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7. AIR QUALITY STUDY

7 .1 Introduction

The proposed facility has commissioned an extensive and detailed examination of air emissions from the proposed waste-to-energy facility in Carranstown, Co. Meath. As described in detail elsewhere, the waste management facility will be based on conventional grate incineration technology. The waste is tipped into a bunker prior to being fed into the furnace. In the furnace the waste is incinerated, producing heat, ash and combustion gases.

The combustion of waste produces a number of emissions, the discharges of which is regulated by the EU Directive on Waste Incineration (2000/76/EC). The emissions to atmosphere which have been regulated are:

- Nitrogen Dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Total Dust (as PM_{10} and $PM_{2.5}$)
- Carbon Monoxide (CO)
- Total Organic Carbon (TOC)
- Hydrogen Fluoride (HF) and Hydrogen Chloride (HCl)
- Dioxins/Furans (PCDD/PCDFs)
- Cadmium (Cd) & Thallium (Tl)
- Mercury (Hg)
- and the sum of Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Maganese (Mn), Nickel (Ni) and Vanadium (V).

In addition, Polycyclic Aromatic Hydrocarbons (PAHs) have been assessed as incineration is a potential emission source for this group of compounds.

The scope of the study consists of the following components:

- Review of maximum emission levels and other relevant information needed for the modelling study;
- Identification of the significant substances which are released from the site;
- Review of background ambient air quality in the vicinity of the plant;
- Air dispersion modelling of significant substances released from the site;
- Air dispersion and deposition modelling of dioxin and heavy metals released from the site;
- Identification of predicted ground level concentrations of released substances at the site boundary and at sensitive receptors in the immediate environment;

- A full cumulative assessment of significant releases from the site taking into account the releases from all other significant industry in the area based on the Prevention of Significant Deterioration (PSD) approach;
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the most stringent ambient air quality standards and guidelines;
- Impact in the unlikely event of “abnormal” operating conditions.

7.2 Study Methodology

7.2.1 Introduction

The air dispersion modelling input data consists of detailed information on the physical environment (including building dimensions and terrain features), design details from all emission points on-site and a full year of worst-case meteorological data. Using this input data, the model predicts ambient ground level concentrations beyond the site boundary for each hour of the modelled meteorological year. The model post-processes the data to identify the location and maximum of the worst-case ground level concentration in the applicable format for comparison with the relevant limit values. This worst-case concentration is then added to the existing background concentration to give the worst-case predicted ambient concentration. The worst-case ambient concentration is then compared with the relevant ambient air quality standard for the protection of human health to assess the significance of the releases from the site.

Throughout this study a worst-case approach was taken. This will most likely lead to an over-estimation of the levels that will arise in practice. The worst-case assumptions are outlined below:

- Emissions from all emission points in the cumulative assessment were assumed to be operating at their maximum emission level, 24 hours/day over the course of a full year. This represents a very conservative approach as typical emission from the proposed facility will be well within the emission limit values set out in the Waste Incineration Directive.

- All emission points were assumed to be operating at their maximum volume flow, 24 hours/day over the course of a full year.

- Maximum predicted ambient concentrations for all pollutants measured within a 9 km radius of the site were reported in this study even though, in most cases, no residential receptors were near the location of this maximum ambient concentration. Concentrations at the nearest residential receptors are generally significantly lower than the maximum ambient concentrations reported.

- Worst-case background concentrations were used to assess the baseline levels of substances released from the site

- Worst-case meteorological conditions have been used in all assessments. Firstly, the worst-case year with regard to the maximum 1-hour concentration (as a 99.8th%ile) was selected for modelling all pollutants except PCDD/PCDFs (Dioxins/Furans), PAHs and heavy metals (Year 1998). Maximum 1-hour concentrations (as a 99.8th%ile) using year 1998 meteorological data are 35% higher than the five-year average. Secondly, the worst-case year with regard to the annual average concentrations was selected for modelling PCDD/PCDFs (Dioxins/Furans), PAHs and heavy metals (Year 2000). Annual average concentrations using year 2000 meteorological data are 4% higher than the five-year average.

7.2.2 Meteorological Considerations

Meteorological data is an important input into the air dispersion model. The local airflow pattern will be greatly influenced by the geographical location. Important features will be the location of hills and valleys or land-water-air interfaces and whether the site is located in simple or complex terrain.

The selection of the appropriate meteorological data has followed the guidance issued by the USEPA(1). A primary requirement is that the data used should have a data capture of greater than 90% for all parameters. Two meteorological stations were identified near the site – Casement Aerodrome and Dublin Airport. Data collection of greater than 90% for all parameters is required for air dispersion modelling. Both Casement Aerodrome and Dublin Airport fulfil this requirement.

The additional requirements of the selection process depend on the representativeness of the data. The representativeness can be defined as “the extent to which a set of measurements taken in a space-time domain reflects the actual conditions in the same or different space-time domain taken on a scale appropriate for a specific application”(2). The meteorological data should be representative of conditions affecting the transport and dispersion of pollutants in the area of interest as determined by the location of the sources and receptors being modelled.

The representativeness of the data is dependent on(1):

1) the proximity of the meteorological monitoring site to the area under consideration,
2) the complexity of the terrain,
3) the exposure of the meteorological monitoring site (surface characteristics around the meteorological site should be similar to the surface characteristics within the modelling domain),
4) the period of time during which data is collected.

In the region of the site, Dublin Airport is the nearest suitable meteorological station to the site and due to its proximity the weather pattern experienced would be expected to be similar. On account of the modest terrain features to the north of the site, some channelling of wind may be expected to occur along the direction of the Boyne Valley. However, this would not be expected to be significant at stack height due to the modest nature and shallow gradient of this terrain feature.

The windrose from Dublin Airport for the years 1998-2002 is shown in Figure 7.1. The windrose indicates the prevailing wind speed and direction over the five-year period. The prevailing wind direction is generally from the W-SW direction. In the worst-case year of 1998, wind speeds were generally moderately strong, averaging around 4-6 m/s.

7.2.3 Modelling Methodology

Emissions from the proposed site have been modelled using the AERMOD dispersion model (Version 04300) which has been developed by the U.S. Environmental Protection Agency (USEPA)(3). The model is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources. The model has been designated the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and complex terrain(1). An overview of the model is outlined in Appendix 7.1.

7.2.4 Assessment Methodology

Council Directive 2000/76/EC

The assessment methodology used in the current study was developed following the recommendations outlined in Council Directive 2000/76/EC on the Incineration of Waste.

The Directive has outlined air emission limit values, which are to be complied with as set out in Table 7.1. The Directive has also outlined stringent operating conditions in order to ensure sufficient combustion of waste thus ensuring that dioxin formation is minimised. Specifically, the combustion gases must be maintained at a temperature of 850°C for at least two seconds under normal operating conditions for non-hazardous waste whilst for hazardous waste containing more than 1% halogenated organic substances, the temperature should be raised to 1100°C for at least two seconds. These measures will ensure that dioxins/furans, polychlorinated biphenyls (PCBs) and PAHs are minimised through complete combustion of waste.

Specific emission measurement requirements have been outlined in the directive for each pollutant:

1) continuous measurements of the following substances; NO_x, CO, total dust, TOC, HCl, and SO_2.
2) bi-annual measurements of heavy metals, dioxins and furans.

Indaver Ireland is committed, as a minimum, to meeting all the requirements of Council Directive 2000/76/EC. Indeed, due to the advanced post-combustion flue gas cleaning technology employed, expected average emission values will be significantly lower than the values used in this study. The maximum and abnormal emission concentrations and mass emission rates have been detailed in Table 7.2.

Very low levels of dioxin will be emitted under typical operating conditions from the incineration process. Typical emissions will be well below the stringent limit value set out in Council Directive 2000/76/EC. This rigorous limit value will be achieved through a targeted removal system over several stages of the flue gas cleaning system. Prior to abatement, the formation of dioxins will be minimised by the maintenance of high combustion temperatures (over 850°C at all times) for a period of two seconds followed by rapid cooling of gases from 400°C to 200°C which is the critical temperature range for dioxins formation in combustion systems. Post-combustion, dioxins will be removed via a two-stage removal process. The first stage involves the injection of activated carbon into the combustion gas duct, directly after the evaporating spray reactor. The large surface area of the activated carbon helps to adsorb dioxins, furans, hydrocarbons and heavy metals. The activated carbon, containing these particulates, is removed from the gases in the baghouse filter. This first stage will meet the requirements of 200/76/EC for dioxin emissions. In the second stage, the flue gases are brought into vigorous contact with activated carbon, which will either consist of a fixed bed in the scrubber or an activated carbon slurry circulated in the scrubber. The combined efficiency of these filters will ensure that emission concentrations will be well below the emissions limits of the EU Council Directive 2000/76/EC. In order to confirm this efficiency target, a continuous dioxin sampler will be employed to determine average fortnightly concentrations, thus allowing an accurate comparison with the emission limit values.

USEPA Guidelines On Air Quality Models

In the absence of detailed local guidance, the selection of appropriate modelling methodology has followed the guidance from the USEPA which has issued detailed and comprehensive guidance on the selection and use of air quality models(1,3,10-11).

Based on guidance from the USEPA, the most appropriate regulatory model for the current application is AERMOD (Version 04300). The model is applicable in both flat and complex terrain, urban or rural locations and for all averaging periods(1,3).

The USEPA has outlined guidance in order to establish the operating conditions that causes the maximum ground level concentration. The guidance indicates that a range of operating conditions should be assessed in the initial screening analysis. Table 7.3 outlines the recommended range of operating conditions to be assessed and which was adopted in the current assessment.

Cumulative Assessment

As the region around Carranstown is partly industrialised and thus has several other potentially significant sources of pollutants, a detailed cumulative assessment has been carried out using the methodology outlined by the USEPA. Table 7.3 outlines the recommended range of operating conditions to be assessed in the cumulative assessment.

The impact of nearby sources should be examined where interactions between the plume of the point source under consideration and those of nearby sources can occur. These include:

1) the area of maximum impact of the point source,
2) the area of maximum impact of nearby sources,
3) the area where all sources combine to cause maximum impact on air quality(1).

Background concentrations for the area, based on natural, minor and distant major sources need also to be taken into account in the modelling procedure. A major baseline monitoring programme (see Section 7.3 below) was undertaken over several months which, in conjunction with other available baseline data, was used to determine conservative background concentrations in the region (see Table 7.12).

The methodology adopted in the cumulative assessment was based on the USEPA recommended Prevention of Significant Deterioration (PSD) increment approach(12). The PSD increment is the maximum increase in concentration that is allowed to occur above a baseline concentration for each pollutant. However, no exceedence of the ambient air quality limit values (or NAAQS in the USA) is allowed even if not all of the PSD increment is consumed.

The PSD has three classifications of land use as outlined below:

Class I Areas:	Class I areas include national parks, national wilderness areas and other areas of special national or regional value.
Class II Areas:	Attainment areas that are neither industrialised nor meet the specific requirements for classification as Class I areas.
Class III Areas:	Industrialised attainment areas.

Although Platin Cement is located close to the proposed facility, the current location would not be considered an industrialised attainment area. It has therefore been considered as a Class II area and thus the PSD applicable to Class II areas has been applied in the current case. Due to the variations in pollutant averaging times and standards between the USA and the EU, only relative PSD Increments can be derived. The relative PSD Increment, as a percentage of the respective NAAQS, is shown in Table 7.4 with the corresponding concentration as it would be applied to the EU ambient air quality standards. In the current context, the PSD increment has been applied only to zones were significant overlap occurs between plumes from each of the sources.

In the context of the cumulative assessment, all significant sources should be taken into account. The USEPA has defined "significance" in the current context as an impact leading to a 1µg/m^3 annual increase in the annual average concentration of the applicable criteria pollutant (PM_{10}, NO_2, and SO_2)$^{(12)}$. However, no significant ambient impact levels have been established for non-criteria pollutants (defined as all pollutants except PM_{10}, NO_2, SO_2, CO and lead). The USEPA does not require a full cumulative assessment for a particular pollutant when emissions of that pollutant from a proposed source would not increase ambient levels by more than the significant ambient impact level (annual average of 1µg/m^3). An assessment of releases from the proposed facility has indicated that releases of SO_2, CO, PM_{10} and TOC are not significant and thus no cumulative assessment need be carried out for these substances (see Table A7.4 in Appendix 7.2). However, due to the presence of Platin Cement, a cumulative impact assessment was conducted for SO_2, PM_{10} and $PM_{2.5}$ thus representing a worst-case approach.

The project impact area for the cumulative assessment is the geographical area for which the required air quality analysis for PSD increments are carried out. The USEPA has defined the "impact area" as a circular area with a radius extending from the source to the most distant point where dispersion modelling predicts a significant ambient impact will occur irrespective of pockets of insignificant impact occurring within it. Within this impact area, all nearby sources should be modelled, where "nearby" is defined as any point source expected to cause a significant concentration gradient in the vicinity of the proposed new source.

In order to determine compliance, the predicted ground level concentration (based on the full impact analysis and existing air quality data) at each model receptor is compared to the applicable ambient air quality limit value or PSD increment. If the predicted pollutant concentration increase over the baseline concentration is below the applicable increment, and the predicted total ground level concentrations are below the ambient air quality standards, then the applicant has successfully demonstrated compliance.

When an air quality standard or PSD increment is predicted to be exceeded at one or more receptor in the impact area, it should be determined whether the net emissions increase from the proposed source will result in a significant ambient impact at the point of each violation, and at the time the violation is predicted to occur. The source will not be considered to cause or contribute to the violation if its own impact is not significant at any violating receptor at the time of each violation$^{(12)}$.

Table 7.1 Council Directive 2000/76/EC, Annex V Air Emission Limit Values

Daily Average Values	**Concentration**	
Total Dust	10 mg/m^3	
Gaseous & vaporous organic substances expressed as total organic carbon (TOC)	10 mg/m^3	
Hydrogen Chloride (HCl)	10 mg/m^3	
Hydrogen Fluoride (HF)	1 mg/m^3	
Sulphur Dioxide (SO_2)	50 mg/m^3	
Nitrogen Oxides (as NO_2)(1)	200 mg/m^3	
Half-hourly Average Values	**Concentration**	
	(100%)	**(97%)**
Total Dust(2)	30 mg/m^3	10 mg/m^3
Gaseous & vaporous organic substances expressed as total organic carbon (TOC)	20 mg/m^3	10 mg/m^3
Hydrogen Chloride (HCl)	60 mg/m^3	10 mg/m^3
Hydrogen Fluoride (HF)	4 mg/m^3	2 mg/m^3
Sulphur Dioxide (SO_2)	200 mg/m^3	50 mg/m^3
Nitrogen Oxides (as NO_2)	400 mg/m^3(1)	200 mg/m^3
Average Value Over 30 mins to 8 Hours	**Concentration(3)**	
Cadmium and its compounds, expressed as Cd	Total 0.05 mg/m^3	
Thallium and its compounds, expressed as Tl		
Mercury and its compounds, expressed as Hg	0.05 mg/m^3	
Antimony and its compounds, expressed as Sb	Total 0.5 mg/m^3	
Arsenic and its compounds, expressed as As		
Lead and its compounds, expressed as Pb		
Chromium and its compounds, expressed as Cr		
Cobalt and its compounds, expressed as Co		
Copper and its compounds, expressed as Cu		
Manganese and its compounds, expressed as Mn		
Nickel and its compounds, expressed as Ni		
Vanadium and its compounds, expressed as V		
Average Values Over 6 – 8 Hours	**Concentration**	
Dioxins and furans	0.1 ng/m^3	
Average Value	**Concentration(4)**	
	Daily Average Value	**30 Min Average Value**
Carbon Monoxide	50 mg/m^3	100 mg/m^3

(1) Until 1/1/2007 the emission limit value for NO_x does not apply to plants only incinerating hazardous waste

(2) Total dust emission may not exceed 150 mg/m^3 as a half-hourly average under any circumstances

(3) These values cover also the gaseous and vapour forms of the relevant heavy metals as well as their compounds

(4) Exemptions may be authorised for incineration plants using fluidised bed technology, provided that emission limit values do not exceed 100 mg/m^3 as an hourly average value.

Table 7.2 Air Emission Values From Proposed Waste-to-Energy Facility, Carranstown, Co. Meath

Daily Average Values	EU Maximum Emission Concentration	Maximum Operating Values	Abnormal Emission Concentration	Abnormal Operating Values
		Emission Rate (g/s)		**Emission Rate (g/s)**
Total Dust	10 mg/m^3	0.41	30 mg/m^3	1.2
Gaseous & vaporous organic substances expressed as total organic carbon (TOC)	10 mg/m^3	0.41	30 mg/m^3	1.2
Hydrogen Chloride (HCl)	10 mg/m^3	0.41	60 mg/m^3	2.5
Hydrogen Fluoride (HF)	1 mg/m^3	0.041	4 mg/m^3	0.16
Sulphur Dioxide (SO_2)	50 mg/m^3	2.0	200 mg/m^3	8.2
Nitrogen Oxides (as NO_2)	200 mg/m^3	8.2	400 mg/m^3	16.3
Hourly Average Value	**Emission Concentration**	**Emission Rate (g/s)**	**Emission Concentration**	**Emission Rate (g/s)**
Cadmium and its compounds, expressed as Cd	Total 0.05 mg/m^3	0.0020	Total 1 mg/m^3	0.041
Thallium and its compounds, expressed as Tl				
Mercury and its compounds, expressed as Hg	0.05 mg/m^3	0.0020	1 mg/m^3	0.041
Antimony and its compounds, expressed as Sb	Total 0.5 mg/m^3	0.020		
Arsenic and its compounds, expressed as As				
Lead and its compounds, expressed as Pb				
Chromium and its compounds, expressed as Cr				
Cobalt and its compounds, expressed as Co			Total 30 mg/m^3	1.2
Copper and its compounds, expressed as Cu				
Manganese and its compounds, expressed as Mn				
Nickel and its compounds, expressed as Ni				
Vanadium and its compounds, expressed as V				
Average Values Over 6 – 8 Hours	**Emission Concentration**	**Emission Rate (g/s)**	**Emission Concentration**	**Emission Rate (g/s)**
Dioxins and furans	0.1 ng/m^3	4.1 x 10^{-9}	0.5 ng/m^3	2.0 x 10^{-8}
Average Value	**Emission Concentration**	**Emission Rate (g/s)**	**Emission Concentration**	**Emission Rate (g/s)**
Carbon Monoxide	100 mg/m^3	4.1	200 mg/m^3	8.2

Table 7.3 Model Input Data For Point Sources For PSD Compliance

Average Time	Emission Limit (mg/m^3)	X Operating Level (mg/hr)	X Operating Factor (hr/year)
Proposed Major New Source			
Annual	Maximum allowable emission limit	Design capacity	Continuous operation
Short term (≤ 24 hrs)	Maximum allowable emission limit	Design capacity	Continuous operation
Nearby Major Source			
Annual	Maximum allowable emission limit	Design capacity	Actual Operating Factor averaged over 2 years
Short term (≤ 24 hrs)	Maximum allowable emission limit	Design capacity	Continuous operation

Table 7.4 PSD Increments Relative To NAAQS (US) and As Applied To EU Directives

Pollutant	Averaging Period	Class II PSD Increment $\mu g/m^3$	% of NAAQS (& % of EU Directives)	PSD Increment as applied to EU Standards ($\mu g/m^3$) / Averaging Periods
PM_{10}	Annual	34	25%	Annual - 10 / 24-Hour – 12.5
$PM_{2.5}$ (1)	Annual	10	25%	Annual - 6.25
SO_2	24-Hour	182	25%	24-Hour – 31.3 / 1-Hour – 87.5
NO_2	Annual	50	25%	Annual - 10 / 1-Hour - 50

(1) PSD Increment not designated - based on the PSD increment for PM_{10}.

7.3 Baseline Monitoring Report

7.3.1 Introduction

A detailed baseline air monitoring programme has been carried out to assess baseline levels of the significant substances which may be released from the proposed waste –to-energy facility in Carranstown, Duleek, County Meath. The substances monitored were NO_2, $PM_{2.5}$, benzene, SO_2 and heavy metals. The air monitoring programme was used to determine long-term average concentrations for pollutants of concern and to provide information on the general air quality in the Carranstown region. This study compliments and updates monitoring previously carried out on-site in 2000 and 2001-2002.

7.3.2 Methodology

$PM_{2.5}$

The $PM_{2.5}$ monitoring programme, using a $PM_{2.5}$ continuous monitor, focused on assessing 24-hour average concentrations at the on-site monitoring station over a three-week period at location N1 (see Figure 7.2). $PM_{2.5}$ sampling was carried out by means of an R&P Partisol®-Plus Sequential Air Sampler (Model 2025). The sampler is a manual air sampling platform which has been designed to meet US EPA Reference Designation (RFPR-0694-09). Approximately 24 m^3 of air was sampled daily through an impactor, which was contained within the $PM_{2.5}$ sampling head. The impactor removed particles with a diameter >2.5 μg and the remaining particles were collected on pre-weighed 47mm diameter filters. The Partisol® sampler was programmed to automatically replace each sampled filter by a new pre-weighed filter at midnight. This ensured that each filter represented a sampling period of exactly 24 hours. Gravimetric determination was carried out at a NAMAS accredited laboratory (Casella Seal Ltd, Manchester, UK). The results, which are shown in Figure 7.3 and Table 7.5, allowed an indicative comparison with both the 24-hour and annual limit values. Weather conditions during the survey periods were also obtained (see Tables 7.6) and may be used to help apportion the source of any raised levels of pollutants during the sampling period.

NO_2

Monitoring of nitrogen dioxide in Carranstown was carried out using passive diffusion tubes. The spatial variation in NO_2 levels away from sources is particularly important, as a complex relationship exists between NO, NO_2 and O_3 leading to a non-linear variation of NO_2 concentrations with distance. In order to assess the spatial variation in NO_2 levels in the Carranstown region, NO_2 was monitored using passive diffusion tubes over three four-week periods at ten locations in the area (see Figure 7.2). Passive sampling of NO_2 involves the molecular diffusion of NO_2 molecules through a polycarbonate tube and their subsequent adsorption onto a stainless steel disc coated with triethanolamine. Following sampling, the tubes were analysed using UV spectrophotometry, at a NAMAS accredited laboratory (Casella Seal Ltd, Manchester, UK, which is part of the Department of the Environment, Transport & the Regions (DETR's) UK Monitoring Network). The diffusion tube locations were strategically positioned to allow an assessment of both worst-case and typical exposure of the residential population. The passive diffusion tube results, which are given in Table 7.7, allow an indicative comparison with the annual average limit value.

Benzene

In order to assess the spatial variation in benzene levels in the Carranstown region, benzene was monitored using passive diffusion tubes over a three-month period at five locations in the area (see Figure 7.2). Passive sampling of benzene involves the molecular diffusion of benzene molecules through a stainless steel tube and their subsequent adsorption onto a stainless steel gauze coated with Chromasorb 106. Following sampling, the tubes were analysed using Gas Chromatography, at a NAMAS accredited laboratory (Casella Seal Ltd). The diffusion tube locations were strategically positioned to allow an assessment of both worst-case and typical exposure of the residential population (see Table 7.8).

SO_2

In order to assess the spatial variation in sulphur dioxide levels in the area, SO_2 was monitored using passive diffusion tubes over a three-month period at five locations (see Figure 7.2 and Table 7.9). Passive sampling of SO_2 involves the molecular diffusion of SO_2 molecules through a tube fabricated of PTFE and their subsequent adsorption onto a stainless steel gauze coated with sodium carbonate. Following sampling, the adsorbed sulphate was removed from the tubes with deionised water and was then analysed using ion chromatography. This analysis was carried out at a NAMAS accredited laboratory (Casella Seal Ltd). The diffusion tube locations were strategically positioned to allow an assessment of both worst-case and typical exposure of the residential population.

