gravels which are extracted, washed and screened on site prior to transportation to points of sale. The site currently extracts approximately 1,250 tonnes per day with 25 30 tonne trucks and 25 20 tonne trucks entering and leaving the Dripsey site per day, six days per week.

Proposed Operations:

It is proposed to apply for permission to also use the site for the following;

- Development of a recycling plant for clean Construction and Demolition (C&D) waste (concrete, rubble, tiles, clean soils & subsoils etc). The processed materials would either be sold for use in construction projects or alternatively be used on-site for restoration purposes. The clean soils and subsoils would be used in the on-site restoration works. It is intended to apply for the acceptance of 180,000 tonnes of clean C&D wastes per annum. Vehicles will enter with C&D and will leave the site with aggregates generated as part of the existing extraction activities or with processed C&D.

- Green Waste Composting (grass cuttings, shrub trimmings and waste from tree surgery and park maintenance). The facility will accept approximately 5,000 tonnes of green wastes per annum and 3,000 tonnes of compost would be consigned. The traffic associated with the composting would be unique to this process.

A one-hour manual classified traffic count was undertaken on the 19th September 2006 at the R619/R618 cross roads junction. All vehicular and pedestrian traffic movements were recorded between the hours of 8.00am and 9:00am. The traffic movements were used to determine the AADT (Annual Average Daily Traffic) using the R619 road as well as the percentage of HGV's present on the route in the vicinity of the Quarry.

This report has been prepared in accordance with the "Guidelines for Traffic Impact Assessments published by the Institution of Highways & Transportation U.K. 1994 ". The purpose of a TIA is to assess the traffic impact of a development on the existing road network and if required, design the most effective road network and junction types to best accommodate the expected traffic volumes generated by the proposed developments.

1.1 Proposed Network Changes

The following are the recommended mitigation measures to be made to the existing road network to cater for the development.

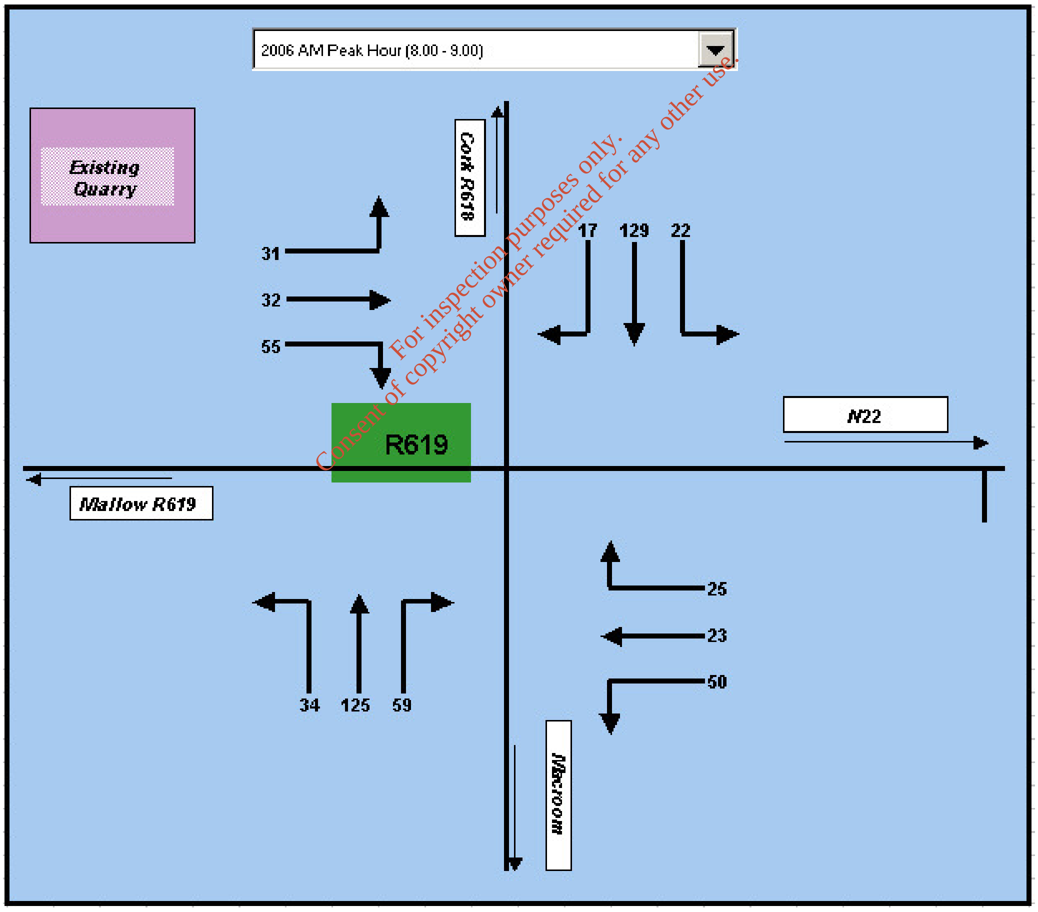
Existing Junction onto R619 – Quarry Junction