Metals

Metal sampling was carried out by means of an R&P Partisol®-Plus Sequential Air Sampler (Model 2025). The sampler is a manual air sampling platform which has been designed to meet US EPA Reference Designation (RFPR-0694-09). Approximately 24 m^3 of air was sampled daily through an impactor, which was contained within a $PM_{2.5}$ sampling head. The impactor removed particles with a diameter >2.5 µg and the remaining particles were collected on pre-weighed 47mm diameter filters. The Partisol® sampler was programmed to automatically replace each sampled filter by a new pre-weighed filter at midnight. This ensured that each filter represented a sampling period of exactly 24 hours.

The filters were acid digested in batches of seven with concentrated nitric acid and hydrogen peroxide in a sealed vessel at 120℃ for 2 hours. An internal standard containing isotopes of bismuth, yttrium, germanium and indium was added prior to the digestion step. The digest was then analysed by Inductively Coupled Plasma - Mass Spectrometry (ICP/MS) by Casella Seal Ltd.

7.3.3 Ambient Air Quality Compliance Criteria

PM_{10} & $PM_{2.5}$

EU Directive 1999/30/EC has set 24-hour and annual limit values for PM_{10} for the protection of human health. A 24-hour limit of 50 μg/m^3 must not be exceeded more than 35 times per year. EU Directive 1999/30/EC has set an annual limit value of 40 μg/m^3.

European Commission sponsored report "Second Position Paper on Particulate Matter" (Final, Dec. 2004), prepared by the CAFE sub-group Working Group on Particulate Matter, recommended that the principal metric for assessing exposure to particulates should be $PM_{2.5}$ rather than PM_{10}, after 2010. The report also suggested that the $PM_{2.5}$ annual average should be in the range 12 – 20 μg/m^3. These indicative limit values were to be reviewed in the light of further information on health and environmental effects, technical feasibility etc.

Following on from this report, Proposed Directive COM(2005) 447 on Ambient Air Quality and Cleaner Air for Europe (21/09/2005) has recently outlined proposals to revise and combine several existing Ambient Air Quality Standards including Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC. In regards to existing ambient air quality standards, it is not proposed to modify the standards but to strengthen existing provisions to ensure that non-compliances are removed. It is however proposed to set new ambient standards for $PM_{2.5}$.

The proposed approach for $PM_{2.5}$ is to establish a concentration cap of 25 μg/m^3, as an annual average (to be attained by 2010), coupled with a non-binding target to reduce human exposure generally to $PM_{2.5}$ between 2010 and 2020. This exposure reduction target is currently proposed at 20% of the average exposure indicator (AEI). The AEI is based on measurements taken in urban background locations averaged over a three year period.

NO_2

EU Directive 1999/30/EC has set 1-hour and annual limit values for NO_2 for the protection of human health. An hourly limit of 200 μg/m^3 must not be exceeded more than 18 times per year. The annual limit value is 40 μg/m^3. A margin of tolerance for both limit values of 20% currently applies. This will reduce linearly to 0% by 2010.

Benzene

EU Directive 2000/69/EC has set an annual limit value for the protection of human health of 5 μg/m^3 for benzene. A margin of tolerance of 80% currently applies. This will reduce linearly to reach 0% by 2010.

SO_2

EU Directive 1999/30/EC has set hourly, daily and annual limit values for the protection of human health for SO_2. The hourly limit value is 350 μg/m^3 which must not be exceeded more than 24 times per annum. The daily and annual limit values are 125 μg/m^3 (not be exceeded more than 3 times per annum) and 20 μg/m^3 respectively.

Metals

Ambient air quality guidelines and limits for the protection of human health for various metals have been set by the European Union, the WHO and in the TA Luft Guidelines. In the absence of statutory standards, ambient air quality guidelines can also be derived from occupational exposure limits (OEL). The ambient air quality standards and guidelines for a number of metals are detailed in Tables 7.54 - 7.55.

7.3.4 Results

$PM_{2.5}$

Daily concentrations of $PM_{2.5}$ measured using the sequential $PM_{2.5}$ sampler are shown in Figure 7.3 and Table 7.5. The 24-hour $PM_{2.5}$ concentrations measured over the three-week period is significantly below the proposed annual average concentration cap of 25 μg/m^3 (for the protection of human health) which may be applicable from 2010 onwards. The average over this period is 15 μg/m^3.

Average wind speed data measured by Met Eireann at Dublin Airport, which would be representative of conditions at Carranstown, are listed in Table 7.6 and are compared to the $PM_{2.5}$ monitoring results in Figure 7.3. Although, wind direction will have an influence on the on-site $PM_{2.5}$ concentrations, the data in Figure 7.3 indicates that $PM_{2.5}$ measured at Carranstown were inversely related to wind speed to a statistically significant degree. This would indicate that there is greater dispersion of $PM_{2.5}$ at higher wind speeds and that wind-blown sources are not significant.

PM_{10} data is also available from a PM_{10} TEOM monitor operated by the EPA at Kiltrough(13) which is situated several kilometres east of the site. The PM_{10} concentration during the same monitoring period as the on-site $PM_{2.5}$ survey averaged 20 μg/m^3 whilst the annual average concentration for PM_{10} in 2005 was 17 μg/m^3. This indicates that during the measurement period PM concentrations were raised relative to the annual limit value (of the order of 15%) indicating that a long-term average may be of the order of 13 μg/m^3.

NO_2

The passive diffusion tube survey targeted the exposure of the nearest residential receptors to the proposed scheme. The monitoring locations have been designed to optimise both the spatial coverage in the region and to determine the worst-case air quality at the nearest sensitive receptors. Average concentration of nitrogen dioxide at Locations M1-M10 (refer to Figure 7.2), are significantly below the EU annual limit value for the protection of human health of 40 μg/m^3, which is enforceable in 2010

(See Table 7.7). The highest NO_2 level, which was measured at the M1/R152 roundabout is still less than 63% of this annual limit value.

Benzene

Average concentrations of benzene measured at five locations are shown in Table 7.8. The results show that levels are significantly below the EU annual limit value for the protection of human health, which is enforceable in 2010. The highest benzene level of 0.8 $\mu g/m^3$, measured at Location M8, peaks at 20% of the limit value which is set at 5 $\mu g/m^3$.

SO_2

Average concentrations of SO_2 measured at the five locations in the Carranstown area are shown in Table 7.9. The results show that levels are significantly below the annual average EU limit value for the protection of ecosystems. The highest SO_2 level of 4 $\mu g/m^3$, measured at Location M2, is only 20% of the annual limit value which is set for the protection of ecosystems.

Metals

Average concentrations of a number of metals measured over a three-week period at the on-site monitoring station in Carranstown are shown in Table 7.10. The results show that the average concentrations of all metals measured were significantly below their respective annual limit values for the protection of human health.

Table 7.5 Measured $PM_{2.5}$ Ambient Concentrations Measured at On-site Monitoring Station.

Date	$PM_{2.5}$ ($\mu g/m^3$)	Date	$PM_{2.5}$ ($\mu g/m^3$)
09-Nov-05	5	05-Dec-05	4
10-Nov-05	3	06-Dec-05	20
11-Nov-05	6	07-Dec-05	9
12-Nov-05	9	08-Dec-05	9
13-Nov-05	9	09-Dec-05	7
14-Nov-05	4	10-Dec-05	14
15-Nov-05	6	11-Dec-05	21
16-Nov-05	15	12-Dec-05	27
17-Nov-05	37	13-Dec-05	39
18-Nov-05	17	14-Dec-05	16
19-Nov-05	22	15-Dec-05	14
20-Nov-05	42	16-Dec-05	15
Average		**15**	
Annual Average Concentration Cap		25 $\mu g/m^3$(1)	

(1) Proposed Directive COM(2005) 447.

Table 7.6 Meteorological Data During The $PM_{2.5}$ Ambient Survey

Date	Wind Speed (m/s)	Rainfall (mm)	Date	Wind Speed (m/s)	Rainfall (mm)
09-Nov-05	7.0	1	05-Dec-05	8.0	0.1
10-Nov-05	7.1	4.4	06-Dec-05	3.6	0
11-Nov-05	11.2	0.9	07-Dec-05	5.9	14.5
12-Nov-05	6.6	0	08-Dec-05	4.0	1.4
13-Nov-05	4.3	0	09-Dec-05	3.0	0.5
14-Nov-05	8.5	0	10-Dec-05	6.0	0
15-Nov-05	5.5	0.1	11-Dec-05	4.9	0
16-Nov-05	4.3	0	12-Dec-05	3.0	0
17-Nov-05	2.2	0	13-Dec-05	4.8	0
18-Nov-05	5.4	0	14-Dec-05	4.6	0
19-Nov-05	1.2	0	15-Dec-05	7.7	0
20-Nov-05	1.4	0	16-Dec-05	7.6	0.2

Source: Met Eireann.

Table 7.7 **Average NO_2 concentrations at each location during the period 16/06/05 – 28/09/05, as measured by passive diffusion tubes.**

Location No.	Location Description	Period 1 16/06/05-19/07/05 ($\mu g/m^3$)	Period 2 19/07/05-22/08/05 ($\mu g/m^3$)	Period 3 22/08/05-28/09/05 ($\mu g/m^3$)	Average ($\mu g/m^3$)
M1	NW of Site	5	6	10	**7**
M2	South of Platin	18	22	22	**21**
M3	Platin North Boundary	10	8	16	**11**
M4	Cruicerath	10	10	11	**10**
M5	Clonlusk	6	7	14	**9**
M6	Commons	6	7	9	**7**
M7	Duleek	13	16	23	**17**
M8	R152 South of Site	10	10	16	**12**
M9	R152 Opposite Site	14	23	24	**20**
M10	M1/R152 Roundabout	18	23	34	**25**
	EU Limit Value ($\mu g/Nm^3$)				40(1)

(1) EU Ambient Air Standard (1999/30/EC) (as an annual average).

Table 7.8 **Average Benzene concentrations at each location during the period 16/06/05 – 28/09/05, as measured by passive diffusion tubes.**

Location No.	Location Description	Period 1 16/06/05-19/07/05 (µg/m^3)	Period 2 19/07/05-22/08/05 (µg/m^3)	Period 3 22/08/05-28/09/05 (µg/m^3)	Average (µg/m^3)
M1	NW of Site	0.2	0.3	0.2	**0.2**
M2	South of Platin	0.2	0.7	0.8	**0.6**
M3	Platin North Boundary	0.2	0.4	0.2	**0.3**
M4	Cruicerath	0.6	0.2	0.4	**0.4**
M8	R152 South of Site	0.7	0.8	0.5	**0.7**
		EU Limit Value (µg/Nm^3)			5(1)

(1) EU Ambient Air Standard (2000/690/EC) (as an annual average).

Table 7.9 **Average Sulphur Dioxide concentrations at each location during the period 16/06/05 – 28/09/05, as measured by passive diffusion tubes.**

Location No.	Location Description	Period 1 16/06/05-19/07/05 (µg/m^3)	Period 2 19/07/05-22/08/05 (µg/m^3)	Period 3 22/08/05-28/09/05 (µg/m^3)	Average (µg/m^3)
M1	NW of Site	0.8	3.0	2.8	**2.2**
M2	South of Platin	0.9	3.7	3.5	**2.7**
M3	Platin North Boundary	1.9	2.7	2.1	**2.2**
M4	Cruicerath	0.8	2.2	2.5	**1.8**
M8	R152 South of Site	1.1	3.1	4.3	**2.8**
		EU Limit Value (µg/Nm^3)			20(1)

(1) EU Ambient Air Standard (1999/30/EC) (as an annual average for the protection of ecosystems).

Table 7.10 **Levels of metals measured at the on-site monitoring station during the period 09/11/05 – 16/12/05.**

Species	Period 1 09/11/05-15/11/05 (ng/m^3)	Period 2 16/11/05-22/11/05 (ng/m^3)	Period 3 10/12/05-16/12/05 (ng/m^3)	Average (ng/m^3)$^{(1)}$	Limit Values (ng/m^3)$^{(2)}$
Arsenic	0.24	0.77	0.29	**0.43**	6
Cadmium	0.04	0.17	0.10	**0.10**	5
Cobalt	0.01	0.07	0.03	**0.04**	1000
Chromium	6.0	6.1	6.1	**6.1**	500
Copper	0.82	11.7	1.9	**4.8**	2000
Mercury	<0.06	0.06	0.06	**0.06**	100
Manganese	0.58	3.6	1.9	**2.0**	150
Nickel	3.2	0.95	0.91	**1.7**	20
Lead	2.4	17.0	4.3	**7.9**	500
Antimony	0.25	2.0	0.35	**0.87**	1000
Thallium	0.01	0.11	0.02	**0.05**	1000
Vanadium	0.27	1.4	0.89	**0.85**	1000

(1) Values at detection limit have been taken to equal to the detection limit

(2) Annual average limit values (see Tables 7.54 - 7.55).

7.4 Modelling Results

7.4.1 Introduction

Emissions from the proposed site has been modelled using the AERMOD dispersion model which is the USEPA's regulatory model used to assess pollutant concentrations associated with industrial sources(1). Emissions have been assessed, firstly under the maximum emissions limits of the EU Directive 2000/76/EC and secondly under abnormal operating conditions.

7.4.2 Process Emissions

Indaver Ireland has one main process emission point (stack). The operating details of this major emission point has been taken from information supplied by Indaver and are outlined in Table 7.11. Full details of emission concentrations and mass emissions are given in Appendix 7.5.

Table 7.11 Process Emission Design Details

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temp (K)	Volume Flow (Nm^3/hr)(1)	Exit Velocity (m/sec actual)(2)
Stack	65	2.0	3.14	373	147000 – Maximum	17.76

(1) Normalised to 273K, 11% Oxygen, dry gas.

(2) 373K, 11% Oxygen, dry gas

Emissions from the site have been assessed both for maximum operating conditions and for abnormal operating conditions. The AERMOD model was run using a unitised emission rate of 1 g/s. The unitised concentration and deposition output has then been adjusted for each substance based on the specific emission rate of each.

7.4.3 Background Concentrations

The ambient concentrations detailed in the following sections include both the emissions from the site and the ambient background concentration for that substance. Background concentrations have been derived from a worst-case analysis of the cumulative sources in the region in the absence of the development.

Firstly, a detailed baseline air quality assessment (see Section 7.3) was carried out to assess baseline levels of those pollutants, which are likely to be significant releases from the site. Secondly, modelling of traffic emissions (see Appendix 7.3) was carried out both with and without the facility to assess the impact of increased traffic emissions in the region. Thirdly, a detailed cumulative assessment of all significant releases from nearby sites was carried out based on an analysis of their IPC Licences (see Appendix 7.2).

Appropriate background values have been outlined in Table 7.12. In arriving at the combined annual background concentration, cognisance has been taken of the accuracy of the approach and the degree of double counting inherent in the assessment. In relation to NO_2, the baseline monitoring programme will have taken into account both the existing traffic levels and existing industrial sources. However, some increases in traffic levels will occur due to the development which has been incorporated into the final combined background levels. Again, in recognition of the various inaccuracies in this approach, the values have been rounded accordingly. A similar approach has been adopted for the other pollutants. In relation to baseline dioxins/furans, a range of concentrations has been given in recognition of the influence that non-detects have on the reported values.

In order to obtain the predicted environmental concentration (PEC), background data was added to the process emissions. In relation to the annual averages, the ambient background concentration was added directly to the process concentration. However, in relation to the short-term peak concentrations,

concentrations due to emissions from elevated sources cannot be combined in the same way. Guidance from the UK Environment Agency(14) advises that an estimate of the maximum combined pollutant concentration can be obtained by adding the maximum short-term concentration due to emissions from the source to twice the annual mean background concentration.

7.5 Nitrogen Dioxide Emissions and Results

7.5.1 Source Information

Source information including emission release heights, volume flows, locations and stack diameters has been summarised in Appendix 7.5.

7.5.2 Modelling of Nitrogen Dioxide

Nitrogen oxides (NO_X), containing both nitrogen oxide (NO) and nitrogen dioxide (NO_2) are emitted from the combustion process on-site, although it is the latter which is considered the more harmful to human health. These combustion processes lead to emissions which are mainly in the form of nitrogen oxide (NO) (typically 95%) with small amounts of the more harmful nitrogen dioxide.

NO_2 has been modelled following the approach outlined by the USEPA(1) for assessing the impact of NO_X from point sources. The approach involves assessing the air quality impact through a three tiered screening technique. The initial analysis, termed the Tier 1 approach, assumes a worst-case scenario that there is total conversion of NO_X to NO_2. The guidance indicates that if this worst-case assumption leads to an exceedance of the appropriate limit value, the user should proceed to the next Tier.

Tier 2 is appropriate for estimating the annual average NO_2 concentration. The Tier 2 approach indicates that the annual average concentration should either be derived from an empirically derived NO_2/NO_X ratio or alternatively to use the default value of 0.75. This default value has been used in the current assessment.

In order to determine the maximum one-hour value, the Tier 3 approach is recommended by the USEPA. The Tier 3 approach involves the application of a detailed screening method on a case-by-case basis. The suggested methodologies include the ozone-limiting method or a site-specific NO_2/NO_X ratio. In the current assessment, no site-specific ratio has been developed because the monitoring data obtained by Indaver measured much lower concentrations than that predicted to occur very occasionally during operations at the boundary of the site. However, empirical evidence suggests that a conservative estimate of this ratio would be 0.50 based on data from the EPA(15). Thus, a ratio of 0.50 for NO_2/NO_X has been used in the current assessment for the 99.8th%ile of one-hour maximum concentrations. Ambient Ground Level Concentrations (GLCs) of Nitrogen Dioxide have been predicted for the following scenarios in Table 7.13.

Table 7.12 **Estimated annual background concentrations In Carranstown Region (µg/m^3).**

	NO_2	SO_2	PM_{10}	$PM_{2.5}$	CO	TOC(1)	HCl	HF	Dioxins(3)	PAHs	Cd	Hg	Sb	As	Ni
Baseline Monitoring Programme(1)	18	3	18	12	-	0.6	0.01	0.005	0.046 pg/m^3 0.028 pg/m^3	0.001	0.001	0.001	0.001	0.001	0.002
Traffic Impact Assessment(4)	1	-	0.3	0.3	100	0.01	-	-	-	-	-	-	-	-	-
Cumulative Assessment	1	1	0.4	0.4	-(2)	-(2)	-(2)	-(2)	0.00004	-(2)	-(2)	-(2)	-(2)	-(2)	-(2)
Annual Background Concentration	**20**	**4**	**20**	**12**	**200**	**0.7**	**0.01**	**0.005**	**0.046 pg/m^3** **0.028 pg/m^3**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.002**

(1) TOC assumed to be composed of benzene solely as a worst-case

(2) No cumulative assessment carried out as emissions from the site (or nearby sites) are less than significance criteria (defined as greater than 2% of ambient limit value)

(3) Baseline results for dioxins given as firstly (i) Non-detects = limit of detection, (ii) Non-detects = 50% of limit of detection.

(4) See Appendix 7.4 for full details of the traffic impact assessment.

Table 7.13 Emission Scenario for Nitrogen Dioxide

Pollutant	Scenario	Concentration	Emission Rate (g/s)
NO_2	Maximum Operation	200 mg/m^3	8.17
	Abnormal Operation$^{(1)}$	400 mg/m^3	16.3

(1) Abnormal operation scenario based on an emission level of 400 mg/m^3 for two hours every Monday for a full year.

Abnormal Operation

Elevated levels of NO_X may occur due to the malfunctioning of the de-NOx system. Such conditions will be detected immediately from an elevation in the NO_2 emission value which will be continuously observed on the computerised control system in the control room. An automatic alarm will be activated well in advance of exceedance of the emission limit value to allow adequate time for intervention. Therefore for the purpose of the air modelling study the following abnormal operation conditions were used: 2hrs of operation at an emission value of 400 mg/Nm^3.

7.5.3 Comparison with Standards and Guidelines

The relevant air quality standard for Nitrogen Dioxide has been detailed in Table 7.14. In this report the ambient air concentrations have been referenced to Council Directive 1999/30/EC, which has been transposed into Irish Law as S.I. 271 of 2002. The directive also details margins of tolerance, which are trigger levels for certain types of action in the period leading to the attainment date. The margin of tolerance is currently 20% for both the hourly and annual limit value for NO_2. The margin of tolerance is reducing every 12 months by equal annual percentages to reach 0% by the attainment date of 2010. However, reflecting a worst-case approach, results have been compared with the applicable limit value which will be enforceable in 2010.

Table 7.14 EU Ambient Air Standards - Council Directive 1999/30/EC

Pollutant	Regulation	Limit Type	Current Margin of Tolerance	Value
Nitrogen Dioxide	1999/30/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	20% in 2006 reducing linearly to 0% by 2010	200 µg/m^3 NO_2
		Annual limit for protection of human health	20% in 2006 reducing linearly to 0% by 2010	40 µg/m^3 NO_2
		Annual limit for protection of vegetation	None	30 µg/m^3 NO + NO_2

Table 7.15 Dispersion Model Results – Nitrogen Dioxide

Pollutant / Scenario	Annual Mean Background ($\mu g/m^3$)(1)	Averaging Period	Process Contribution ($\mu g/m^3$)	Predicted Emission Concentration ($\mu g/Nm^3$)	Standard(2) ($\mu g/Nm^3$)	Indaver emissions as a % of ambient limit value
NO_2 / Maximum	20	Annual Mean(3)	1.1	21.1	40	3%
		99.8th%ile of 1-hr means(4)	19.0	59.0	200	10%
NO_2 / Abnormal Operation	20	Annual Mean(3)	1.1	21.1	40	3%
		99.8th%ile of 1-hr means(4)	19.0	59.0	200	10%

(1) Includes contribution from traffic and background sources (based on results from diffusion tubes) and incorporating the cumulative assessment results.

(2) Directive 1999/30/EC

(3) Conversion factor following guidance from USEPA (Tier 2 analysis, annual average) based on the default ratio of 0.75 (worst-case).

(4) Conversion factor, following guidance from USEPA (Tier 3 analysis), based on empirically derived site-specific maximum 1-hour value for NO_2 / NO_X of 0.50

Table 7.16 Dispersion Model Results – Nitrogen Dioxide Maximum Operation, Specific Receptors

Pollutant / Location	Annual Mean Background ($\mu g/m^3$)(1)	Averaging Period	Process Contribution ($\mu g/m^3$)	Predicted Emission Concentration ($\mu g/Nm^3$)	Standard(2) ($\mu g/Nm^3$)	Indaver emissions as a % of ambient limit value
NO_2 Maximum / Worst-case Residential Receptor	20	Annual Mean(3)	0.37	20.4	40	1%
		99.8th%ile of 1-hr means(4)	6.1	46.1	200	3%
NO_2 Maximum / Donore School	20	Annual Mean(3)	0.10	20.1	40	0.25%
		99.8th%ile of 1-hr means(4)	3.9	43.9	200	2%
NO_2 Maximum / Duleek	20	Annual Mean(3)	0.07	20.1	40	0.18%
		99.8th%ile of 1-hr means(4)	2.5	42.5	200	1.3%
NO_2 Maximum / Drogheda	20	Annual Mean(3)	0.075	20.1	40	0.19%
		99.8th%ile of 1-hr means(4)	2.0	42.0	200	1%
NO_2 Maximum / Newgrange Cemetery	20	Annual Mean(3)	0.021	20.0	40	0.05%
		99.8th%ile of 1-hr means(4)	1.2	41.2	200	0.6%

(1) Includes contribution from traffic and background sources (based on results diffusion tubes) and incorporating the cumulative assessment results.

(2) Directive 1999/30/EC

(3) Conversion factor following guidance from USEPA (Tier 2 analysis, annual average) based on site-specific ratio of 0.75 (worst-case).

(4) Conversion factor, following guidance from USEPA (Tier 3 analysis), based on empirically derived site-specific maximum 1-hour value for NO_2 / NO_X of 0.50

7.5.4 Modelling Results

Modelling was carried out for the two scenarios described in Section 7.4.2. Table 7.15 details the predicted Tier 2 (applied to the annual average) & Tier 3 (applied to the maximum one-hour) NO_2 GLC for each scenario at the worst-case locations whereas Table 7.16 details the spatial variation in nitrogen dioxide concentrations at specific locations in the surrounding region.

7.5.5 Concentration Contours

The geographical variation in NO_2 ground level concentrations beyond the site boundary are illustrated as concentration contours in Figures 7.4 to 7.5. The contents of each figure are described below.

Figure 7.4	Maximum Operations: Predicted Tier 3 NO_2 99.8th Percentile Concentration
Figure 7.5	Maximum Operations: Predicted Tier 2 NO_2 Annual Average Concentration

7.5.6 Result Findings

In relation to the maximum one-hour limit value, NO_2 Tier 3 modelling results indicate that the ambient ground level concentrations are below these ambient standards for the protection of human health under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient NO_2 concentrations (including background concentrations) which are 30% of the maximum ambient 1-hour limit value (measured as a 99.8th%ile) at the worst-case receptor (2km north-west of the site-boundary). The annual average concentration (including background concentration) is also significantly below the limit value for the protection of human health accounting for 53% of the annual limit value at the worst-case receptor which is located 500m east of the site. The impact under abnormal operation is essentially unchanged compared to normal operation due to the infrequent nature of the occurrence (approximately 1% of the time in any one week).

The modelling results indicate that the maximum 1-hour and annual average concentrations occur at or near the site's north-west to eastern boundaries. Concentrations fall off rapidly away from this maximum and for the maximum 1-hour concentration (as a 99.8th%ile) will be only 3% of the limit value (not including background concentrations) at the nearest sensitive receptor to the site (see Table 7.16). The annual average concentration decreases away from the site with concentrations from emissions at the proposed facility accounting for only 1% of the limit value (not including background concentrations) at worst case sensitive receptors near the site. Thus, the results indicate that the potential impact from the proposed facility on human health and the environment is minor and limited to the immediate environs of the site (i.e. close to the site boundary).

In the surrounding main population centres, Drogheda and Duleek, levels are significantly lower than background sources with the concentration from emissions at the proposed facility accounting for less than 0.25% of the annual limit value for the protection of human health.

7.6 Sulphur Dioxide and Total Dust (as PM_{10} and $PM_{2.5}$) Emissions and Results

7.6.1 Source Information

Source information including emission release heights, volume flows, locations and stack diameters has been summarised in Appendix 7.5.

Ambient Ground Level Concentrations (GLC's) of Sulphur Dioxide (SO_2) and Total Dust (as PM_{10} and $PM_{2.5}$) have been predicted for the following scenarios in Table 7.17.

Table 7.17 Emission Scenario for Sulphur Dioxide and Total Dust (as PM_{10} and $PM_{2.5}$)

Pollutant	Scenario	Concentration	Emission Rate (g/s)
SO_2	Maximum Operation	50 mg/m^3	2.0
	Abnormal Operation(1)	200 mg/m^3	8.2
Total Dust	Maximum Operation	10 mg/m^3	0.41
	Abnormal Operation(2)	30 mg/m^3	1.2

(1) Abnormal operation scenario based on an emission level of 200 mg/m^3 for six hours every Monday for a full year.

(2) Abnormal operation scenario based on an emission level of 30 mg/m^3 for eight hours every Monday for a full year.

Abnormal Operation

Elevated levels of SO_2 may occur due to the malfunctioning of the evaporating spray reactor or the wet scrubber. Such conditions will be detected immediately from an elevation in the SO_2 emission value which will be continuously observed on the computerised control system in the control room. An automatic alarm will be activated well in advance of exceedance of the emission limit value to allow adequate time for intervention. Therefore for the purpose of the air modelling study the following abnormal operation conditions were used: 6hrs of operation at an emission value of 200 mg/Nm^3.

Elevated levels of dust may occur due to malfunctioning of one or more bags of the baghouse filter. Dust is continuously monitored therefore this abnormal condition will be detected immediately from an elevation in the dust emission values which will be continuously observed on the computerised control system in the control room. An automatic alarm will be activated well in advance of exceedance of the emission limit value to allow adequate time for intervention. The baghouse filter consists of a number of compartments, including a spare compartment. Each compartment can be checked individually to detect the malfunctioning bag. This bag will be by-passed and retrofitted. If dust emissions exceed the daily average emission of 10 mg/Nm^3 an alarm will be activated resulting in automatic shut down of the facility. Therefore for the purpose of the air modelling study the following abnormal operation conditions were used: 8hrs of operation at an emission value of 30 mg/Nm^3.

7.6.2 Comparison with Standards And Guidelines

The relevant air quality standards for Sulphur Dioxide, PM_{10} and $PM_{2.5}$ have been detailed in Table 7.18. In this report the ambient air concentrations for SO_2 and PM_{10} have been referenced to Council Directive 1999/30/EC, which has been transposed into Irish Law as S.I. 271 of 2002.

Table 7.18 EU Ambient Air Quality Current & Proposed Standards

Pollutant	Regulation	Limit Type	Current Margin of Tolerance	Value
Sulphur Dioxide	1999/30/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	None	350 µg/m^3
		Daily limit for protection of human health - not to be exceeded more than 3 times/year	None	125 µg/m^3
		Annual & Winter limit for the protection of ecosystems	None	20 µg/m^3
PM_{10}	1999/30/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	None	50 µg/m^3
		Annual limit for protection of human health	None	40 µg/m^3
$PM_{2.5}$	Proposed Directive COM(2005) 447	Annual limit for protection of human health	None	25 µg/m^3

7.6.3 Modelling Results

Modelling was carried out for the two scenarios described in Section 7.5.1. Tables 7.19 – 7.21 details the predicted SO_2, PM_{10} and $PM_{2.5}$ GLC for each scenario.

Table 7.19 Dispersion Model Results – Sulphur Dioxide

Pollutant / Scenario	Background (μg/m^3)	Averaging Period	Process Contribution (μg/m^3)	Predicted Emission Concentration (μg/Nm^3)	Standard(1) (μg/Nm^3)
SO$_2$ / Maximum Operation	4	99.7th%ile of 1-hr means	7.6	15.6	350
		99.2th%ile of 24-hr means	2.0	6.0	125
SO$_2$ / Abnormal Operation	4	99.7th%ile of 1-hr means	8.9	16.9	350
		99.2th%ile of 24-hr means	2.3	6.3	125

(1) Directive 1999/30/EC

Table 7.20 Dispersion Model Results – Total Dust (referenced to PM$_{10}$)

Pollutant / Scenario	Annual Mean Background (μg/m^3)	Averaging Period	Process Contribution (μg/m^3)	Predicted Emission Concentration (μg/Nm^3)	Standard(1) (μg/Nm^3)
PM$_{10}$ / Maximum	20	90.5th%ile of 24-hr means	0.22	20.2	50
		Annual mean	0.08	20.1	40
PM$_{10}$ / Abnormal Operation	20	90.5th%ile of 24-hr means	0.24	20.2	50
		Annual mean	0.08	20.1	40

(1) Directive 1999/30/EC

Table 7.21 Dispersion Model Results – Total Dust (referenced to $PM_{2.5}$)

Pollutant / Scenario	Annual Mean Background ($\mu g/m^3$)	Averaging Period	Process Contribution ($\mu g/m^3$)	Predicted Emission Concentration ($\mu g/Nm^3$)	Target Value(1) ($\mu g/Nm^3$)
$PM_{2.5}$ / Maximum	12	Annual mean	0.08	12.1	25
$PM_{2.5}$ / Abnormal Operation	12	Annual mean	0.08	12.1	25

(1) Proposed Directive COM(2005) 447

7.6.4 Concentration Contours

The geographical variation in SO_2, PM_{10} and $PM_{2.5}$ ground level concentrations beyond the site boundary are illustrated as concentration contours in Figures 7.6 to 7.10. The contents of each figure are described below.

Figure 7.6	Maximum Operations: Predicted SO_2 99.7th Percentile of Hourly Concentrations
Figure 7.7	Maximum Operations: Predicted SO_2 99.2th Percentile of 24-Hourly Concentrations
Figure 7.8	Maximum Operations: Predicted PM_{10} 90.5th Percentile of 24-Hourly Concentrations
Figure 7.9	Maximum Operations: Predicted PM_{10} Annual Concentrations
Figure 7.10	Maximum Operations: Predicted $PM_{2.5}$ Annual Concentrations

7.6.5 Result Findings

SO_2

SO_2 modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health for sulphur dioxide under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient SO_2 concentrations (including background concentrations) which are 4% of the maximum ambient 1-hour limit value (measured as a 99.7th%ile) and 5% of the maximum ambient 24-hour limit value (measured as a 99.2th%ile) at the worst-case receptor.

PM_{10}

PM_{10} modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health for PM_{10} under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient PM_{10} concentrations (including background concentrations) which are 40% of the maximum ambient 24-hour limit value (measured as a 90.5th%ile) and 50% of the annual average limit value at the worst-case receptor.

$PM_{2.5}$

$PM_{2.5}$ modelling results indicate that the ambient ground level concentrations are below the proposed air quality standard for the protection of human health for $PM_{2.5}$ under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient $PM_{2.5}$ concentrations (including background concentrations) which are 48% of the proposed annual average limit value at the worst-case receptor, with the contribution from the proposed facility equating to 0.32% of the limit value.

7.7 Total Organic Carbon (TOC), Hydrogen Chloride and Hydrogen Fluoride Emissions and Results

7.7.1 Source Information

Source information including emission release heights, volume flows, locations and stack diameters has been summarised in Appendix 7.5.

Ambient Ground Level Concentrations (GLC's) of Total Organic Carbon (TOC), Hydrogen Chloride (HCl) and Hydrogen Fluoride (HF) have been predicted for the following scenarios in Table 7.22.

Table 7.22 Emission Scenario for TOC, HCl and HF

Pollutant	Scenario	Concentration	Emission Rate (g/s)
TOC	Maximum Operation	10 mg/m^3	0.41
	Abnormal Operation(1)	30 mg/m^3	1.23
HCl	Maximum Operation	10 mg/m^3	0.41
	Abnormal Operation(2)	60 mg/m^3	2.45
HF	Maximum Operation	1 mg/m^3	0.041
	Abnormal Operation(3)	4 mg/m^3	0.163

(1) Abnormal operation scenario based on an emission level of 30 mg/m^3 for eight hours every Monday for a full year.

(2) Abnormal operation scenario based on an emission level of 60 mg/m^3 for four hours every Monday for a full year.

(3) Abnormal operation scenario based on an emission level of 4 mg/m^3 for six hours every Monday for a full year.

Abnormal Operation

Elevated levels of HCl and HF may occur due to the malfunctioning of the evaporating spray reactor or the wet scrubber. Such conditions will be detected immediately from an elevation in the SO_2 emission value which will be continuously observed on the computerised control system in the control room. An automatic alarm will be activated well in advance of exceedance of the emission limit value to allow adequate time for intervention.

Taking HCl as an example, as there are two stages of HCl removal in the flue gas cleaning system, namely the evaporating spray reactor and the wet scrubber, excess levels of HCl observed on the computerised control system in the control room will immediately indicate a malfunctioning of one of these systems. By increasing the supply of lime to the spray reactor, the wet scrubber will ensure HCl emission values are within the emission limit in the absence of a functioning evaporating spray reactor and visa versa.

Similar conditions apply for elevated levels of HF. Therefore for the purpose of the air modelling study the following abnormal operation conditions were used:

- HCl: 4hrs of operation at an emission value of 60 mg/Nm^3,
- HF: 6hrs of operation at an emission value of 4 mg/Nm^3.

Elevated levels of TOC may occur due to abnormal operating conditions in the furnace. This abnormal condition will be detected immediately from an elevation in the TOC emission value which will be continuously observed on the computerised control system in the control room. An automatic alarm will be activated well in advance of exceedance of the emission limit value to allow adequate time for intervention. Therefore for the purpose of the air modelling study the following abnormal operation conditions were used: 8hrs of operation at an emission value of 30 mg/Nm^3.

7.7.2 Comparison With Standards And Guidelines

The organic emissions from the site will consist of a range of aliphatic and aromatic compounds at low concentration. The toxicity of these compounds will vary by several orders of magnitude. Ambient benzene levels have been regulated by the EU (Council Directive 2000/69/EC) due to the higher toxicity of this compound compared to other common hydrocarbons. In this assessment, it has been assumed that all emissions from the site are composed of benzene. This is a very pessimistic assumption and thus will significantly overestimate the impact of TOC emissions from the site.

TA Luft standards have been proposed for HCl and HF. The TA-Luft standard is based on a 30-minute averaging period. As the meteorological data used in the modelling is collated on an averaging period of one hour, the dispersion model can only predict concentrations for averaging periods of one hour or above. Predicted hourly-average concentrations have subsequently been compared against the standard. Typically the peak 30-minute average will be 10 to 20% higher than the corresponding 1-hour period average.

Table 7.23 Air Standards for TOC, HCl and HF

Pollutant	Regulation	Limit Type	Value
TOC (assumed to be benzene)	EU Council Directive 2000/69/EC	Annual Average	5 µg/m^3
HCl	TA Luft	Hourly limit for protection of human health – expressed as a 98th%ile	100 µg/m^3
HF	TA Luft	Hourly limit for protection of human health – expressed as a 98th%ile	3 µg/m^3
HF	WHO	Gaseous fluoride (as HF) as an annual average.	0.3 µg/m^3
HF	Dutch	Mean fluoride (as HF) concentration during the growing season (April to September)	0.4 µg/m^3
HF	Dutch	Ambient gaseous fluoride (as HF) as a 24-hour average concentration.	2.8 µg/m^3

7.7.3 Modelling Results

Modelling was carried out for the three scenarios described in Section 7.6.1 for each pollutant.

Tables 7.24 – 7.26 details the predicted TOC, HCl and HF GLC for each scenario.

Table 7.24 Dispersion Model Results – TOC (assumed to be benzene)

Pollutant / Scenario	Annual Mean Background (µg/m^3)	Averaging Period	Process Contribution (µg/m^3)	Predicted Emission Concentration (µg/Nm^3)	Standard(1) (µg/Nm^3)
TOC / Maximum	0.7	Annual Average	0.07	0.77	5
TOC / Abnormal Operation	0.7	Annual Average	0.08	0.78	5

(1) Council Directive 2000/69/EC

Table7.25 Dispersion Model Results – HCl

Pollutant / Scenario	Annual Mean Background (µg/m^3)	Averaging Period	Process Contribution (µg/m^3)	Predicted Emission Concentration (µg/Nm^3)	Standard(1) (µg/Nm^3)
HCl / Maximum	0.01	98th%ile of 1-hr means	0.80	0.82	100
HCl / Abnormal Operation	0.01	98th%ile of 1-hr means	0.82	0.84	100

(1) TA Luft Emission Standard

Table 7.26 Dispersion Model Results – HF

Pollutant / Scenario	Annual Mean Background (μg/m^3)	Averaging Period	Process Contribution (μg/m^3)	Predicted Emission Concentration (μg/Nm^3)	Standard (μg/Nm^3)
HF / Maximum	0.005	98th%ile of 1-hr means	0.080	0.090	3.0(1)
		Maximum 24-hr	0.06	0.065	2.8(2)
		Annual Average	0.007	0.012	0.3(3)
HF / Abnormal Operation	0.005	98th%ile of 1-hr means	0.083	0.093	3.0(1)
		Maximum 24-hr	0.11	0.12	2.8(2)
		Annual Average	0.008	0.013	0.3(3)

(1) TA Luft Immission Standard
(2) Netherlands Emission Regulations Staff Office
(3) World Health Organisation

7.7.4 Concentration Contours

The geographical variation in TOC (as benzene), HCl and HF ground level concentrations beyond the site boundary is illustrated as concentration contours in Figures 7.11 – 7.14. The content of the figures is described below.

Figure 7.11	Maximum Operations: Predicted TOC (as benzene) Annual Average Concentration
Figure 7.12	Maximum Operations: Predicted HCl Maximum 1-Hour Concentration (as a 98th%ile)
Figure 7.13	Maximum Operations: Predicted HF 98th Percentile Of Hourly Concentrations
Figure 7.14	Maximum Operations: Predicted HF Annual Average Concentration

7.7.5 Result Findings

TOC

TOC modelling results indicate that the ambient ground level concentrations are below the relevant air quality standard for the protection of human health for benzene under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to a maximum ambient TOC concentration (including background concentration) which is 15% of the benzene annual limit value.

HCl

HCl modelling results indicate that the ambient ground level concentrations are below the relevant air quality guideline for the protection of human health for HCl under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient HCl concentrations (including background concentrations) which are 0.82% of the maximum ambient 1-hour limit value (measured as a 98th%ile).

HF

HF modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards and guidelines for HF for the protection of human health and vegetation under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient HF concentrations (including background concentrations) which are 3% of the maximum ambient 1-hour limit value (measured as a 98th%ile) and 4% of the annual limit value.

7.8 Dioxin-Like Compounds

7.8.1 Description of Dioxin-Like Compounds

The term "Dioxin-like Compounds" generally refers to three classes of compounds; polychlorinated dibenzo-p-dioxins (PCDDs or CDDs), polychlorinated dibenzofurans (PCDFs or CDFs), and polychlorinated biphenyls (PCBs). PCDDs include 75 individual compounds, or congeners, PCDFs include 135 congeners and PCBs include 209 congeners (see Table 7.27). Both PCDDs and PCDFs are usually formed as unintentional by-products through a variety of chemical reactions and combustion processes. These compounds are lipophilic that bind to sediment and organic matter in the environment and tend to be absorbed in animal and human fatty tissue. They are also generally extremely resistant towards chemical and biological degradation processes, and, consequently, persist in the environment and accumulate in the food chain(16).

The toxic effects of dioxins are initiated at the cellular level, by the binding of the dioxin to a specific protein in the cytoplasm of the body cells, the aryl hydrocarbon receptor (AhR). The binding of TCDD to the Ah receptor constitutes a first and necessary step to initiate the toxic and biochemical effects of this compound. Dioxins effects in humans include increased prevalence of diabetes, immunotoxic effects and effects on neurodevelopment and neurobehaviour in children. Studies have shown TCDD to be carcinogenic but a lack of direct DNA-damaging effects indicates that TCDD is not an initiator but a promoter of carcinogenesis(17).

130 of the 209 PCB congeners have historically been manufactured for a variety of uses including dielectric fluids in transformers and capacitors and as lubricants and adhesives. However, the marketing, use and disposal of PCBs has been severely restricted in the EU through Directives 85/467/EC and 96/59/EC(16).

The toxicity of dioxins varies widely with 2, 3, 7, 8-TCDD being the most potent dioxin congener and with only particular configurations of these compounds thought to have dioxin-like toxicity (See Table 7.28). For PCDDs (Dioxins), only 7 of the 75 congeners have dioxin-like toxicity; these are the ones with chlorine substitutions in, at least, the 2, 3, 7 and 8 positions. For PCDFs (Furans), only 10 of the 135 congeners have dioxin-like toxicity; these are again the ones with chlorine substitutions in, at least, the 2, 3, 7 and 8 positions. In relation to PCBs, only 13 of the 209 congeners are likely to have dioxin-like toxicity; these are the PCBs with four or more chlorines with just one or no substitutions in the ortho position (coplanar)(16,18).

As dioxin-like compounds have varying degrees of toxicity, a toxicity equivalency procedure has been developed to describe the cumulative toxicity of these mixtures. The procedure involved assigning individual Toxicity Equivalency Factors (TEFs) to the 2, 3, 7, 8- substituted PCDD and PCDF congeners and to selected coplanar and mono-ortho PCBs. The TEFs are referenced to 2, 3, 7, 8-TCDD, which is assigned a TEF of 1.0. Calculation of the toxic equivalency (TEQ) of a mixture involves multiplying the concentration of individual congeners by their respective TEF. The sum of the TEQ concentrations for the individual congeners is the TEQ concentration for the mixture.

Since 1989, three different TEF schemes have been developed(18):

I-TEQ$_{DF}$ – Developed by NATO/CCMS in 1988, the I-TEQ$_{DF}$ (DF = dioxin, furan, I = International) procedure assigns TEFs only for the 7 dioxins (PCDDs) and 10 furans (PCDFs). This scheme does not include dioxin-like PCBs. This scheme has been adopted in Council Directive 2000/76/EC and has been applied in the current assessment.

TEQ$_{DFP}$-WHO$_{94}$ – In 1994, the WHO added 13-dioxin-like PCBs to the TEF scheme for dioxins and furans. However, no changes were made to the TEFs for dioxins and furans I-TEQ$_{DF}$ (DFP = dioxin, furan, PCBs).

TEQ$_{DFP}$-WHO$_{98}$ – In 1998, the WHO re-evaluated the TEF scheme for dioxins, furans and dioxin-like PCBs. Changes were made to the TEFs for dioxins, furans and dioxin-like PCBs. Table 7.28 outlines the TEF for the most recent scheme for comparison with the scheme recommended in Council Directive 200/76/EC (I-TEQ$_{DF}$).

7.8.2 Modelling Strategy

The emissions of dioxin-like compounds from the waste-to-energy plant have been evaluated in this chapter. Firstly, the stack emissions have been characterised in terms of mass of each Dioxin/Furan congener released, and the partitioning of these releases into a vapour and particle phase. Thereafter, air dispersion modelling has been used to translate these releases to ambient air vapour and particle phase concentrations, and wet vapour and wet and dry particulate deposition fluxes, in the vicinity of the release.

As recommended by the USEPA, individual dioxin congeners have been modelled from source to receptor. Only at the interface to human exposure, e.g., ingestion, inhalation, dermal absorption, etc., are the individual congeners recombined and converted into the toxic equivalence of 2, 3, 7, 8-TCDD to be factored into a quantitative risk assessment.

Emission Rate

The dioxin emission factor is defined as the total mass (in vapour and particulate form) of dioxin-like compound emitted per mass of feed material combusted. For the current proposal, a test burn is not possible as the waste-to-energy plant has not been commissioned yet. However, Indaver has several flue gas cleaning systems similar to that proposed in the current facility, in operation in Belgium. An analysis of these flue gas cleaning systems has suggested that the likely emission rate will out perform the most stringent limit value set by the EU in the recent Council Directive on Incineration (2000/76/EC).