The current junction operates well within its capacity given the volumes of traffic recorded for the R619. The speed limit on the approaches to the junction is 80kph on a relatively wide section of road, 8.3m surveyed. On the day of the site visit the road had been recently surfaced and was without road markings. The observed speed was in excess of 80kph however sight lines to the north are inadequate to cater for this speed. Given the nature of the proposed development and the expected rise in heavy goods vehicles entering and leaving the site it is proposed that a dedicated right hand turn lane be provided on the R619 with advanced permanent signage in place on the approach to the junction. In addition to providing storage the reduced lane widths will act as a traffic-calming device for through traffic. It is further proposed that sight lines in both directions be cleared to the required 160m measured at a set-back of 2.4m from the road edge to the near-side carriageway. A proposed layout is shown on the accompanying drawing DQ-TIA-P01.

2.0 EXISTING CONDITIONS

The site is situated on the R619 road linking Coachford to Mallow and intersecting the R579 road at Crean's Crossroads. The road has an average width of 5.5m with a realigned area in the vicinity of the Quarry giving a road width in excess of 8.0m. In general the road has a better horizontal alignment to the north of the Quarry entrance in the direction of Mallow and the R579 than in the direction of Coachford and the R618. A peak hour traffic count was carried out to determine the existing AADT on the R619 and the current HGV content. This count was carried out at the Coachford junction and indicates an AADT of 2,000 vehicles with 7 % Heavy Goods Vehicle content.

The survey recorded the following traffic movements in Table 1 below at this location during the 1 hour period on the busiest day of the week, ie. Tuesday. These figures were then interpolated to determine the Annual Average Daily Traffic Flow by applying the NRA publication RT201 "Expansion Factors for Short Period Traffic Counts" for a Rural Intertown Route.



Traffic Volumes Recorded

3.0 PROPOSED DEVELOPMENT

The proposed development consists of a recycling plant for clean Construction and Demolition (C&D) waste. The processed materials would either be sold for use in construction projects or alternatively be used on-site for restoration purposes. The clean soils and sub-soils would be used in the on-site restoration works. It is intended to apply for the acceptance of 180,000 tonnes of clean C&D wastes per annum. Vehicles will enter with C&D and will leave the site with aggregates generated as part of the existing extraction activities or with processed C&D.

Green Waste Composting (grass cuttings, shrub trimmings and waste from tree surgery and park maintenance). The facility will accept approximately 5,000 tonnes of green wastes per annum. 5,000 tonnes of green wastes would be accepted at the facility per annum and 3,000 tonnes of compost would be consigned. The traffic associated with the composting would be unique to this process.

4.0 MODAL CHOICE AND TRIP ATTRACTION

At present the Quarry attracts the following recorded trips per day, 25 – 30 tonne trucks and 25 - 20 tonne trucks. This equates to 1,250 tonnes of aggregate per day. The facility currently operates from 06:00 to 19:00 Monday to Saturday. The remainder of trips generated by the development will be those of the employees, customers and sales representatives, potential customers and official inspectors etc. It is a fair assumption that all of these will be by private car or motor-cycle.

Therefore the primary mode of transport generated by the development will be via the road network and will be predominantly heavy goods vehicles transporting materials to and from the recycling facility and the existing quarry operation.

Of the trips generated by the heavy goods vehicles transporting materials to the recycling facility it is expected that this figure will vary greatly and may be of the order of 4 to 5 vehicles in quiet periods but may be up to 45 vehicles per day during the peak of a major construction/demolition project. Of the 180,000 tonnes imported it is assumed that 90,000 will be recycled and transported of-site. This implies 270,000 tonnes of material per annum could be expected to generate 10,000 trips /annum or on average 45 trips per day.