Congener-specific emission data are needed for the analyses of the ambient air impacts and deposition flux of dioxin-like compounds using air dispersion and deposition models. As each specific congener has different physico-chemical properties, the proportion of each congener will affect the final result. Thus, the congener profile expected from the current facility must be derived. The congener profile will be dependent on various factors including the type of waste being burnt, the temperature of combustion, the type of combustion chamber being operated and the air pollution control devices (APCDs) installed. In the present case, no site-specific stack testing for specific congeners is possible as the facility is not yet built. Shown in Table 7.29 are typical relative PCDD/PCDF (Dioxins/Furans) congener emission factors for a municipal waste incinerator similar to that proposed in the current facility, a mass burn refractometry system with wet scrubbing (MB-REF WS) taken from the Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States (USEPA, 1998 (CD-ROM))(19). It would be expected that the relative congener profiles for this type of waste-to-energy plant would be somewhat similar to the current case. Figures 7.15 – 7.16 show the ratio of congeners and the TEQ equivalent releases from this type of facility corrected to the maximum emission limit outlined in Council Directive 2000/76/EC.

Abnormal Operation

As there is a two stage of dioxin removal system, namely injection of activated carbon or lignite cokes prior to baghouse filter and again in the wet scrubber, during the malfunctioning of one stage the alternative stage can provide a back up system.

If the first stage malfunctions, operation of the second stage alone will result in a typical dioxin emission value of 0.5ngTEQ/Nm^3. Should the second stage fail, the first stage will result in a typical dioxin emission value of 0.1ngTEQ/Nm^3.

There is little likelihood of the first dioxin removal system malfunctioning for any significant length of time as this would occur due to a failing of the activated carbon or lignite coke injection. This injection system and the weight of the carbon/coke in the storage silo are monitored continuously. A small bin(volumetric dosing device) continuously transfers carbon or coke from the silo and injects it into flue gases. The bin must be filled 10 times per day and this is monitored. If the number of fills is less than a preset daily value this activates an automatic alarm. No change in the weight of carbon in the silo after one or two days would also clearly indicate a malfunctioning of the system. Therefore the worst case scenario would be where the first stage malfunctions but is detected within two days from monitoring the dosing bin.

While dioxin emissions are continuously sampled, emission values would be historic. It would typically take two weeks to analyse a dioxin filter which operates on a two-week cycle. Therefore for the purpose of the air modelling study the following two abnormal operation conditions were used: firstly, dioxin emission values of 0.5 ngTEQ/Nm^3 for two days per month and secondly, a dioxin emission values of 0.5 ngTEQ/Nm^3 for five weeks per year (based on a two week sampling period and three week analysis period).

Vapour / Particulate Partitioning

In order to accurately model emissions of PCDD/PCDFs (Dioxins/Furans), PAHs and mercury, the partitioning of stack emissions into the vapour and particle (V/P) state is required.

In relation to PCDD/PCDFs (Dioxins/Furans), V/P partitioning based on stack tests data is highly uncertain(10). Research has indicated that higher temperatures favour the vaporous states for the lower chlorinated congeners and the particulate state for the higher chlorinated congeners(10). However, measured data has indicated significant variability in the V/P partitioning. For these reasons, the USEPA has indicated that V/P distributions obtained from stack sampling should not be used.

Data can also be obtained from ambient air sampling using a glass fibre particulate filter and polyurethane foam (PUF) absorbent trap. As the sampler is not subjected to artificial heating or cooling, the method can be used to imply the vapour phase and particle bound partitioning of PCDD/Fs

(Dioxins/Furans) in ambient air. However, the results will be only approximate as mass transfer between the particulate matter on the filter and the vapour trap cannot be ruled out(10).

The recommended USEPA approach to obtaining the vapour/particulate partitioning at the current time is theoretical and based on the Junge-Pankow model for estimating the particle/gas distribution of PCDD/PCDFs (Dioxins/Furans) (10). This model is the one most commonly used for estimating the adsorption of semi-volatile compounds to aerosols:

$$\Phi = c\Theta / (\rho^o_L + c\Theta)$$

where:
Φ = fraction of compound adsorbed to aerosol particles
c = constant (assumed 17.2 Pa-cm)
Θ = particle surface area per unit volume of air, cm^2 aerosol/cm^3 air
ρ^o_L = saturation liquid phase vapour pressure, Pa

The particulate fraction can also be expressed by:

$$\Phi = C_p(TSP) / (C_g + C_p(TSP))$$

where:
Φ = fraction of compound adsorbed to aerosol particles
C_p = concentration of semi-volatile compounds associated with aerosols, ng/µg particles
C_g = gas-phase concentration, ng/m^3
TSP = total suspended particle concentration, µg/m^3

In the above calculations, it is assumed that all compounds emitted from the combustion sources are freely exchangeable between vapour and particle fractions. This may be a simplification as some of the particulate fraction may be trapped and be unavailable for exchange.

As the ρ^o_L is referenced to 25ºC and an ambient temperature of 10ºC has been assumed which is appropriate for average annual temperatures in Ireland, the ρ^o_L has been converted to the ambient temperature as indicated in Table 7.30. Other relevant data used in the calculations and the derived particle fraction at 10ºC is also shown in Table 7.30.

The advantages of the theoretical approach is that it is based on current adsorption theory, considers the molecular weight and degree of halogenation of the congeners and uses the availability of surface area for adsorption of atmospheric particles corresponding to specific airsheds (background plus local sources used in the current case).

7.8.3 Modelling of Vapours and Particles Concentrations

PCDD/PCDFs (Dioxins/Furans) have a range of vapour pressures and thus exist in both vapour and particle-bound states to various degrees. In order to adequately model dispersion and deposition of PCDD/PCDFs (Dioxins/Furans), modelling of both vapour and particle-bound states is thus necessary. For the vapour phase modelling, no dry deposition was assumed, as recommended by the USEPA(10,11). Using the congener profile from Table 7.29 and the vapour – particle partitioning from Table 7.30, the vapour concentrations of the respective dioxin congeners was determined as outlined in Tables 7.32 for a default MWI (MS-Ref WS) profile and diagrammatically in Figure 7.17. Results are shown under maximum operating conditions.

When modelling semi-volatile organics (such as Dioxins/Furans and PAHs) and mercury (Hg) the surface area weighting rather than mass weighting is used for deposition. The surface weighting reflects the mode of formation where volatiles condense on the surface of particulates in the post-combustion chamber (see Column 6 of Table 7.31). Thus, the apportionment of emissions by particle size becomes a function of the surface area of the particle which is available for chemical adsorption.

For the particle-phase concentration, the congener profile from Table 7.29 and the vapour – particle partitioning from Table 7.30 were used to give the particulate concentrations of the respective dioxin congeners as determined in Table 7.33 and diagrammatically in Figure 7.17. Results are shown under maximum operating conditions.

7.8.4 Deposition Modelling of Particulates

Deposition refers to a range of mechanisms which can remove emissions from the atmosphere. These include Brownian motion of aerosol particles and scavenging of particles and vapours by precipitation.

Dry Deposition

Dry deposition of particles refers to the transfer of airborne particles to the surface by means of the forces of gravity and turbulent diffusion followed by diffusion through the laminar sub-layer (thickness of 10^{-1} to 10^{-2} cm) to the surface (collectively know as the deposition flux)(10). The meteorological factors which most influence deposition include the friction velocity and aerodynamic surface roughness. The AERMOD model uses an algorithm which relates the deposition flux to functions of particle size, density, surface roughness and friction velocity.

In order to model dry deposition using AERMOD, the particle-size distribution from the stack must be derived. In the absence of a site-specific particle-size distribution, a generalised distribution recommended by the USEPA has been outlined in Table 7.31. This distribution is suitable as a default for some combustion facilities equipped with either electrostatic precipitators (ESPs) or fabric filters (such as the current case), because the distribution is relatively typical of particle size arrays that have been measured at the outlet to advanced equipment designs(11). As described above, the particles are apportioned based on the fraction of available surface area (see Column 6 of Table 7.31).

Dry gaseous deposition, although considered in the AERMOD model, has not been calibrated for the estimation of the deposition flux of dioxin-like compounds into vegetation and thus the USEPA has recommended that this algorithm should not be used for site-specific applications(10,11).

Wet Particulate Deposition

Wet particulate deposition physically washes out the chemically contaminated particulates from the atmosphere. Wet deposition flux depends on the fraction of the time precipitation occurs and the fraction of material removed by precipitation per unit of time by particle size. The AERMOD model uses the particle-phase washout coefficient, precipitation rate and the concentration of particulate in air.

Modelling Approach

For the deposition modelling of Dioxins/Furans, both wet and dry particulate deposition fluxes were calculated. The modelling also incorporated wet and dry depletion into the calculations to ensure that the conservation of mass was maintained, as recommended by the USEPA.

For the particle-phase deposition, the congener profile from Table 7.29 and the vapour – particle partitioning from Table 7.30 were used to give the particulate emission rate of the respective dioxin congeners as determined in Table 7.34. The deposition flux for each congener was calculated by multiplying the emission rate of each congener by the unitised deposition flux as shown in Table 7.34 and diagrammatically in Figure 7.18. Results are shown under maximum operating conditions.

7.8.5 Comparison with Standards And Guidelines

Currently, no internationally recognised ambient air quality concentration or deposition standards exist for PCDD/PCDFs (Dioxins/Furans). Both the USEPA and WHO recommended approach to assessing the risk to human health from Dioxins/Furans entails a detailed risk assessment analysis involving the determination of the impact of Dioxins/Furans in terms of the TDI (Tolerable Daily Intake) approach(20,21). A TDI has been defined by the WHO as “an estimate of the intake of a substance over a lifetime that is considered to be without appreciable health risk”(21). Occasional short term excursions above the TDI would have no health consequences provided the long-term average is not exceeded. The WHO currently proposes a maximum TDI of between 1-4 pgTEQ/kg of body weight per day. A TDI of 4 pgTEQ/kg of body weight per day should be considered a maximal tolerable intake on a provisional basis and that the ultimate goal is to reduce human intake levels of below 1 pgTEQ/kg of body weight per day. This reflects the concept that guidance values for the protection of human health should consider total exposure to the substance including air, water, soil, food and other media sources.

Table 7.27 **The number of dioxin-like and total congeners within dioxin, furan, and coplanar PCB Homologue groups[1].**

Homologue Group	n: Number of Dioxin-Like Congeners	N: Number of Congeners	1/N
I. Dioxins			
Tetra-CDD	1	22	0.022
Penta-CDD	1	14	0.071
Hexa-CDD	3	10	0.100
Hepta-CDD	1	2	0.500
Octa-CDD	1	1	1.000
II. Furans			
Tetra-CDF	1	38	0.026
Penta-CDF	2	28	0.036
Hexa-CDF	4	16	0.063
Hepta-CDF	2	4	0.250
Octa-CDF	1	1	1.000
III. Mono-ortho coplanar PCBs			
Tetrachloro-PCBs	1	42	0.024
Pentachloro-PCBs	5	46	0.022
Hexachloro-PCBs	4	42	0.024
Heptachloro-PCBs	3	24	0.042

(1) USEPA (2000) Estimating Exposure to Dioxin-Like Compounds Volume II, Chapter 3

Table 7.28 The TEF scheme for TEQ_{DFP}-WHO_{98} and I-TEQ_{DF} (1).

Dioxin Congeners	TEF	Furan Congeners	TEF
2,3,7,8-TCDD	1.0	2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDD	1.0 (0.5)(2)	1,2,3,7,8-PeCDF	0.05
1,2,3,4,7,8-HxCDD	0.1	2,3,4,7,8-PeCDF	0.5
1,2,3,6,7,8-HxCDD	0.1	1,2,3,4,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDD	0.1	1,2,3,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDD	0.01	1,2,3,7,8,9-HxCDF	0.1
OCDD	0.0001 (0.001)(2)	2,3,4,6,7,8-HxCDF	0.1
PCB Chemical Structure	**TEF**	1,2,3,4,6,7,8-HpCDF	0.01
3,3’,4,4’-TeCB	0.0001	1,2,3,4,7,8,9-HpCDF	0.01
3,4,4’,5-TCB	0.0001	OCDF	0.0001 (0.001)(2)
2,3,3’,4,4’-PeCB	0.0001		
2,3,4,4’,5-PeCB	0.0005		
2,3’,4,4’,5-PeCB	0.0001		
2’,3,4,4’,5-PeCB	0.0001		
3,3’,4,4’,5-PeCB	0.1		
2,3,3’,4,4’,5-HxCB	0.0005		
2,3,3’,4,4’,5’-HxCB	0.0005		
2,3’,4,4’,5,5’-HxCB	0.00001		
3,3’,4,4’,5,5’-HxCB	0.01		
2,3,3’,4,4’,5,5’-HpCB	0.0001		

(1) USEPA (2000) Estimating Exposure to Dioxin-Like Compounds Volume II, Chapter 1

(2) Values in parentheses are those given in Annex 1, Council Directive 2000/76/EC and equate to I-TEQ_{DF}.

Table 7.29 PCDD/PCDF Relative Emission Factors for Municipal Waste Incinerator (MB-Ref WS)(1)

	Emission Factor (relative to sum of toxic congeners)	**Emission Concentration (ng/m^3 from stack)**	**Emission Factor (ng/sec from stack)**
Congener Group	Nondetects set to zero	Nondetects set to zero	Nondetects set to zero
2,3,7,8-TCDD	0.0009	0.00231	0.09663
1,2,3,7,8-PeCDD	0.0068	0.00896	0.37559
1,2,3,4,7,8-HxCDD	0.0117	0.00307	0.12880
1,2,3,6,7,8-HxCDD	0.0235	0.00620	0.25975
1,2,3,7,8,9-HxCDD	0.0284	0.00747	0.31281
1,2,3,4,6,7,8-HpCDD	0.2063	0.00543	0.22757
OCDD	0.3152	0.00083	0.03477
2,3,7,8-TCDF	0.0310	0.00817	0.34222
1,2,3,7,8-PeCDF	0.0062	0.00082	0.03438
2,3,4,7,8-PeCDF	0.0163	0.02150	0.90081
1,2,3,4,7,8-HxCDF	0.0484	0.01275	0.53433
1,2,3,6,7,8-HxCDF	0.0161	0.00423	0.17705
1,2,3,7,8,9-HxCDF	0.0032	0.00085	0.03553
2,3,4,6,7,8-HxCDF	0.0535	0.01409	0.59045
1,2,3,4,6,7,8-HpCDF	0.0878	0.00231	0.09680
1,2,3,4,7,8,9-HpCDF	0.0267	0.00070	0.02950
OCDF	0.1178	0.00031	0.01300
Total PCDD/PCDF	**1.0**	**0.1 ng/m^3**	**4.19 ng/sec**

(1) Database of Sources of Environmental Releases of Dioxin-Like Compounds in the United States (1998, USEPA (CD-ROM)).

Table 7.30 PCDD/PCDF Particle Fraction, Φ, at 10ºC In Airshed (Background plus Local Sources)(1)

Congener Group	E-Hρº$_L$ (25ºC)	E-Hρº$_L$ (10ºC)(2)	Particle Fraction
2,3,7,8-TCDD	1.14×10^{-4}	1.87×10^{-5}	0.763
1,2,3,7,8-PeCDD	1.74×10^{-5}	2.47×10^{-6}	0.961
1,2,3,4,7,8-HxCDD	3.96×10^{-6}	4.98×10^{-7}	0.992
1,2,3,6,7,8-HxCDD	3.96×10^{-6}	4.98×10^{-7}	0.992
1,2,3,7,8,9-HxCDD	3.96×10^{-6}	4.98×10^{-7}	0.992
1,2,3,4,6,7,8-HpCDD	1.02×10^{-6}	1.18×10^{-7}	0.998
OCDD	2.77×10^{-7}	2.91×10^{-8}	0.9995
2,3,7,8-TCDF	1.23×10^{-4}	2.01×10^{-5}	0.75
1,2,3,7,8-PeCDF	3.64×10^{-5}	5.46×10^{-6}	0.917
2,3,4,7,8-PeCDF	2.17×10^{-5}	3.11×10^{-6}	0.951
1,2,3,4,7,8-HxCDF	8.09×10^{-6}	1.09×10^{-6}	0.982
1,2,3,6,7,8-HxCDF	8.09×10^{-6}	1.09×10^{-6}	0.982
1,2,3,7,8,9-HxCDF	4.99×10^{-6}	6.49×10^{-7}	0.989
2,3,4,6,7,8-HxCDF	4.99×10^{-6}	6.49×10^{-7}	0.989
1,2,3,4,6,7,8-HpCDF	2.24×10^{-6}	2.77×10^{-7}	0.995
1,2,3,4,7,8,9-HpCDF	1.31×10^{-6}	1.56×10^{-7}	0.9974
OCDF	2.60×10^{-7}	2.71×10^{-8}	0.9995

(1) USEPA (2000) Estimating Exposure to Dioxin-Like Compounds Volume II, Chapter 3

(2) Background plus local sources default values: $\Theta = 3.5 \times 10^{-6}$ cm^2 aerosol/cm^3 air, TSP =42 µg/m^3.

Table 7.31 Generalized Particle Size Distribution & Proportion of Available Surface Area(1)

Mean Particle Diameter (□m)	**Particle Radius** (□m)	**Surface Area/Volume** (□m^{-1})	**Fraction of Total Mass(2)**	**Proportion Available Surface Area**	**Fraction of Total Surface Area(3)**
>15.0	7.50	0.400	0.128	0.0512	0.0149
12.5	6.25	0.480	0.105	0.0504	0.0146
8.1	4.05	0.741	0.104	0.0771	0.0224
5.5	2.75	1.091	0.073	0.0796	0.0231
3.6	1.80	1.667	0.103	0.1717	0.0499
2.0	1.00	3.000	0.105	0.3150	0.0915
1.1	0.55	5.455	0.082	0.4473	0.1290
0.7	0.40	7.500	0.076	0.5700	0.1656
>0.7	0.40	7.500	0.224	1.6800	0.4880

(1) USEPA (1998) Chapter 3: Air Dispersion and Deposition Modelling, Human Health Risk Assessment Protocol, Region 6 Centre for Combustion Science and Engineering

(2) Used in the deposition modelling of metals (except Hg)

(3) Used in the deposition modelling of PCDD/PCDFs, PAHs and Hg.

7.7.6 Modelling Results

Tables 7.32 – 7.36 details the predicted PCCD/PCDFs (Dioxins/Furans) GLC and deposition flux for the maximum scenario.

Table 7.32 PCDD/PCDF Annual Vapour Concentrations (Based on a Default MWI Profile (MB-Ref WS)) Under Maximum Operating Conditions

Congener Group	Vapour Fraction	Vapour Emission Rate (ng/sec)	Annual Vapour Concentration (fg/m^3)
2,3,7,8-TCDD	0.237	0.02241	0.00410
1,2,3,7,8-PeCDD	0.039	0.01433	0.00262
1,2,3,4,7,8-HxCDD	0.008	0.00101	0.00018
1,2,3,6,7,8-HxCDD	0.008	0.00203	0.00037
1,2,3,7,8,9-HxCDD	0.008	0.00245	0.00045
1,2,3,4,6,7,8-HpCDD	0.002	0.00045	0.00008
OCDD	0.0005	0.00002	0.00000
2,3,7,8-TCDF	0.25	0.08372	0.01532
1,2,3,7,8-PeCDF	0.083	0.00279	0.00051
2,3,4,7,8-PeCDF	0.049	0.04319	0.00790
1,2,3,4,7,8-HxCDF	0.018	0.00941	0.00172
1,2,3,6,7,8-HxCDF	0.018	0.00312	0.00057
1,2,3,7,8,9-HxCDF	0.011	0.00038	0.00007
2,3,4,6,7,8-HxCDF	0.011	0.00636	0.00116
1,2,3,4,6,7,8-HpCDF	0.005	0.00047	0.00009
1,2,3,4,7,8,9-HpCDF	0.0026	0.00008	0.00001
OCDF	0.0005	0.00001	0.000001
Sum			**0.035 fg/m^3**

Table7.33 **PCDD/PCDF Annual Particulate Concentrations (Based on a Default MWI Profile (MB-Ref WS)) Under Maximum Operating Conditions**

Congener Group	Particulate Fraction	Particulate Emission Rate (ng/sec)	Annual Particulate Concentration (fg/m^3)
2,3,7,8-TCDD	0.763	0.07214	0.01327
1,2,3,7,8-PeCDD	0.961	0.35319	0.06499
1,2,3,4,7,8-HxCDD	0.992	0.12503	0.02300
1,2,3,6,7,8-HxCDD	0.992	0.25213	0.04639
1,2,3,7,8,9-HxCDD	0.992	0.30364	0.05587
1,2,3,4,6,7,8-HpCDD	0.998	0.22224	0.04089
OCDD	0.9995	0.03400	0.00626
2,3,7,8-TCDF	0.75	0.25116	0.04621
1,2,3,7,8-PeCDF	0.917	0.03085	0.00568
2,3,4,7,8-PeCDF	0.951	0.83827	0.15424
1,2,3,4,7,8-HxCDF	0.982	0.51345	0.09447
1,2,3,6,7,8-HxCDF	0.982	0.17013	0.03130
1,2,3,7,8,9-HxCDF	0.989	0.03438	0.00633
2,3,4,6,7,8-HxCDF	0.989	0.57141	0.10514
1,2,3,4,6,7,8-HpCDF	0.995	0.09425	0.01734
1,2,3,4,7,8,9-HpCDF	0.9974	0.02880	0.00530
OCDF	0.9995	0.01271	0.00234
Sum			**0.719 fg/m^3**

Table 7.34 **PCDD/PCDF Annual Particulate Deposition Fluxes (Based on a Default MWI Profile (MB-Ref WS)) Under Maximum Operating Conditions**

Congener Group	Particulate Emission Rate (ng/sec)	Dry Particulate Deposition Flux (ng/m^2)	Wet Particulate Deposition Flux (ng/m^2)	Combined Particulate Deposition Flux (ng/m^2)
2,3,7,8-TCDD	0.07214	0.00307	0.00150	0.00320
1,2,3,7,8-PeCDD	0.35319	0.01501	0.00735	0.01565
1,2,3,4,7,8-HxCDD	0.12503	0.00531	0.00260	0.00554
1,2,3,6,7,8-HxCDD	0.25213	0.01072	0.00524	0.01117
1,2,3,7,8,9-HxCDD	0.30364	0.01290	0.00632	0.01345
1,2,3,4,6,7,8-HpCDD	0.22224	0.00945	0.00462	0.00985
OCDD	0.03400	0.00145	0.00071	0.00151
2,3,7,8-TCDF	0.25116	0.01067	0.00522	0.01113
1,2,3,7,8-PeCDF	0.03085	0.00131	0.00064	0.00137
2,3,4,7,8-PeCDF	0.83827	0.03563	0.01744	0.03714
1,2,3,4,7,8-HxCDF	0.51345	0.02182	0.01068	0.02275
1,2,3,6,7,8-HxCDF	0.17013	0.00723	0.00354	0.00754
1,2,3,7,8,9-HxCDF	0.03438	0.00146	0.00072	0.00152
2,3,4,6,7,8-HxCDF	0.57141	0.02428	0.01189	0.02531
1,2,3,4,6,7,8-HpCDF	0.09425	0.00401	0.00196	0.00418
1,2,3,4,7,8,9-HpCDF	0.02880	0.00122	0.00060	0.00128
OCDF	0.01271	0.00054	0.00026	0.00056
Sum		**0.166 ng/m^2**	**0.081 ng/m^2**	**0.173 ng/m^2**
Equivalent Daily Deposition Flux		**0.455 pg/m^2/day**	**0.223 pg/m^2/day**	**0.474 pg/m^2/day**

Table 7.35 **Dispersion Model Summary of Combined Vapour and Particulate Concentrations – PCCD/PCDFs.**

Pollutant / Scenario	Annual Mean Background[1] (pg/m³)	Averaging Period	Process Contribution (pg/m³)	Predicted Emission Concentration (pg/Nm³)
PCCD/PCDFs / Maximum Operation	0.028 0.046	Annual Average	0.0008	0.0288 0.0468
PCCD/PCDFs / Abnormal Operation A[2]	0.028 0.046	Annual Average	0.0009	0.0289 0.0469
PCCD/PCDFs / Abnormal Operation B[3]	0.028 0.046	Five weeks	0.0036	0.032 0.050
PCCD/PCDFs / Abnormal Operation B[3]	0.028 0.046	Annual Average	0.0010	0.0290 0.0470

[1] Baseline results for dioxins given as sum of cumulative impacts (in the absence of the proposed facility) and baseline monitoring data firstly as (i) Non-detects = zero, (ii) Non-detects = limit of detection.

[2] Abnormal operation A scenario based on an emission level of 0.5 ng/m^3 for 2 days per month.

[3] Abnormal operation B scenario based on an emission level of 0.5 ng/m^3 for five weeks in a full year.

Table 7.36 **Deposition Model Summary of Combined Particulate Deposition Flux – PCCD/PCDFs.**

Pollutant / Scenario	Averaging Period	Process Contribution (pg/m²/day)	Predicted Total Particulate Deposition Flux (pg/m²/day)
PCCD/PCDFs / Maximum	Annual Average	0.47	0.47
PCCD/PCDFs / Abnormal A	Annual Average	0.60	0.60
PCCD/PCDFs / Abnormal B	5 Weeks	0.48	0.48
PCCD/PCDFs / Abnormal B	Annual Average	0.80	0.80

Table 7.37 I-TEQ values derived from measurements of airborne dioxins in various locations

Location	Site Type	I-TEQ⁽¹⁾ (fg/m^3)
Kilcock , Co. Meath (1998)(2)	Rural	Range 2.8 – 7
Ireland(2)	Baseline	Mean – 26
	Potential Impact Areas	Mean – 49
Ringaskiddy (2001)(3)	Industrial	Lower Limit – 4.0(7) Upper Limit – 16.4(8)
Germany (1992)(4)	Rural	< 70
	Urban	71 – 350
	Close to Major Source	351 – 1600
UK(5)	London (1993)	Mean – 50
	Manchester (1993)	Mean – 100
	Cardiff (1993)	Mean – 100
	Stevenage (1993)	Mean – 70
Sweden(5)	Urban/Suburban	13 – 24
	Remote/Coastal	3 – 4
Manchester (2000 - 2003)(6)	Urban	Range – 61 - 92
Middlesbrough (2000 - 2003)(6).	Urban	Range –- 31 - 52
Hazelrigg (2000 - 2003)(6)	Semi-rural	Range – 8 - 11
Stoke Ferry (2000 - 2003)(6)	Rural	Range – 18 - 21
High Muffles (2000 - 2003)(6)	Rural	Range – 6 - 8

(1) I-TEQ$_{DF}$ values based on NATO/CCMS (1988) and as used in Annex 1, Council Directive 2000/76/EC.

(2) Taken from Chapter 8 of Thermal Waste Treatment Plant, Kilcock EIS, Air Environment (1998)

(3) Taken from Chapter 9 of Waste Management Facility, Indaver Ireland Ringaskiddy EIS, Baseline Dioxin Survey (2001)

(4) Raffe, C (1996) Sources and environmental concentrations of dioxins and related compounds, *Pure & Appl. Chem* **Vol. 68**, No. 9, pp 1781-1789

(5) Duarte-Davidson et al (1994) Polychlorinated Dibenzo-*p*-Dioxins (PCDDs) and Furans (PCDFs) in Urban Air and Deposition, *Environ. Sci. & Pollut. Res.*, **1 (4)**, 262-270

(6) Taken from TOMPS Network website, www.defra.gov.uk/environment/statistics/airqual/aqpops.htm#aqtb29.

(7) Lower Limit TEQ calculated assuming non-detects are equal to zero.

(8) Upper limit assuming non-detects are equal to limit of detection.

Table 7.38 **Mean I-TEQ Deposition Fluxes Of Dioxins In Various Locations**

Location	Site Type	Mean I-TEQ(1) (pg/m^2/ day)
Germany (1992)(2)	Rural	5 -22
	Urban	10 – 100
	Close to Major Source	123 - 1293
UK(3)	Stevenage	3.2
	London	5.3
	Cardiff	12
	Manchester	28

(1) I-TEQ$_{DF}$ values based on NATO/CCMS (1988) and as used in Annex 1, Council Directive 2000/76/EC.

(2) Raffe, C (1996) Sources and environmental concentrations of dioxins and related compounds, *Pure & Appl. Chem* Vol. 68, No. 9, pp 1781-1789

(3) Duarte-Davidson et al (1994) Polychlorinated Dibenzo-*p*-Dioxins (PCDDs) and Furans (PCDFs) in Urban Air and Deposition, *Environ. Sci. & Pollut. Res.*, 1 (4), 262-270

7.8.7 Concentration Contours

The geographical variation in PCCD/PCDFs (Dioxins/Furans) ground level concentrations and deposition fluxes beyond the site boundary are illustrated as concentration contours in Figures 7.19 - 7.21. The content of the figure is described below.

Figure 7.19 Maximum Operations: Predicted PCCD/PCDFs (Dioxins/Furans) Annual Average Vapour Concentration

Figure 7.20 Maximum Operations: Predicted PCCD/PCDFs (Dioxins/Furans) Annual Average Particulate Concentration

Figure 7.21 Maximum Operations: Predicted PCCD/PCDFs (Dioxins/Furans) Annual Average Total Particulate Deposition

7.8.8 Result Findings

Background levels of PCDD/PCDFs (Dioxins/Furans) occur everywhere and existing levels in the surrounding area have been extensively monitored as part of this study. Monitoring results indicate that the existing levels are significantly lower than urban areas and typical of rural areas in the UK and Continental Europe. The contribution from the site in this context is minor with levels under both maximum and abnormal operations remaining significantly below levels which would be expected in urban areas even at the worst-case receptor to the east of the site (see Table 7.37). Levels at the nearest residential receptor will be minor, with the annual contribution from the proposed facility accounting for less than 0.6% of the existing background concentration under maximum operating conditions and accounting for less than 0.8% of the existing background concentration under abnormal operating conditions.

Shown in Table 7.36 is the maximum dioxin deposition rate. Modelled total dioxin particulate deposition flux indicate that deposition levels under both maximum and abnormal operations would be expected to be significantly less than that experienced in either urban or rural locations (< 5 pg/m^2/day) (see Table 7.38).

7.9 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous chemicals found in urban airsheds throughout the world(22). They are formed from the incomplete combustion of organic matter and are released into ambient air as constituents of highly complex mixtures of polycyclic organic matter (POM). They are also found in crude oil, coal tar, creosote and asphalt. In towns and cities, road traffic emissions are the dominant source of PAHs. In a recent study in Birmingham 88% of the concentration of benzo[*a*]pyrene (B[*a*]P) in air was due to road traffic emissions(23).

PAHs can occur in the form of gases (e.g. 2-ringed naphthalene), solids adsorbed to surfaces of fine particles (e.g. 5-ringed benzo[*a*]pyrene) and in both gas- and particle-phases (e.g. 3-ringed phenanthrene). The air concentrations of gas-phase 2- and 3-ring PAHs are generally significantly higher than those of the 5- and 6- ring particle phase species. Moreover, the percentage found in the gas phase decreases with the size of the PAH. It has also been found that at higher masses of suspended particulate matter (TSP) in the air parcel the percentage of PAHs in the particle phase increases significantly(22).

The International Agency for Research on Cancer (IARC) has classified 48 PAHs according to their likely human carcinogenicity in 1987. The three potent animal carcinogens benzo[*a*]pyrene, benz[*a*]anthracene and dibenz[*ah*]anthracene are classified as “probably carcinogenic to humans”. “Possible human carcinogens“ consisted of four compounds – benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, indeno[123-*cd*]pyrene and chrysene. The USEPA has also classified seven chemicals as probable human carcinogens (USEPA Class B2). In 1993, the USEPA formally adopted provisional guidance for estimating cancer risks associated with PAHs(24). The procedure makes use of the relative potencies of several PAHs with respect to benz[*a*]pyrene which is though to be one of the most potent PAH’s(21,22,24-25).

Various approaches have been adopted to quantify exposure to the complex mixtures of PAHs including total PAH levels or the level of a marker substance such as benzo[*a*]pyrene. Recent studies have found that the relation of B[*a*]P to the levels of 18 other individual PAHs was relatively stable(26). Together these 19 PAH compounds constitute 90-95% of the PAHs measured in the air in this study(26). The UK

DETR Expert Panel on PAHs$^{(25)}$ has reviewed extensively the data available in terms of animal toxicology in deriving an ambient air quality standard for PAHs. The approach used by the Panel was to compare the sum of potential carcinogenic contribution of 7 individual PAHs (possible & probable carcinogens, see above) in ambient air with that of B[*a*]P. Contributions to total carcinogenicity from other PAH compounds are expected to be small relative to those considered above. Results from the comparison indicated that the estimated contribution of B[*a*]P to the total carcinogenicity of the seven chosen PAH compounds was similar in the three locations studied (ranging from 37.5%-49.3%)$^{(25)}$. The overall conclusion from this approach was that using B[*a*]P as a marker of PAH exposure in the environment was suitable so long as major changes in the ambient mixture of PAH compounds do not occur in the future and that an air quality standard for PAH mixtures could be expressed in terms of the ambient concentration of B[*a*]P.

The EU has confirmed the validity of this approach in Council Directive 2004/107/EC which designates B[*a*]P as a marker for PAHs in general. The Directive has set a target value for the protection of human health for B[*a*]P of 1 ng/m^3 to be achieved prior to 2013.

Background PAHs are routinely monitored at seven sites in the UK as part of the Toxic Organic Micropollutants Network (TOMPS)$^{(27)}$. Shown in Table 7.39 are representative concentrations of PAHs at selected sites in the UK. Annual average rural and semi-rural background concentrations of B[*a*]P in this network ranged from 0.02 - 0.09 ng/m^3 over the period 2001 - 2004. In general, urban PAH concentrations are higher than rural background PAH concentrations due to the concentration of emission sources in urban areas.

Table 7.39 Annual average B[a]P at selected sites in UK In 2001 - 2004

Year	**B[a]P Annual Mean Concentration (ng/m^3) in 2001 - 2004**			
	Belfast	**Hazelrigg**	**High Muffles**	**Stoke Ferry**
	Urban	Semi-rural	Rural	Rural
2001	0.37	0.083	0.05	0.09
2002	0.13	0.048	0.043	0.083
2003	0.08	0.043	0.045	0.08
2004	0.15	0.02	0.026	0.043

7.9.1 Modelling Strategy

Data from the monitoring of PAHs in Indaver facilities in Belgium indicates that benzo[a]pyrene, which is the parameter identified in the proposed EU ambient standard(28), has never been detected above the detection limit of 0.1 – 0.3 μg/m^3. For the purposes of this assessment, emissions from the facility have been assumed to be at the upper range of the detection limit (0.3 μg/m^3). Literature data has indicated that B[*a*]P exists almost solely in the particulate phase(22) and the EU reference method for the monitoring of B[*a*]P is based on particulate sampling only(28). Therefore, the current analysis assumes that B[a]P exists in the particulate phase only.

The emission of B[*a*]P from the waste-to-energy plant has thus been evaluated in terms of mass of release into the particle-bound phase. Thereafter, air dispersion and deposition modelling has been employed to translate these releases to ambient air particle phase concentration and wet and dry particulate deposition amounts, in the vicinity of the release. The maximum scenario has been modelled as outlined in Table 7.40. Abnormal operation was also investigated based on the same assumptions as for dioxins (an increase in the maximum operational emission limit by a factor of 5 for 5 weeks every year).

When modelling PAHs the surface area weighting rather than mass weighting is used for deposition. The surface weighting reflects the mode of formation where volatiles condense on the surface of particulates in the flue gas cleaning system (see Column 6 of Table 7.31). Thus, the apportionment of emissions by particle size becomes a function of the surface area of the particles which is available for chemical adsorption.

The particulate concentration of B[a]P was determined as shown in Table 7.42. Results are shown under both maximum and abnormal operating conditions.

7.9.2 Deposition Modelling of Particulates

In order to model dry deposition of PAHs, using AERMOD, the generalised particle-size distribution recommended by the USEPA has again been used as outlined in Table 7.31(11). For the deposition modelling of B[a]P both wet and dry particulate deposition were calculated. The modelling also incorporated wet and dry depletion into the calculations to ensure that the conservation of mass was maintained, as recommended by the USEPA(11). Results are shown in Tables 7.43 for the maximum and abnormal operating conditions.

Table 7.40 Emission Scenario for B[*a*]P

Pollutant	Scenario	Emission Concentration	Emission Rate (µg/s)
B[*a*]P	Maximum Operation	0.3 µg/m^3	12.3
B[*a*]P	Abnormal Operation(1)	1.5 µg/m^3	61.5

(1) Abnormal operation scenario based on an emission level of 1.5 µg/m^3 for five weeks per annum.

7.9.3 Comparison With Standards And Guidelines

Predicted GLCs have been compared with the applicable EU ambient air quality target value for B[*a*]P as set out in Table 7.41.

Table 7.41 B[a]P Ambient Air Quality Standards & Guidelines

Pollutant	Regulation	Limit Type	Target Value
B[a]P	Council Directive 2004/107/EC	Annual Average	1.0 ng/m^3

7.9.4 Modelling Results

Tables 7.42 – 7.44 details the predicted B[a]P GLC for the particulate concentration and deposition scenarios.

Table 7.42 B[a]P Particulate Concentrations Under Maximum And Abnormal Operating Conditions

Compound	Particulate Fraction	Particulate Emission Rate (µg/sec)	Annual Averaged Particulate Concentration (pg/m^3)
B[a]P	1.0	Maximum - 12.3	2.3
B[a]P	1.0	Abnormal - 61.5(1)	3.2

(1) Abnormal operation scenario based on an emission level of 1.5 µg/m^3 for five weeks per annum.

Table 7.43 B[*a*]P Deposition Fluxes – Maximum Operating and Abnormal Conditions

Compound	Fraction	Emission Rate (µg/sec)	Annual Deposition Flux (µg/m^2)
B[a]P - Maximum Operation	Dry particulate	12.3	0.52
	Wet particulate		0.26
	Total particulate		0.55
Sum of Total Particulate Deposition			**0.55 µg/m^2**
			1.5 ng/m^2/day
B[a]P - Abnormal Operation	Dry particulate	61.5$^{(1)}$	0.90
	Wet particulate		0.28
	Total particulate		0.92
Sum of Total Particulate Deposition			**0.92 µg/m^2**
			2.5 ng/m^2/day

(1) Abnormal operation scenario based on an emission level of 1.5 µg/m^3 for five weeks per annum.

Table 7.44 Dispersion Model Summary Of Particulate B[a]P Concentrations Under Maximum And Abnormal Operating Conditions.

Pollutant / Scenario	Annual Mean Background (pg/m^3)$^{(1)}$	Averaging Period	Process Contribution (pg/m^3)	Predicted Emission Concentration (pg/Nm^3)	Standard (pg/Nm^3)
B[a]P / Maximum	90	Annual mean	2.3	92.3	1000
B[a]P / Abnormal	90	Annual mean	3.2	93.2	1000

(1) Based on data from semi-rural locations in the UK (see Table 7.39)

7.9.5 Concentration Contours

The geographical variation in particulate B[*a*]P ground level concentrations beyond the site boundary is illustrated as concentration contours in Figure 7.22. The geographical variation in B[*a*]P total particle-bound deposition beyond the site boundary is illustrated as concentration contours in Figure 7.23:

Figure 7.22 Maximum Operations: Predicted B[*a*]P Annual Average Particulate Concentration

Figure 7.23 Maximum Operations: Predicted B[*a*]P Annual Average Total Particle-Bound Deposition

7.9.6 Result Findings

B[*a*]P modelling results indicate that the ambient ground level concentrations are significantly below the EU target value for the protection of human health under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient B[a]P particle-bound concentration (excluding background concentrations) which are only 0.2% of the annual average limit value at the boundary of the site.

7.10 Mercury

7.10.1 Mercury's Environmental Transport & Fate

Mercury exists in three oxidation states; metallic or elemental (Hg^0); mercurous (Hg_2^{2+}); and mercuric (Hg^{2+}). Elemental Hg is a liquid at room temperature with low volatility. Other forms of mercury are solids with low vapour pressures. It is naturally occurring and cycles between the atmosphere, land and water through a series of complex transformations. Elemental mercury is the most common form of mercury found in the atmosphere whereas in all other environmental media, mercury is found in the form of inorganic mercuric salts and organo-mercury compounds(29).

USEPA methodology relating to waste-to-energy plants assumes that stack emissions containing mercury include both vapour and particle-bound phases. Additionally, the USEPA assumes that mercury exits the stack in only the elemental and divalent species. Of the total mercury in the stack, 80% is estimated to be in the vapour phase and 20% is particle-bound. In addition, the USEPA assumes that speciation of the total mercury is 80% divalent (20% in the particle-bound and 60% in the vapour phase) and 20% elemental (all 20% in the vapour phase)(29). Although the USEPA allows a loss to the global cycle for each form of mercury (99% of the elemental vapour form, 32% of the divalent vapour form, and 64% of the particle-bound form are assumed lost to the global cycle and do not deposit within the localized study area), this has not been incorporated into the current assessment in keeping with the worst-case approached adopted in this assessment.

7.10.2 Modelling Strategy

The emissions of mercury from the waste-to-energy plant have been evaluated in terms of mass of release into both vapour and particle-bound phases. Thereafter, air dispersion and deposition modelling has been employed to translate these releases to ambient air vapour and particle phase concentrations, and wet vapour & wet and dry particulate deposition amounts, in the vicinity of the release. Both maximum and abnormal scenarios have been modelled as outlined in Table 7.45.

Vapour / Particulate Partitioning

In order to adequately model dispersion and deposition of mercury, modelling of both vapour and particle-bound states is thus necessary. For the vapour phase modelling, no dry deposition was assumed, as recommended by the USEPA(11,29). Using the vapour – particle partitioning described in Section 7.7.2, the vapour concentrations of mercury was determined as outlined in Table 7.47. Results are shown under maximum operating conditions.

When modelling mercury (Hg) the surface area weighting rather than mass weighting is used for deposition. The surface weighting reflects the mode of formation where volatiles condense on the surface of particulates in the flue gas cleaning system (see Column 6 of Table 7.31). Thus, the apportionment of emissions by particle size becomes a function of the surface area of the particle which is available for chemical adsorption.

For the particle-phase concentration, the vapour – particle partitioning described in Section 7.7.2 was used to give the particulate concentrations of mercury as determined in Table 7.48. Results are shown under both maximum and abnormal operating conditions.

7.10.3 Deposition Modelling of Particulates

In order to model dry deposition, using AERMOD, the generalised particle-size distribution recommended by the USEPA has again been used for Hg as outlined in Table 7.31(11). Dry gaseous deposition, although considered in the AERMOD model, has not been adequately calibrated for the estimation of the deposition flux into vegetation and thus the USEPA has recommended that this algorithm should not be used for site-specific applications(10).

For the deposition modelling of mercury both wet and dry particulate deposition were calculated. The modelling also incorporated wet and dry depletion into the calculations to ensure that the conservation of mass was maintained, as recommended by the USEPA(11). Results are shown in Tables 7.49 and 7.50 for both maximum and abnormal operating conditions.

Table 7.45 Emission Scenario for Mercury

Pollutant	Scenario	Emission Concentration	Emission Rate (g/s)
Hg	Maximum Operation	0.05 mg/m^3	0.0020
	Abnormal Operation(1)	1 mg/m^3	0.041

(1) Abnormal operation scenario based on an emission level of 1 mg/m^3 for two days every month for a full year.

Abnormal Operation

Hg is absorbed by activated carbon / lignite cokes and thus elevated levels are detected in the same way as dioxins as outlined in Section 7.7.2.

For the purpose of the air modelling study the following abnormal operation conditions were used: Hg: 1 mg/Nm3 for two days.

7.10.4 Comparison With Standards And Guidelines

Predicted GLCs have been compared with the applicable WHO ambient air quality guideline for the protection of human health for mercury as set out in Table 7.46.

Table 7.46 Hg Ambient Air Quality Standards & Guidelines

Pollutant	Regulation	Limit Type	Value
Inorganic Mercury (as Hg)	WHO	Annual Average	1.0 µg/m^3

7.10.5 Modelling Results

Tables 7.47 – 7.51 details the predicted mercury GLC for each vapour and particulate concentration and deposition scenario.

Table 7.47 Mercury Vapour Concentrations Under Both Maximum and Abnormal Operating Conditions

Oxidation State	Vapour Fraction	Vapour Emission Rate (g/sec)	Vapour Concentration (ng/m^3)
Elemental Hg	0.20	Maximum - 0.00041	0.075
Divalent Hg^{2+}	0.60	Maximum - 0.00122	0.22
Sum			**0.30 ng/m^3**
Elemental Hg	0.20	Abnormal Operation - 0.062	0.16
Divalent Hg^{2+}	0.60	Abnormal Operation - 0.186	0.48
Sum			**0.63 ng/m^3**

(1) Abnormal operation scenario based on an emission level of 1 mg/m^3 for two days every month for a full year.

Table 7.48 Mercury Particulate Concentrations Under Both Maximum & Abnormal Operating Conditions

Oxidation State	Particulate Fraction	Particulate Emission Rate (g/sec)	Particulate Concentration (ng/m^3)
Divalent Hg^{2+}	0.20	Maximum - 0.00041	0.075
Divalent Hg^{2+}	0.20	Abnormal - 0.0082	0.165

Table 7.49 Mercury Deposition Fluxes – Maximum Operating Conditions

Oxidation State	Fraction	Emission Rate (g/sec)	Annual Deposition Flux (µg/m^2)
Divalent Hg^{2+}	Dry particulate	0.00041	17.3
	Wet particulate		8.5
	Total particulate		18.1
Sum of Total Particulate Deposition			**18.1 µg/m^2**
			49.6 ng/m^2/day

Table 7.50 Mercury Deposition Fluxes – Abnormal Operating Conditions

Oxidation State	Fraction	Emission Rate (g/sec)	Annual Deposition Flux (µg/m^2)
Divalent Hg^{2+}	Dry particulate	0.0082	38.2
	Wet particulate		18.6
	Total particulate		39.8
Sum of Total Particulate Deposition			**39.8 µg/m^2** **109 ng/m^2/day**

Table 7.51 Dispersion Model Summary Of Combined Vapour And Particulate Hg Concentrations Under Both Maximum And Abnormal Operating Conditions

Pollutant / Scenario	Annual Mean Background (ng/m^3)	Averaging Period	Process Contribution (ng/m^3)	Predicted Emission Concentration (ng/Nm^3)	Standard (ng/Nm^3)
Hg / Maximum	1.0	Annual mean	0.38	1.38	100
Hg / Abnormal	1.0	Annual mean	0.80	1.80	100

7.10.6 Concentration Contours

The geographical variation in mercury ground level concentrations beyond the site boundary is illustrated as concentration contours in Figure 7.24. The geographical variation in mercury total particle-bound deposition beyond the site boundary is illustrated as concentration contours in Figure 7.25:

Figure 7.24 Maximum Operations: Predicted Mercury Annual Average Concentration

Figure 7.25 Maximum Operations: Predicted Mercury Annual Average Total Particle-Bound Deposition

7.10.7 Result Findings

Hg modelling results indicate that the ambient ground level concentrations are significantly below the WHO guideline for the protection of human health under both maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary.