The green waste composting operation is not open to the general public but would be serviced by landscape contractors and local authority Bring Sites. It is expected that the average trip would carry approximately 1 tonne of material implying a total number of trips generated in the region of 5,000 per annum. This on average would equate to an additional 16 trips per day but again may fluctuate depending on time of year and season.

The overall daily trip generation by both the existing and proposed operations would be as follows:

Existing Quarry facility. 50 HGV's
Proposed Recycling Plant. 45 HGV's
Proposed Green Waste Facility. 16 HGV's

This equates to a 55% increase in HGV's using the Quarry.

5.0 TRIP DISTRUBITION

The catchment area and hence the Origin/Destination for the traffic being generated by the proposed development is Cork City and its environs. The traffic generated by the development is described in section 4.0 above. All these generated trips are assumed to be "new" trips. No redistribution of trips from the surrounding network is expected to be caused by the development.

The "non primary" trips (i.e. the pass-by trips already on the R619) are described in section 2.0.

The current distribution of traffic on the R619 at the existing junction is as follows;

A 61/39 split over the peak hour period with 61% southbound towards Coachford.

This peak hour directional split pattern is assumed to remain constant for the non-primary trips with the passage of time.

The destination for all trips being generated by the development is the development itself. The origins on the other hand will principally be Cork City and the greater Cork area. The exact distribution to these destinations cannot be exactly determined as it will depend on various locations of construction projects. However it is safe to assume that given the nature of the horizontal alignment on the R619 in the direction of Coachford the main percentage of HGV's will access the Quarry from Crean's Cross Roads and the R579

Trip Distribution from development: **90% Northbound, 10% Southbound.**

6.0 ASSIGNMENT OF DEVELOPMENT TRAFFIC

Access to the development is being provided via a modified T-junction layout onto the R619. The modifications suggested are shown on the accompanying drawing DQ-TIA-P01 and are required from a road safety perspective. It is proposed to provide a dedicated right hand turn/storage lane to allow Heavy Goods Vehicles adequate stopping distance and storage on the Coachford approach to the Quarry entrance without interfering with straight through traffic. In addition to segregating development traffic the provision of this additional lane implies a reduced carriageway width in the vicinity of the entrance and hence an expected reduction in speed.

7.0 ASSESSMENT YEARS.

A model of the existing junction using the PICADY software package indicates a 99% spare capacity at the junction. Given the low volumes of traffic generated by the development and the low AADT on the existing road the capacity of this junction will never be an issue.

8.0 HIGHWAY IMPACT.

The proposed changes to the junction should be carried out in accordance with the "National Roads Authority Road Geometry Handbook" (December 2000) and should be lined and signed appropriately.

Sight Distance

The Sight distances measured on site are inadequate to cater for the design speed of the road. The proper sightlines should be provided as per the requirements outlined in the NRA Road Geometry Handbook Addendum TD 41/95 "Vehicular Access to all-purpose National Roads" paragraph 2.22. We can take the R619 design speed as being 80kph requiring 160m sight distance at 4.5m set back. The proposed junction layout drawing shows the required set back of existing vegetation to achieve this. The set back is within the boundaries of the Quarry lands and is achievable.

Road Alignment

The current alignment of the R619 in the vicinity of the development junction is more than adequate to cater for the expected development traffic. However, from a road safety point of view the addition of slow moving HGV's at a junction could lead to accidents. The provision of a right hand turn lane would alleviate this potential problem with the added benefit of acting as a traffic-calming device along this stretch of the R619.

9.0 ROAD SAFETY

Adequate advance warning signs for the facility and heavy goods vehicle usage should be positioned on the R619 on both sides of the development. In addition the provision of public lighting along this stretch of road should be considered specifically given the nature of the development. Sightlines to both sides of the entrance should be kept clear of planting and signage.
All new signage shall be in accordance with the Department of Environment "Traffic Signs Manual".