Emissions at maximum operations equate to ambient mercury combined concentration (both vapour and particle-bound) (excluding background concentrations) which are only 0.38% of the annual average limit value at the boundary of the site.

7.11 Heavy Metal Emissions and Results (excl. Mercury)

7.11.1 Modelling Approach

The emissions of heavy metals (except Hg) from the waste-to-energy plant have been evaluated in terms of mass of release into the particulate phase only as recommended by the USEPA(10,11). Thereafter, air dispersion and deposition modelling has been employed to translate these releases to ambient particle phase concentrations, and wet and dry particulate deposition amounts, in the vicinity of the release.

When modelling heavy metals (except Hg) the mass weighting rather than surface weighting is used for deposition as it is assumed that the metals are all in the particulate state (see Column 4 of Table 7.31). Results are shown under both maximum and abnormal operating conditions.

For the deposition modelling of heavy metals (except Hg) both wet and dry particulate deposition were calculated. The modelling also incorporated wet and dry depletion into the calculations to ensure that the conservation of mass was maintained, as recommended by the USEPA(11).

Ambient ground level concentrations and deposition values (GLCs) of the Sum of antimony (Sb), arsenic (As), lead (Pb), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni) and vanadium (V) have been investigated using the concentration limits outlined in Council Directive 2000/76/EC (see Table 7.52) and also under abnormal operations at the site.

Data is available from a similar Indaver site in Beveren, Belgium (see Table 7.53) indicating the actual emission levels of these metals based on typical and maximum recorded levels over the period 2000 - 2004. This data has been used to identify the likely ratio of metals when emitting under both maximum and abnormal operation conditions. It should be noted that modelled levels are significantly higher than that detected at this facility over this five year period.

Table 7.52 Emission Scenario for Heavy Metals Taken From Council Directive 2000/76/EC

Pollutant	Scenario	Concentration	Emission Rate (g/s)
Sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V	Maximum Operation	0.50 mg/m^3	0.020
	Abnormal Operation(1)	30 mg/m^3	1.18

(1) Abnormal operation scenario based on an emission level of 30 mg/m^3 for two days every month for a full year.

Abnormal Operation

Heavy metals are absorbed by activated carbon / lignite cokes and thus elevated levels are detected in the same way as dioxins as outlined in Section 7.7.2.

For the purpose of the air modelling study the following abnormal operation conditions were used: Cd: 1 mg/Nm^3 for two days, Tl: 1 mg/Nm^3 for two days and Heavy metals: 30 mg/Nm^3 for two days.

Table 7.53 Actual Measured Emission Data From An Indaver Site In Belgium Over The Period 2000 - 2004 (mg/Nm^3)

	Average(1)	Maximum(1)	Maximum Operation(2)	Abnormal Operation(2)
	2000 - 2004	**2000 - 2004**	**0.50 mg/m^3**	**30 mg/m^3**
As	0.012	0.020	0.054	3.23
Cd	0.001	0.008		
Co	0.008	0.040	0.037	2.23
Cr	0.014	0.059	0.062	3.71
Cu	0.011	0.070	0.049	2.95
Mn	0.018	0.200	0.081	4.84
Ni	0.005	0.036	0.023	1.38
Pb	0.013	0.042	0.058	3.50
Sb	0.012	0.020	0.053	3.18
Sn	0.011	0.057	0.049	2.96
Tl	0.011	0.020		
V	0.008	0.020	0.035	2.07
Sum Cd+Tl	0.008	0.030		
Hg	0.002	0.024		
Sum Sb/As/Pb/Cr/Co/Cu/Mn /Ni/V/Sn	0.060	0.37	0.50	30.0

(1) Non-detects reported at the detection limit.

(2) Based on the ratio under average operation.

7.11.2 Comparison with Standards And Guidelines

Predicted GLCs have been compared with the applicable ambient air quality guidelines and standards for the protection of human health as set out in Table 7.54 and 7.55.

In the absence of statutory standards, ambient air quality guidelines can also be derived from occupational exposure limits (OEL). The OEL for each compound (where available) divided by an appropriate safety factor may be used. This factor accounts for increased exposure time and susceptibility of the general population in comparison to on-site personnel. The OEL can be expressed on the basis of two averaging periods; an eight-hour average and a fifteen-minute average (the short term exposure limit or STEL). The OEL (8-hour reference) divided by a factor of 100 may be applied to generate an ambient air quality guideline or Environmental Assessment Level (EAL) for comparison with predicted annual averages and the STEL divided by 40 may be applied for comparison with the one-hour concentrations.

A comparison of Table 7.53 with Table 7.55 indicates that Arsenic is the metal which is emitted at the most significant level relative to its annual average limit value and thus has been reported below. All other metals will have a lower impact on the ambient environment. Antimony has also been investigated as it is emitted at the most significant level relative to the short-term limit values.

Table 7.54 Cd and Tl Ambient Air Quality Standards & Guidelines

Pollutant	Regulation	Limit Type	Value
Cd	TA Luft	Annual Average	0.04 $\mu g/m^3$
Cd	WHO	Annual Average	0.005 $\mu g/m^3$
Cd	EU	Annual Average	0.005 $\mu g/m^{3(1)}$
Tl	EAL	Annual Average	1.0 $\mu g/m^3$

(1) Council Directive 2004/107/EC(28)

Table 7.55 Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V Ambient Air Quality Standards & Guidelines

Pollutant	Regulation	Limit Type	Value
Sb (organic compounds)	EAL	Maximum One-Hour	5 µg/m^3
Sb (organic compounds)	EAL	Annual Average	1.0 µg/m^3
As	WHO	Annual Average	0.005 µg/m^3
As	EU	Annual Average	0.006 µg/m^3(1)
Pb	EU	Annual Average	0.5 µg/m^3
Cr (except VI)	EAL	Annual Average	5.0 µg/m^3
Cr (VI)	EAL	Annual Average	0.5 µg/m^3
Co	EAL	Annual Average	1.0 µg/m^3
Cu (fumes)	EAL	Annual Average	2.0 µg/m^3
Cu (dust & mists)	EAL	Annual Average	10 µg/m^3
Mn	WHO	Annual Average	0.15 µg/m^3
Mn (fume)	EAL	Maximum One-Hour	75 µg/m^3
Ni	EU	Annual Average	0.02 µg/m^3(1)
V (fume & respirable dust)	EAL	Annual Average	0.4 µg/m^3
V	WHO	24-Hour Average	1.0 µg/m^3

(1) Council Directive 2004/107/EC(28)

7.11.3 Modelling Results

Air dispersion and deposition modelling was carried out for the two scenarios described in Section 7.10.1. Table 7.56 outlines the maximum and abnormal emission levels for Cd and Tl and Table 7.57 – 7.59 details the predicted Cd & Tl GLC and deposition value for each scenario and averaging period.

Table 7.56 Maximum And Abnormal Operations for Cd & Tl

Heavy Metal	Limit Type	Value
Cd & Tl	Maximum Operation	0.05 mg/m^3
	Abnormal Operation(1)	1 mg/m^3

(1) Abnormal operation scenario based on an emission level of 1 mg/m^3 for two days every month for a full year.

Table 7.57 Cd & Tl Particulate Concentrations Under Maximum And Abnormal Operation

Heavy Metal	Emission Rate (g/sec)	Concentration (ng/m^3)
Cd & Tl	Maximum Operation - 0.0020	0.37
	Abnormal Operation - 0.039	0.82

Table 7.58 Cadmium Deposition Fluxes – Maximum and Abnormal Operation

Heavy Metal	Fraction	Emission Rate (g/sec)	Annual Deposition Flux (µg/m^2)
Cd & Tl / Maximum Operation	Dry particulate	0.002	0.45
	Wet particulate		0.27
Sum of Total Deposition			**0.47 µg/m^2**
			1.28 ng/m^2/day
Cd & Tl / Abnormal Operation	Dry particulate	0.039	0.98
	Wet particulate		0.059
Sum of Total Deposition			**1.03 µg/m^2**
			2.82 ng/m^2/day

Table 7.59 Cadmium & Thallium Particulate Concentration Summary

Pollutant / Scenario	Annual Mean Background (ng/m^3)	Averaging Period	Process Contribution (ng/m^3)	Predicted Emission Concentration (ng/Nm^3)	Standard (ng/Nm^3)$^{(1)}$
Cd / Maximum	1.0	Annual mean	0.37	1.37	5.0
Cd / Abnormal	1.0	Annual mean	0.82	1.82	5.0

(1) Council Directive 2004/107/EC(28)

Tables 7.60 – 7.62 details the predicted GLC and deposition values for each scenario for arsenic and antimony.

Table 7.60 **Arsenic and Antimony Particulate Concentration Under Both Maximum & Abnormal Operating Conditions**

Heavy Metal	Emission Rate (g/sec)	Maximum 1-hour Concentration (µg/m^3)	Annual Concentration (ng/m^3)
Arsenic	Maximum - 0.0022		0.40
Antimony	Maximum - 0.0022	20	
Arsenic	Abnormal - 0.13		1.93
Antimony	Abnormal - 0.13	96	

Table 7.61 **Arsenic Deposition Fluxes – Maximum & Abnormal Operating Conditions**

Heavy Metal	Fraction	Emission Rate (g/sec)	Annual Deposition Flux (µg/m^2)
Arsenic / Maximum	Dry particulate	0.0022	0.48
	Wet particulate		0.29
Sum of Total Deposition			**0.50 µg/m^2**
Arsenic / Abnormal	Dry particulate	0.13	2.31
	Wet particulate		1.39
Sum of Total Deposition			**2.42 µg/m^2**

Table 7.62 Dispersion Model Results – Arsenic and Antimony

Heavy Metal / Scenario	Annual Mean Background (ng/m^3)	Averaging Period	Process Contribution (ng/m^3)	Predicted Emission Concentration (ng/Nm^3)	Standard (ng/Nm^3)
Arsenic / Maximum	1.0(1)	Annual mean	0.40	1.40	**6.0(3)**
Antimony / Maximum	1.0(2)	Maximum One-Hour	20	21	**5000(4)**
Arsenic / Abnormal	1.0(1)	Annual mean	1.93	2.93	**6.0(3)**
Antimony / Abnormal	1.0(2)	Maximum One-Hour	96	97	**5000(4)**

(1) Background concentration for arsenic based on on-site monitoring

(2) Background concentration for antimony based on on-site monitoring

(3) Ambient standard for arsenic which is the most stringent applicable limit value for this averaging period

(4) Ambient standard for antimony which is the most stringent applicable limit value for this averaging period.

7.11.4 Concentration Contours

The geographical variations in heavy metal ground level concentrations and deposition flux beyond the site boundary are illustrated as a concentration and deposition contours in Figures 7.26 to 7.29. The content of the figure is described below.

Figure 7.26 Maximum Operation: Predicted Cd Annual Average Concentration

Figure 7.27 Maximum Operation: Predicted Cd Annual Deposition Flux

Figure 7.28 Maximum Operation: Predicted As Annual Average Concentration

Figure 7.29 Maximum Operation: Predicted As Annual Deposition Flux

7.11.5 Result Findings

Cd and Tl

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standards for the protection of human health for cadmium under both maximum and abnormal operations of the site. Emissions at maximum operations equate to an ambient Cd and Tl concentration (excluding background concentration) which is 7% of the annual target value for Cd close to the site boundary (the comparison is made with the Cd limit value as this is more stringent than that for Tl).

Sum of As, Ni, Sb, Pb, Cr, Co, Cu, Mn and V

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health for arsenic and antimony (the metals with the most stringent limit values) under both maximum and abnormal emissions from the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient As concentrations (excluding background concentrations) which are only 7% of the annual limit value at the worst-case receptor whilst emissions at maximum operations equate to ambient Sb concentrations (excluding background concentrations) which are only 0.4% of the maximum 1-hour limit value at the worst-case receptor. Emissions under abnormal operations equate to ambient As concentrations (excluding background concentrations) which are only 32% of the annual limit value at the worst-case receptor whilst emissions at maximum operations equate to ambient Sb concentrations (excluding background concentrations) which are only 2% of the maximum 1-hour limit value at the worst-case receptor.

7.11.6 Summary Of Impacts

Based on the emission guidelines outlined in Council Directive 2000/76/EC, detailed air dispersion modelling has shown that the most stringent ambient air quality standards for the protection of human health are not exceeded either as a result of operating under either maximum or abnormal operating conditions.

The modelling results indicate that the maximum ambient GLC occurs at or near the site's north-western to eastern boundaries. Concentrations fall off rapidly away from this maximum and for the short-term limit values at the nearest residential receptors will be less than 3.5% of the short-term limit values under maximum operations of the site. The annual average concentration has an even more dramatic decrease in maximum concentration away from the site with concentrations from emissions at the proposed facility accounting for less than 1% of the limit value (not including background concentrations) at worst case sensitive receptors near the site under maximum operations of the site. Thus, the results indicate that the impact from the proposed facility is minor and limited to the immediate environs of the site.

In the surrounding main population centres, Duleek and Drogheda, levels are significantly lower than background sources with the concentrations from emissions at the proposed facility accounting for less than 0.5% of the annual limit values for the protection of human health for all pollutants under maximum operations of the site.

7.12 Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention on Persistent Organic Pollutants (the Convention) was signed by 151 nations on May 23 2001 (or within one year from this date)(30). The Convention entered into force on the 17th May 2004 on the 90th day after the fiftieth country (France) ratified the Convention.

Persistent organic pollutants (POPs) are a small group of organic chemicals exhibiting the combined properties of persistence, bioaccumulation, toxicity, and long-range environmental transport(31). The 12 POPs referred to in the Convention are as outlined in Table 7.63:

Table 7.63 Priority Persistent organic pollutants

12 Priority POPS of Global Concern	Source	Convention Category
Aldrin	Fertilizer (Insecticide)	Annex A
Dieldrin	Fertilizer	Annex A
Endrin	Fertilizer	Annex A
DDT	Fertilizer, Disease vector control use (malaria)	Annex B
Chlordane	Fertilizer	Annex A
Heptachlor	Termiticide	Annex A
Mirex	Termiticide	Annex A
Toxaphene	Fertilizer	Annex A
Hexachlorobenzene (HCB)	Solvent in pesticide	Annex A
Polychlorinated Biphenyls (PCBs)	Unintentional release from thermal processes	Annex C
Polychlorinated dibenzo-p-dioxins (Dioxins)	Unintentional release from thermal processes	Annex C
Polychlorinated dibenzofurans (Furans)	Unintentional release from thermal processes	Annex C

The objective for POPs which fall under Annex A (see Table 7.63) is to have the production and use of these compounds eliminated whilst Annex B should only be used for disease vector control use (malaria control). In relation to Annex C, which includes dioxins and furans, a series of measures have been agreed to reduce or eliminate the release of these compounds.

Each signatory has agreed to a number of items which have relevance to the release of dioxins and furans including Article 5 - Measures to reduce or eliminate releases from unintentional production:

- Promote the application of available, feasible and practical measures that can achieve a realistic and meaningful level of release reduction or source elimination;
- Promote the development and, where it deems appropriate, require the use of substitute or modified materials, products and processes to prevent the formation and release of the chemicals listed in Annex C;
- Promote and require the use of best available techniques for new sources with a particular initial focus on source categories identified in Part II of Annex C;
- Parties are to promote the use of best environmental practices;
- Release limit values or performance standards can be used to fulfil the commitment for best available techniques.

Waste Incineration of municipal waste is defined as a Part II source category under the Convention. In Annex C general guidance is given in relation to what constitutes best available techniques (BAT) and best environmental practices including:

- The use of low-waste technology;
- The use of less hazardous substances;
- The promotion of the recovery and recycling of waste and of substances generated and used in a process;
- Replacement of feed materials which are persistent organic pollutants or where there is a direct link between the materials and release of persistent organic pollutants from the source;
- Good housekeeping and preventive maintenance programmes;
- Improvements in waste management with the aim of the cessation of open and other uncontrolled burning of wastes, including the burning of landfill sites.

Measures which can be considered in determining best available techniques include:

- Use of improved methods for flue-gas cleaning such as thermal or catalytic oxidation, dust precipitation, or adsorption;
- Treatment of residuals, wastewater, wastes and sewage sludge by, for example, thermal treatment or rendering them inert or chemical processes that detoxify them;
- Process changes that lead to the reduction or elimination of releases, such as moving to closed systems;
- Modifications of process designs to improve combustion and prevent formation of the chemicals listed in this Annex, through the control of parameters such as incineration temperature or residence time.

In relation to Carranstown Waste Management Facility, best available technology (BAT) has been employed in line with the Convention, Council Directive 2000/76/EC and the IPPC BREF Notes on waste incineration. Council Directive 2000/76/EC has outlined stringent operating conditions in order to ensure sufficient combustion of waste thus ensuring that dioxin formation is minimised. The Directive has outlined air emission limit values for dioxins which have been set at 0.1 ng/Nm^3. Indaver Ireland is committed, as a minimum, to meeting all the requirements of Council Directive 2000/76/EC. Indeed, due to the advanced post-combustion flue gas-cleaning technology employed, expected average emission values will be significantly below than these values. The proposed facility will thus significantly outperform the very stringent limit values imposed by Council Directive 2000/76/EC and thus in doing so will fulfil the requirements of BAT (Article 5).

The use of an advanced flue-gas cleaning systems and the controlling of incineration temperatures is also in accordance with Annex C Part IV Definitions B. Best Available Techniques which includes the use of improved methods for flue-gas cleaning such as thermal or catalytic oxidation, dust precipitation, or adsorption; the treatment of wastes by, for example, thermal treatment; and modifications of process designs to improve combustion and prevent formation of the chemicals listed in this Annex, through the control of parameters such as incineration temperature or residence time.

The Report of the first meeting of the Expert Group on Best Available Techniques and Best Environmental Practices (2005)(32) focuses on the issue of the destruction and irreversible transformation of the persistent organic pollutant content in wastes. The Expert Group noted that only two processes have been recommended as BAT. The two processes are hazardous waste incineration and cement kiln co-incineration. A further eight possible processes are currently being assessed by a working group.

The Report of the Second Session of the Expert Group on Best Available Techniques and Best Environmental Practices (2003)(33) focuses on draft guidelines on BAT and BEP for municipal waste incineration. The session recommends that techniques which have been demonstrated to be highly effective in preventing the formation and release of the unintentionally produced POPs are recommended. Techniques in the “Relatively Low to Moderate“ category were defined as 0.1-10 ng TEQ/kg waste. Carranstown, under maximum operation of the facility, will emit 0.1 g TEQ/annum of dioxins/furans which is equivalent to 0.5 ng TEQ/kg waste based on 200,000 tonnes / annum and thus is at the lower end of the recommended range.

Thus, the proposed waste-to-energy facility fulfils the definition of BAT under the Convention, both in terms of Article 5 of the Convention and in terms of Annex C Part IV. A comparison of Carranstown Waste Management facility’s operations with the obligations under the Stockholm Convention on Persistent Organic Pollutants indicates that the facility will achieve and promote the objectives of the Convention in terms of recovery, recycling, waste separation, release reduction, process modification and BAT.

7.13 References

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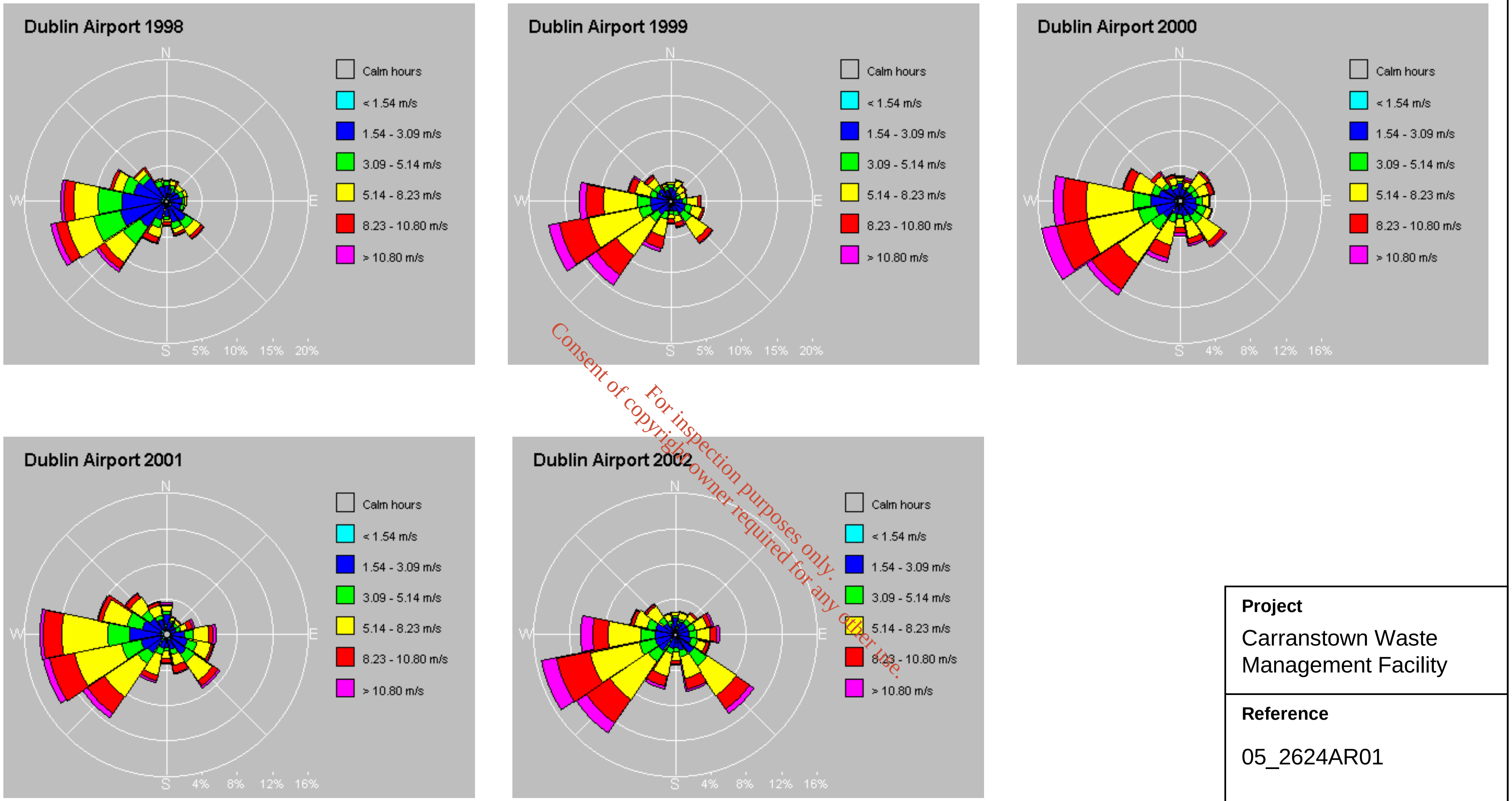

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Figure 7.1

Dublin Airport
Windrose 1998-2002

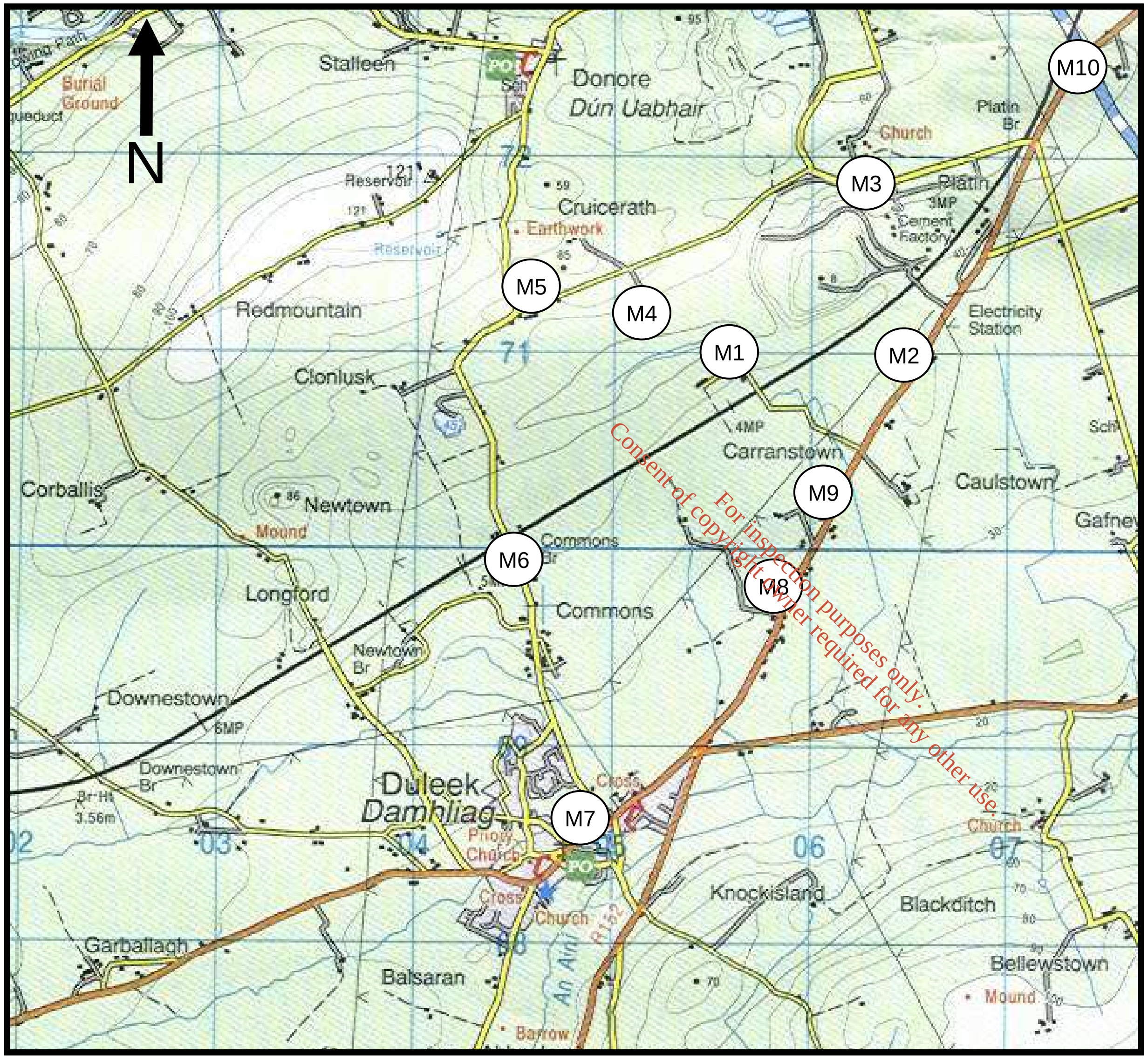

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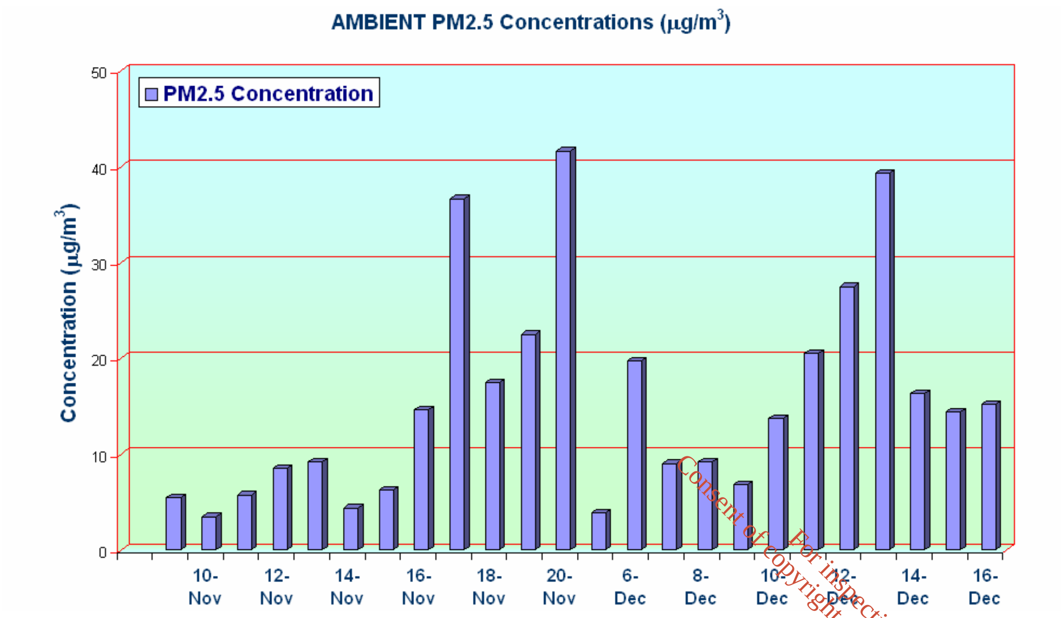
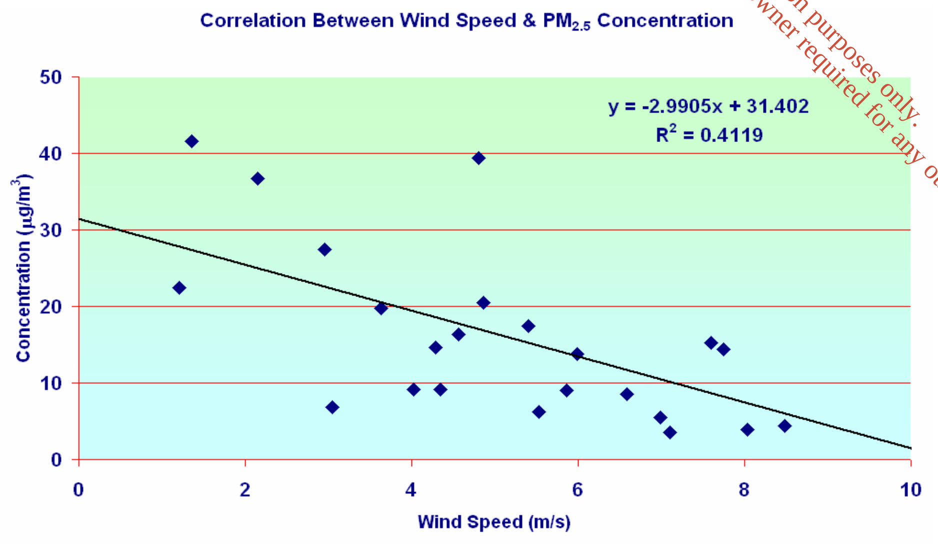
Figure 7.2
Air Monitoring Locations

awn consulting


AMBIENT PM2.5 Concentrations (µg/m^3)


Correlation Between Wind Speed & PM$_{2.5}$ Concentration

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05_2624AR01

Figure 7.3
PM$_{2.5}$ Monitoring Results & Correlation with Wind Speed

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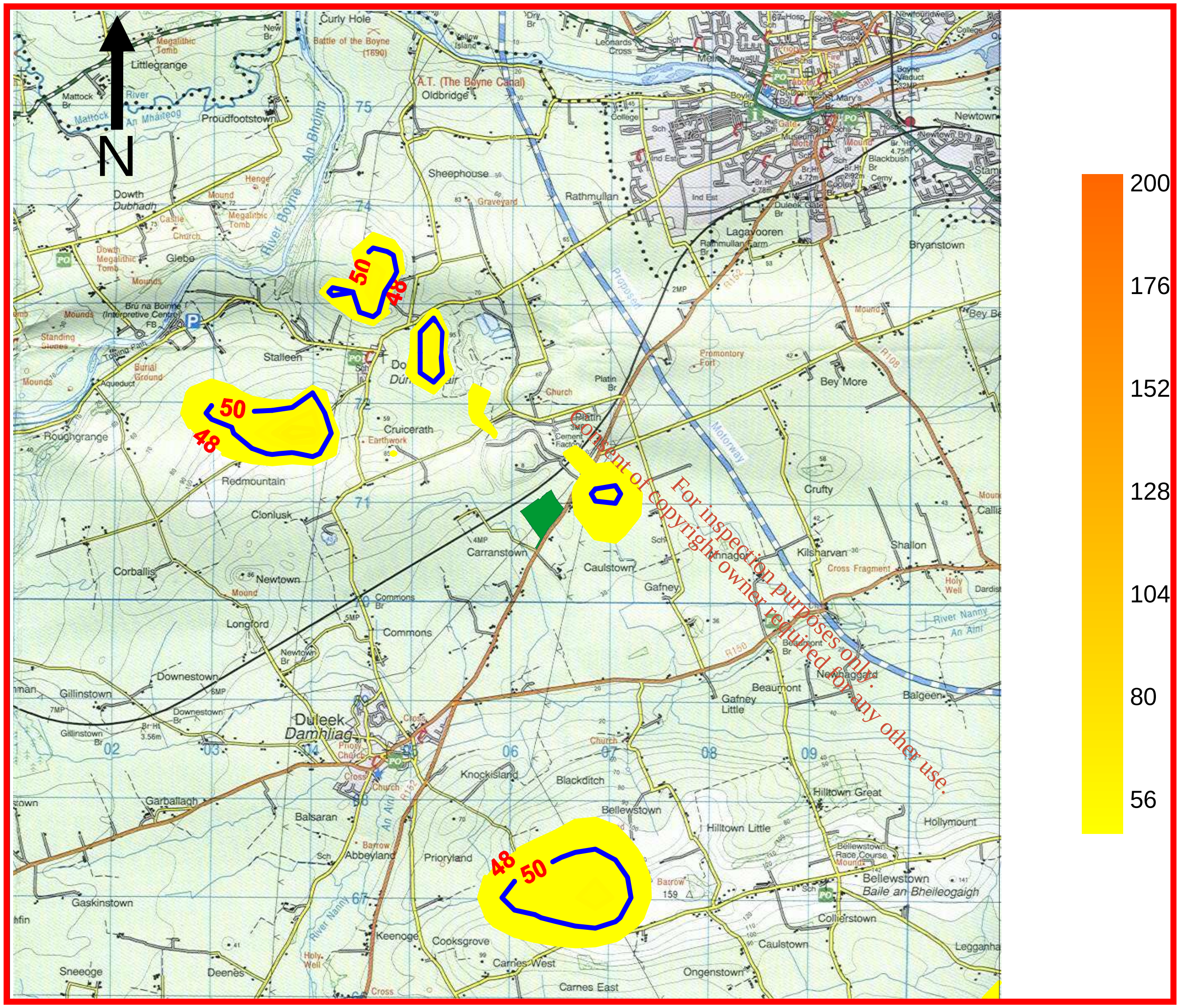

Maximum 1-Hour NO_2 Concentration
Blue Contour = 50 µg/m^3

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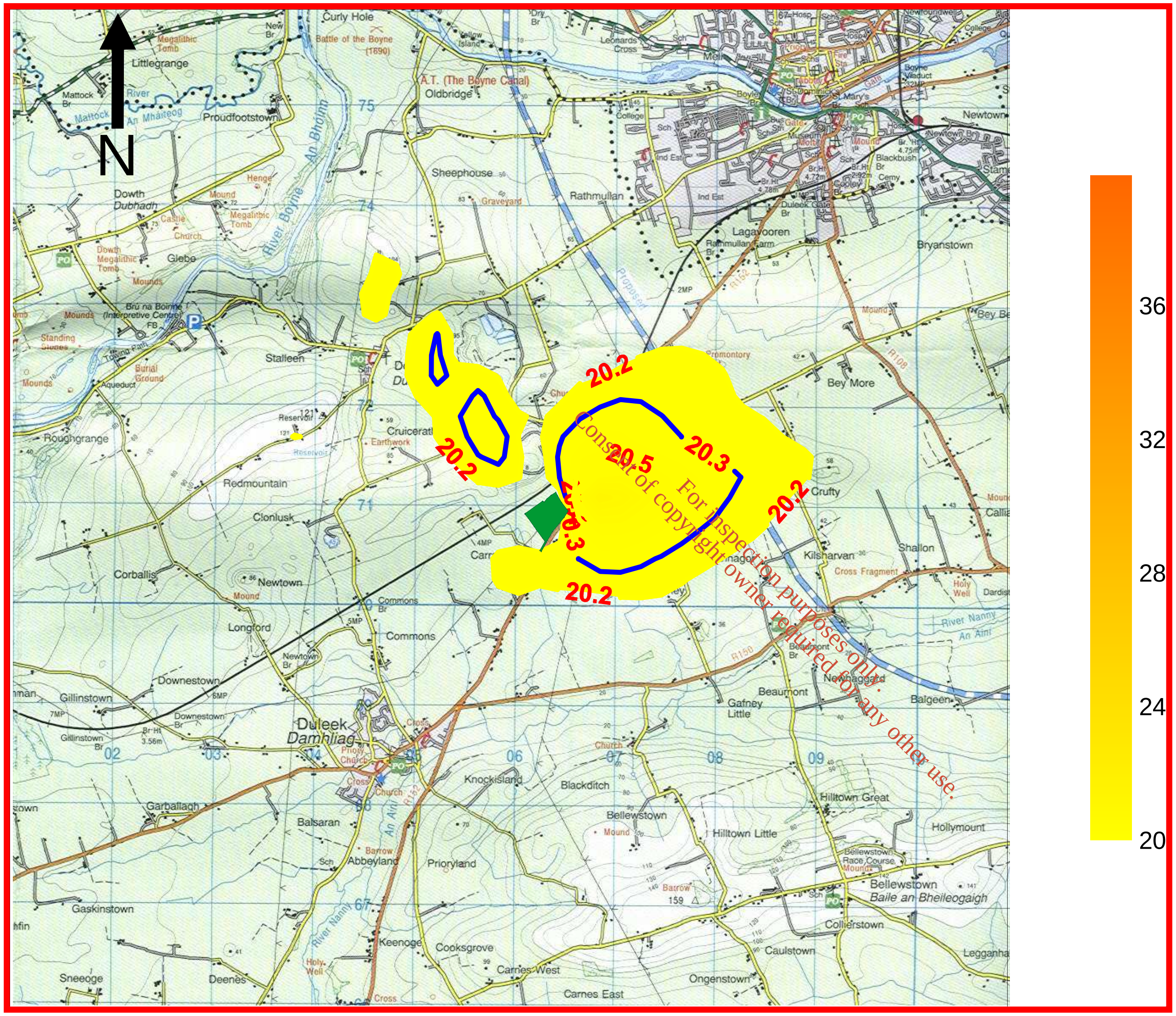
Figure 7.4
Predicted 99.8th%ile of NO_2 1-Hour Concentrations (µg/m^3)



Annual Average NO_2
Concentration
Blue Contour = 20.3 µg/m^3

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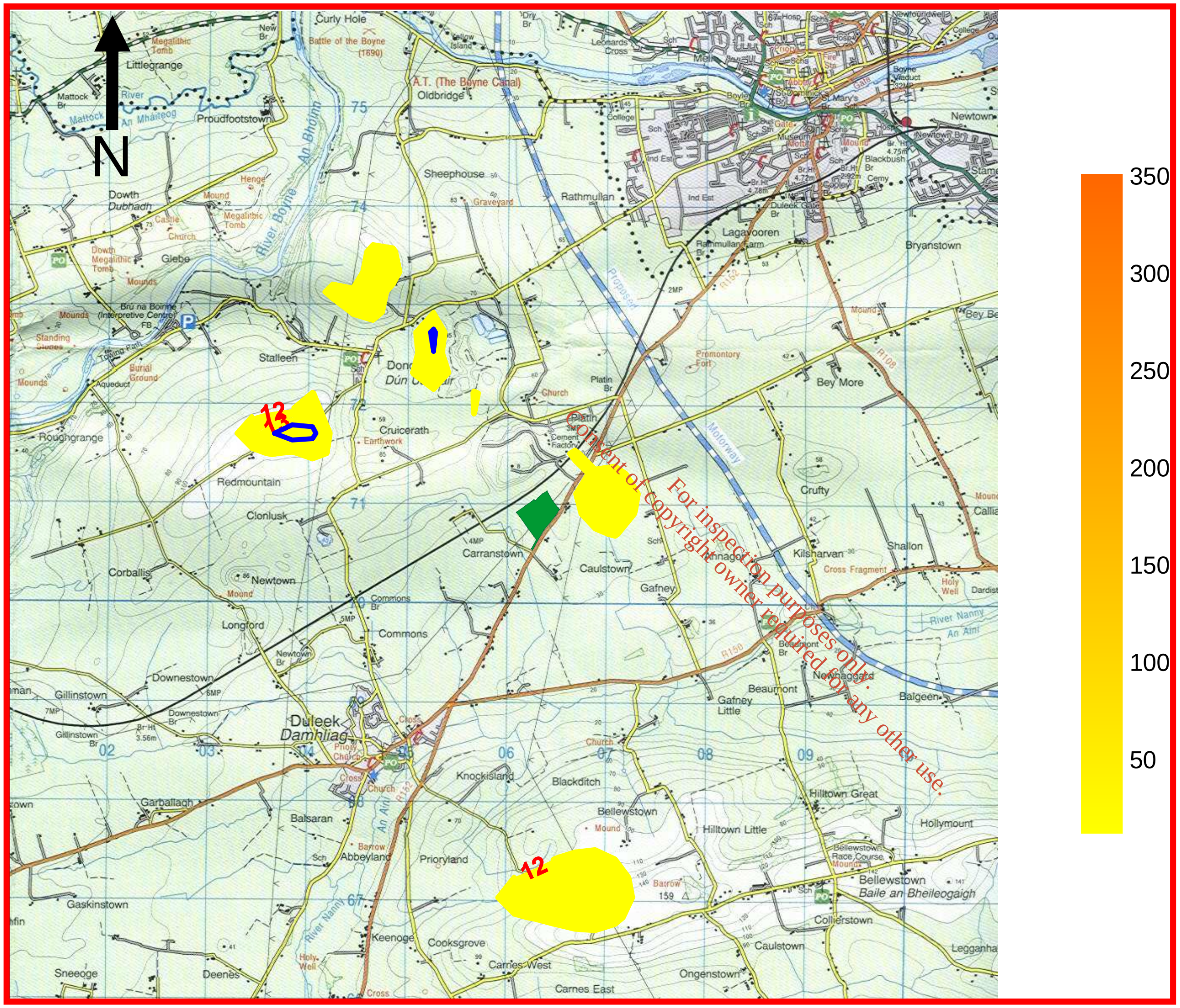
Figure 7.5
Predicted Annual
Average NO_2
Concentrations (µg/m^3)



Maximum 1-Hour SO_2
Concentration
Blue Contour = 14 µg/m^3

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Figure 7.6

Predicted 99.7th%ile of SO_2 1-Hour Concentrations (µg/m^3)

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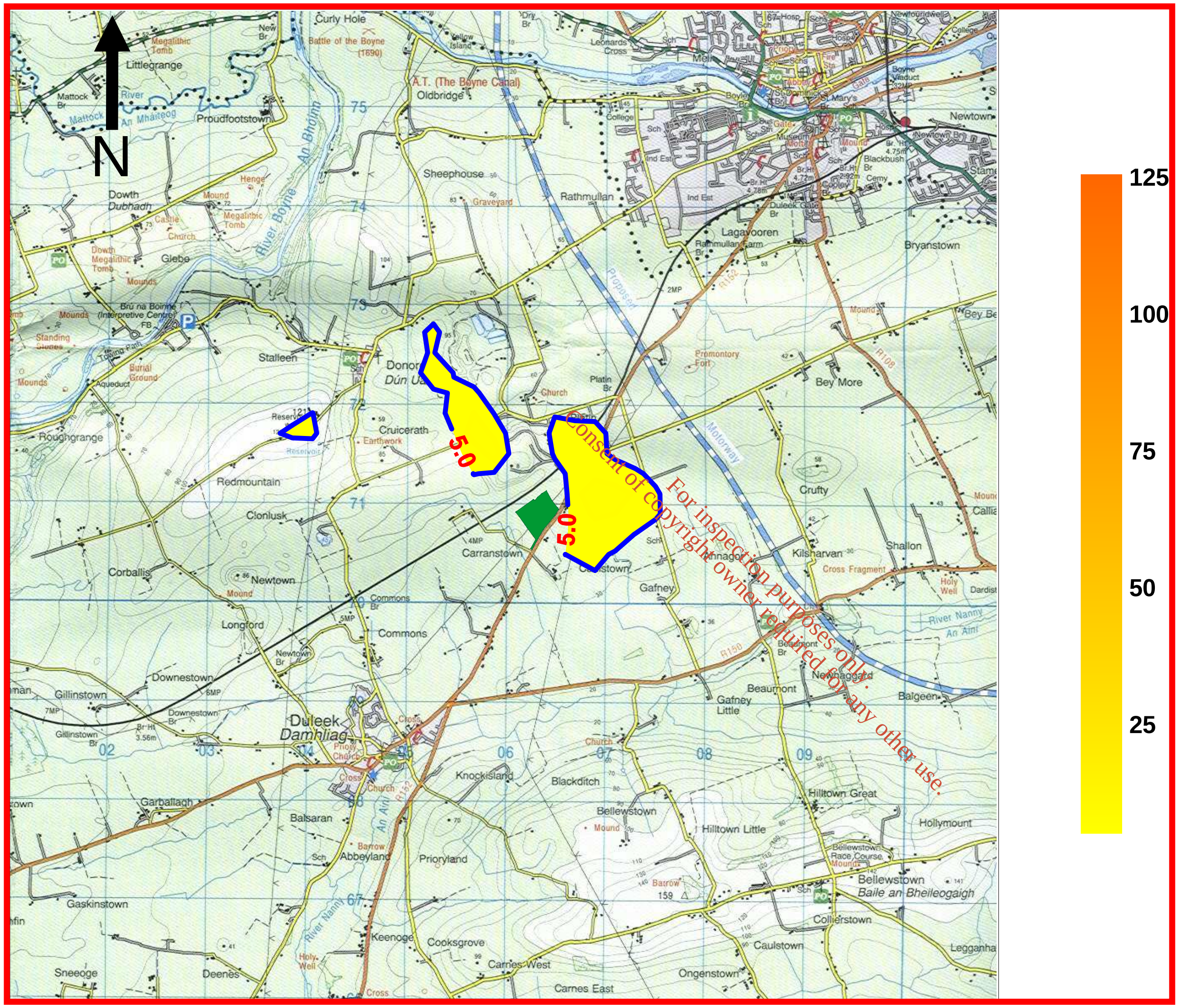