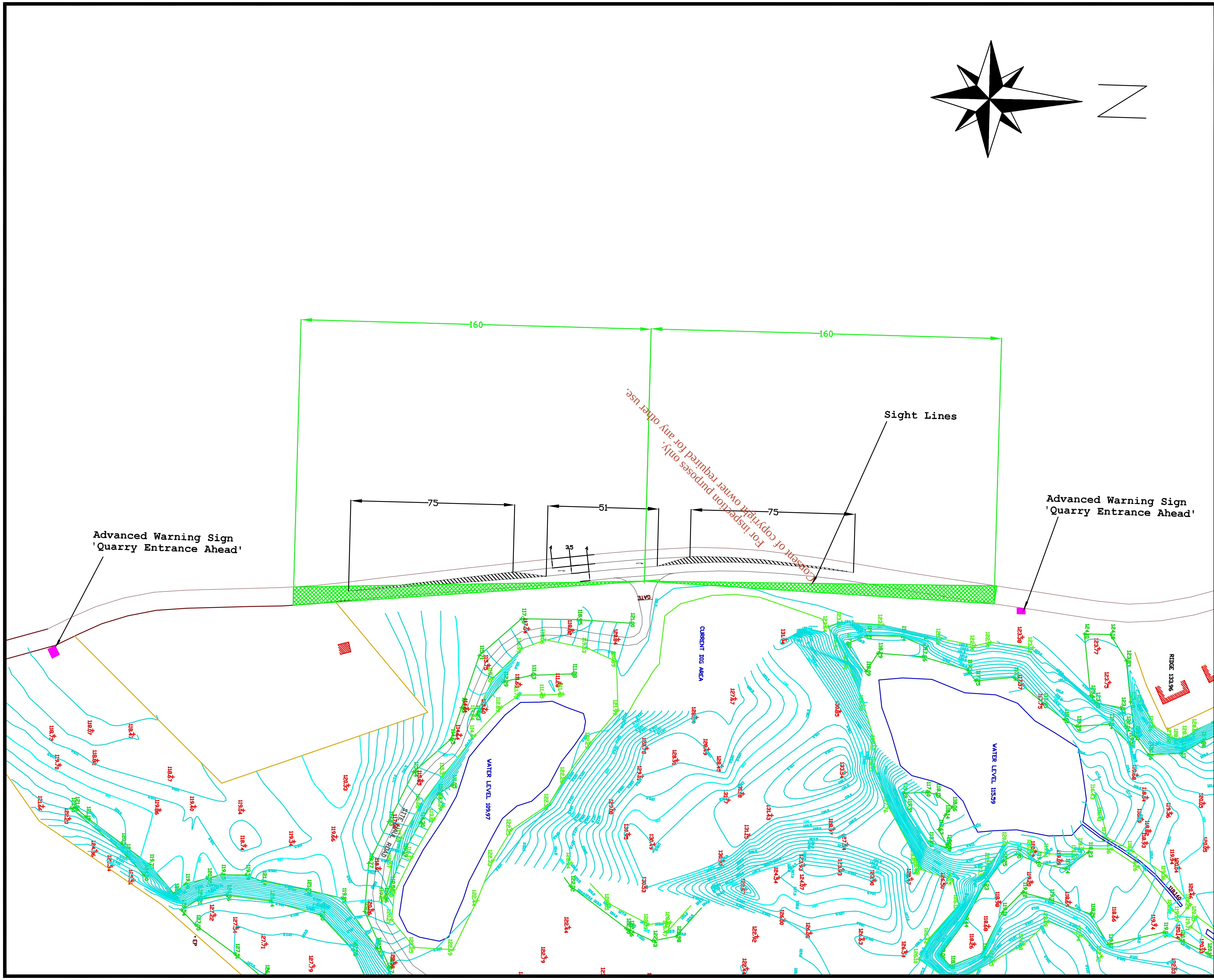
10.0 INTERNAL LAYOUT.

No details of the internal road network were supplied

11.0 PARKING PROVISIONS.

Not applicable

APPENDIX A : Drawings



Notes:

Do not scale from drawing. All dimensions are in metres.
For any discrepancies found please consult with design office.
This drawing should be read in conjunction with all Contract Drawings, Documents and Specifications.

Rev.	By.	Date.	Description.

Drawing Status:

Project Title: Dripsey Quarry

Drawing Title: Proposed Quarry Junction layout

Client: OCM Envioronmental Consultants

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Designed: KM **Drawn:** MAC
Scale: Not to Scale **Date:** Sept 2006
Drawing No. DQ-TIA-P01 **Revision.**