Maximum 24-Hour SO_2 Concentration
Blue Contour = 5.0 µg/m^3

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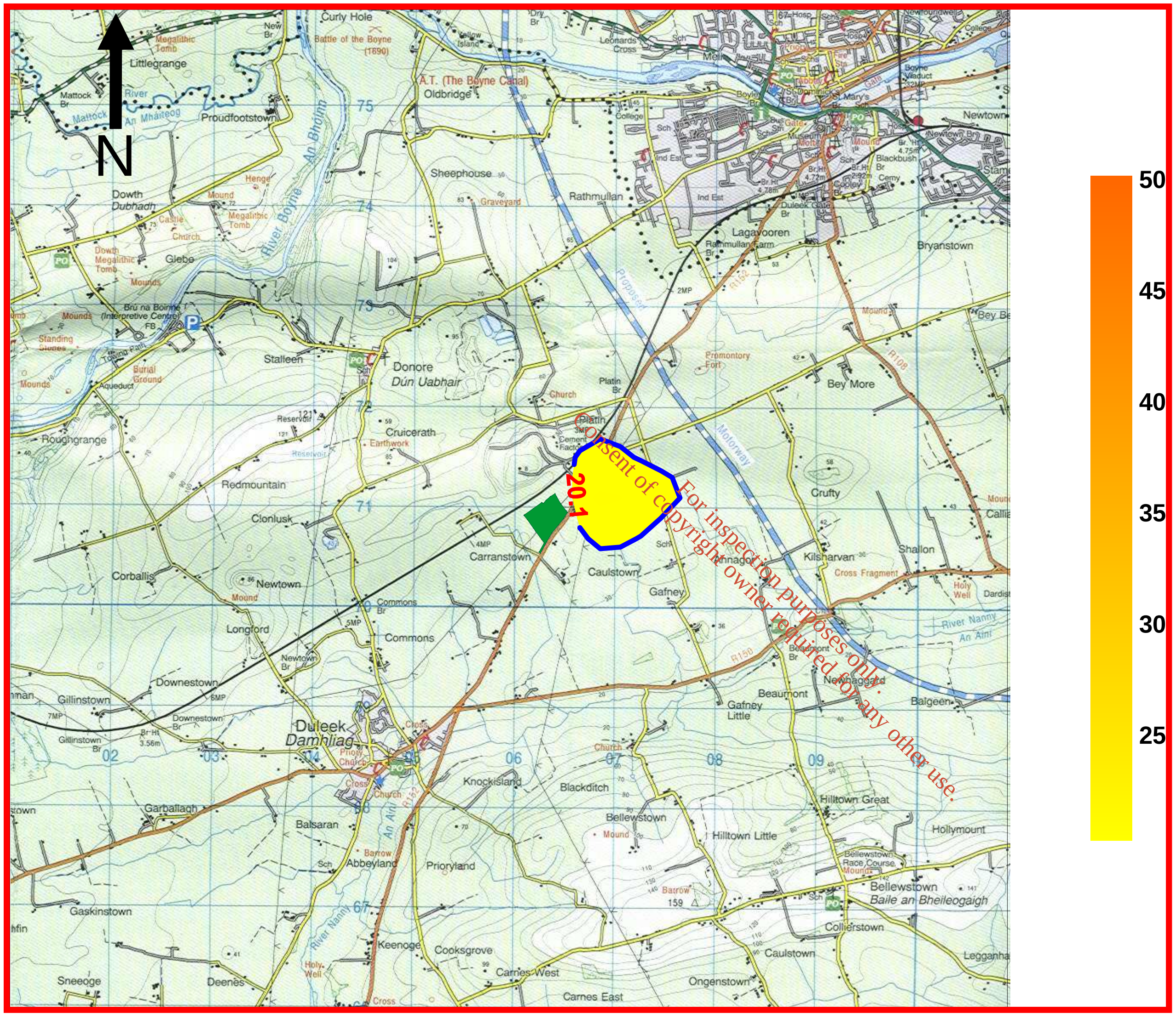
Figure 7.7

Predicted 99.2th%ile of SO_2 24-Hour Concentrations (µg/m^3)



Maximum 24-Hour PM_{10} Concentration
Blue Contour = 20.1 $\mu g/m^3$

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Figure 7.8
Predicted 90^{th}%ile of PM_{10} 24-Hour Concentrations ($\mu g/m^3$)

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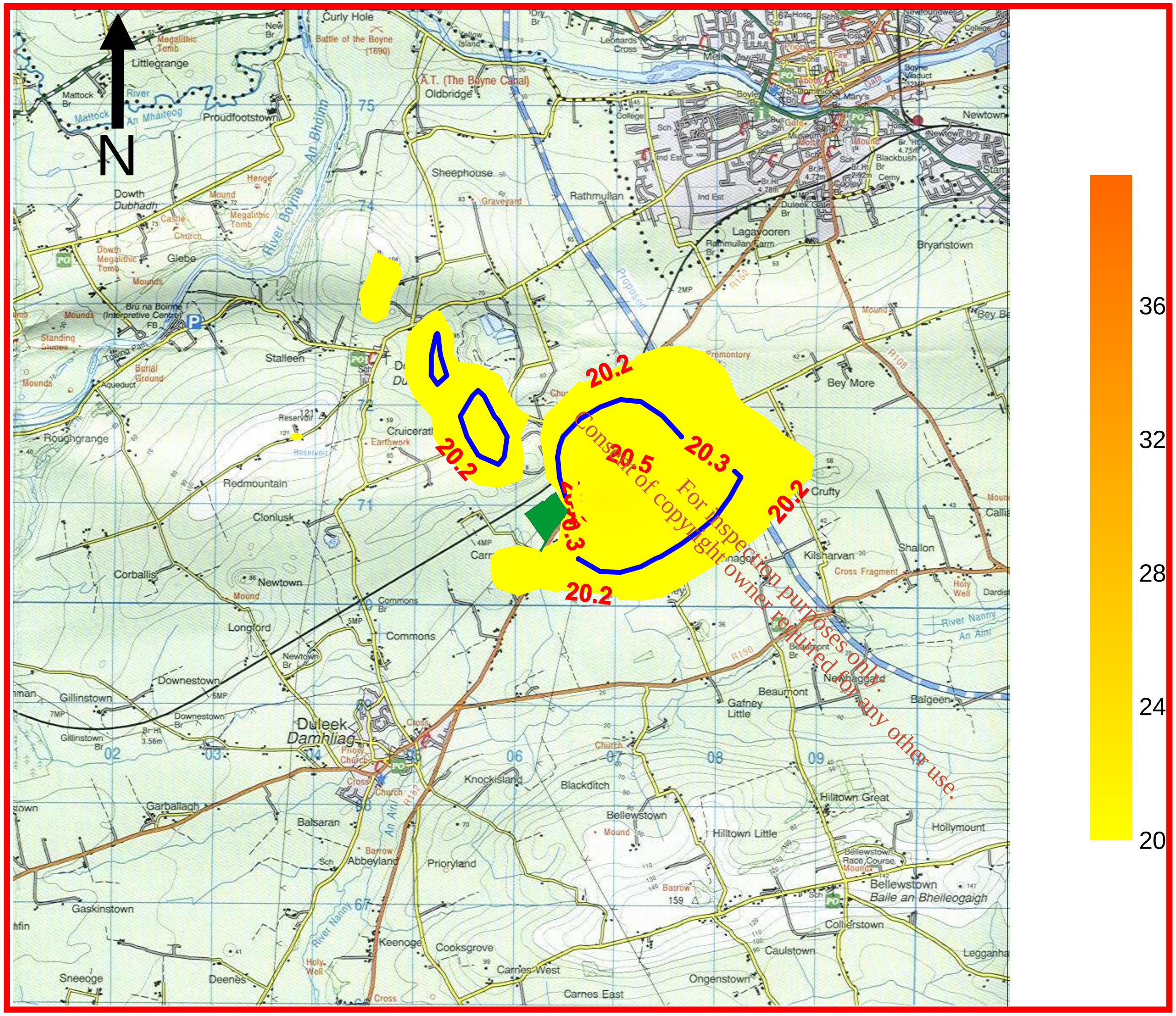

Annual Average PM_{10}
Concentration
Blue Contour = 20.3 µg/m^3

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Figure 7.9

Predicted Annual Average PM_{10} Concentrations (µg/m^3)

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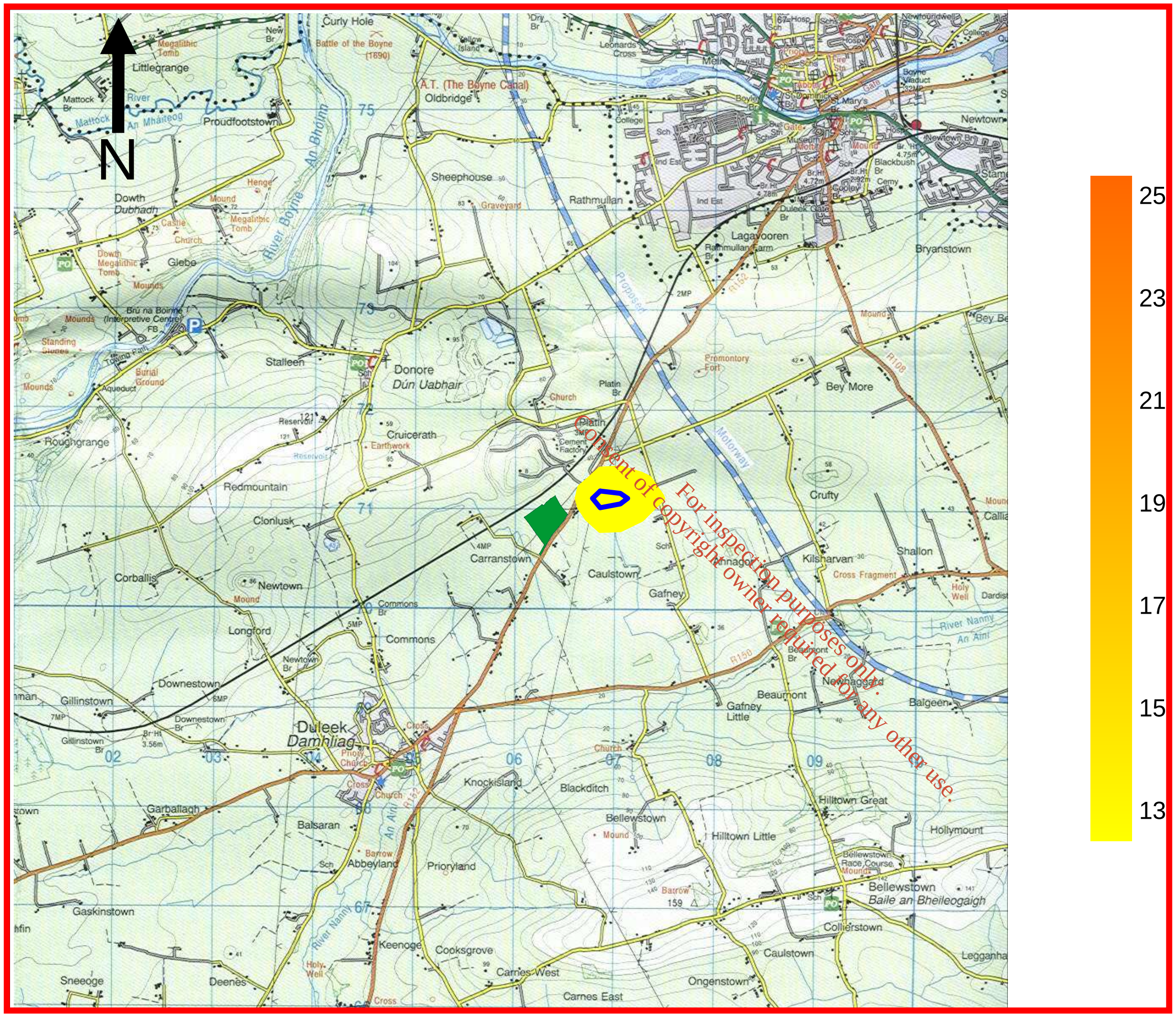

Annual Average PM$_{2.5}$
Concentration
Blue Contour = 12.06 µg/m^3

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Figure 7.10
Predicted Annual
Average PM$_{2.5}$
Concentrations (µg/m^3)

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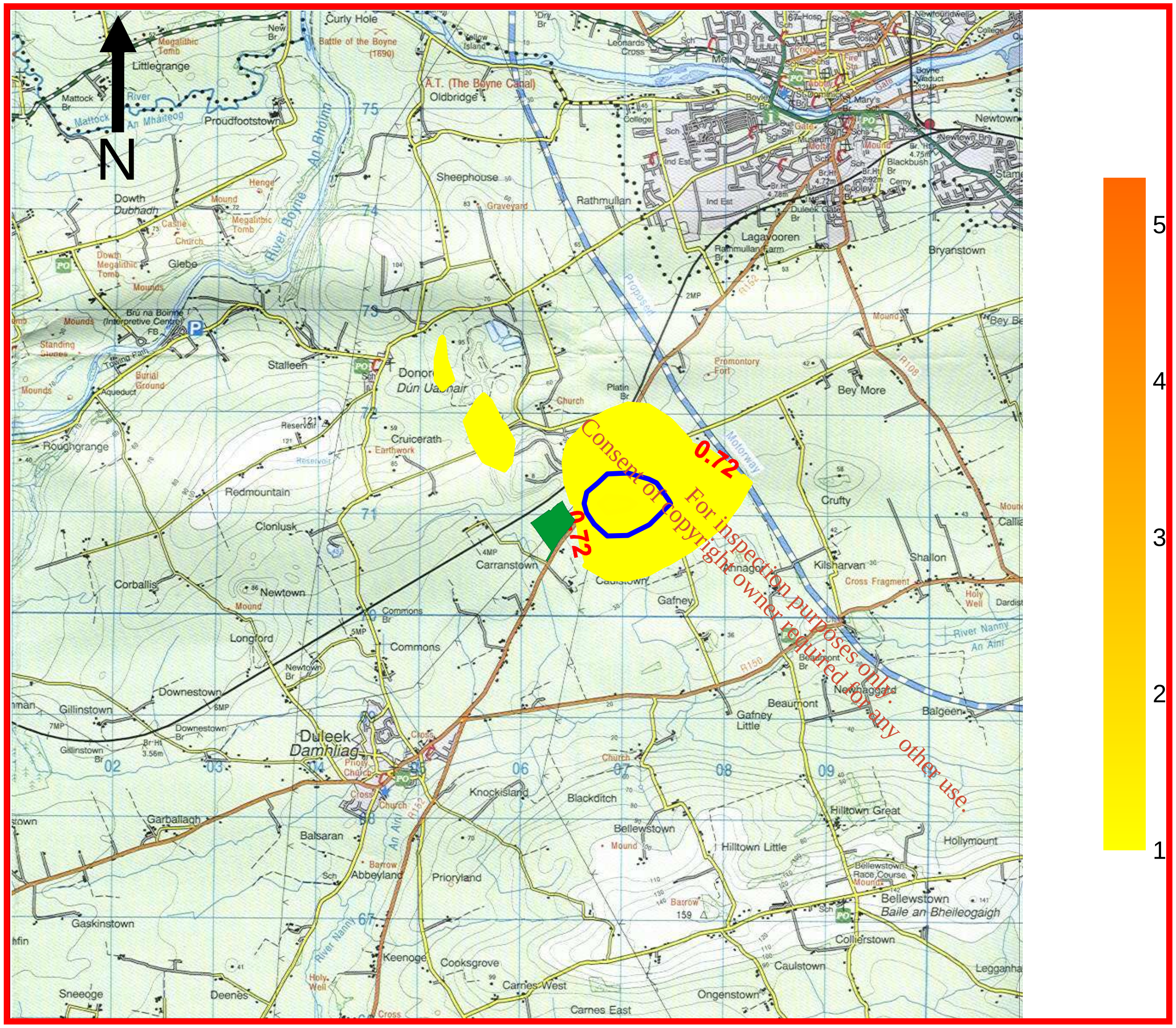

Annual Average Benzene Concentration
Blue Contour = 0.74 $\mu g/m^3$

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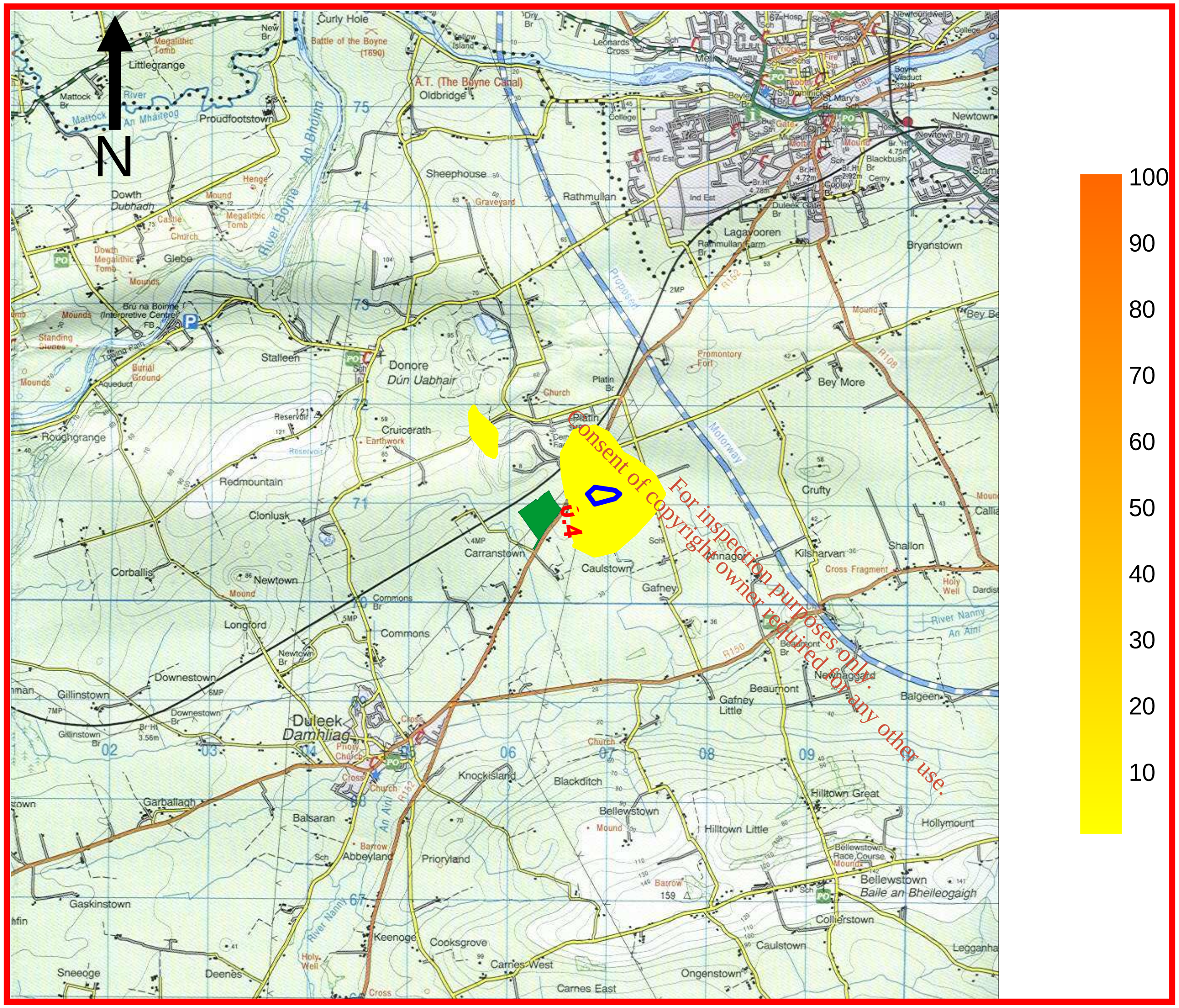
Figure 7.11
Predicted Annual Average Benzene Concentrations ($\mu g/m^3$)



Maximum 1-Hour HCl
Concentration
Blue Contour = 0.70 $\mu g/m^3$

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Figure 7.12
Predicted 98^{th}%ile of HCl
1-Hour Concentrations
($\mu g/m^3$)

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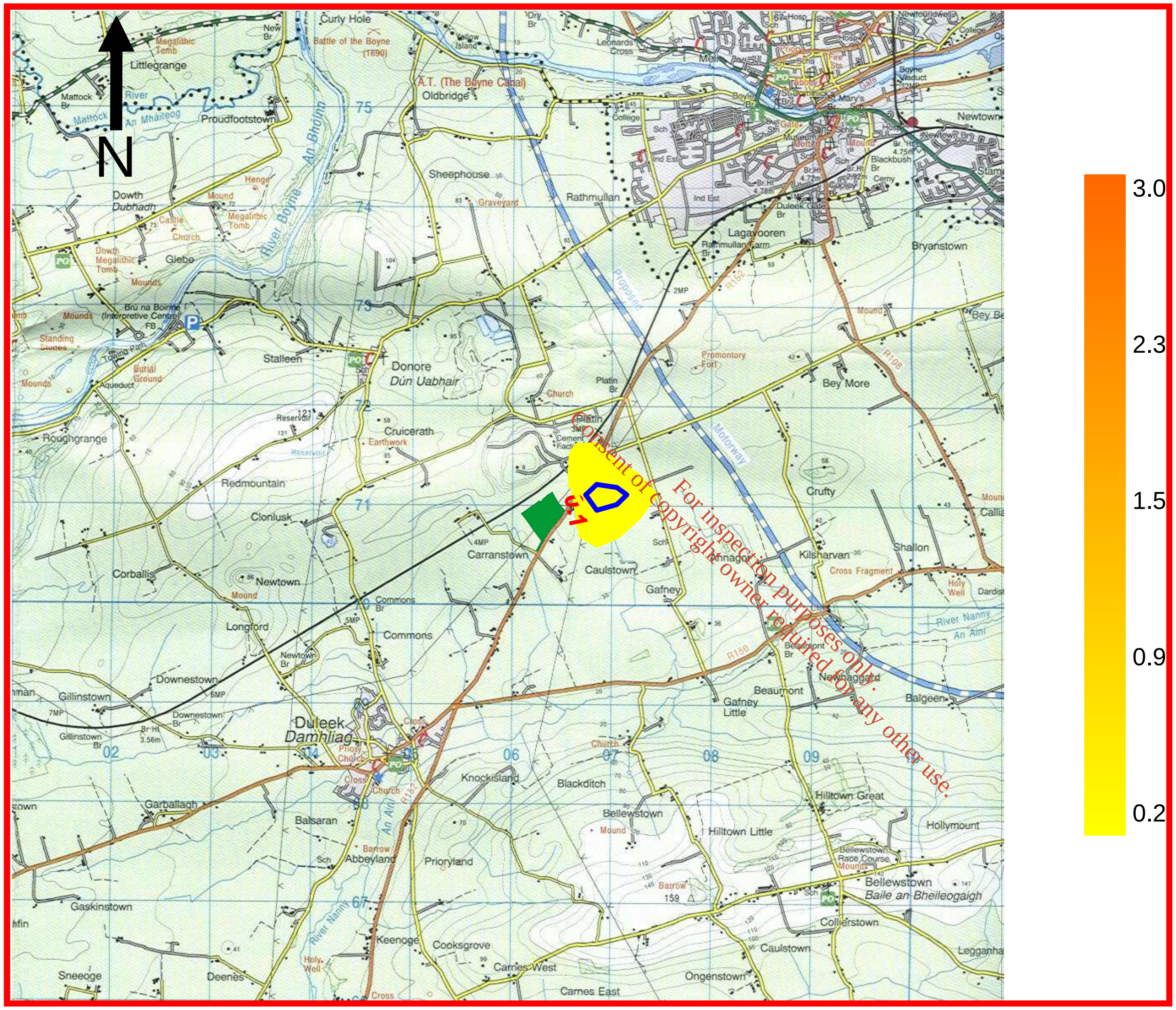

Maximum 1-Hour HF
Concentration
Blue Contour = 0.07 µg/m^3

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Scale 1:70,000 approx

Project

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Reference

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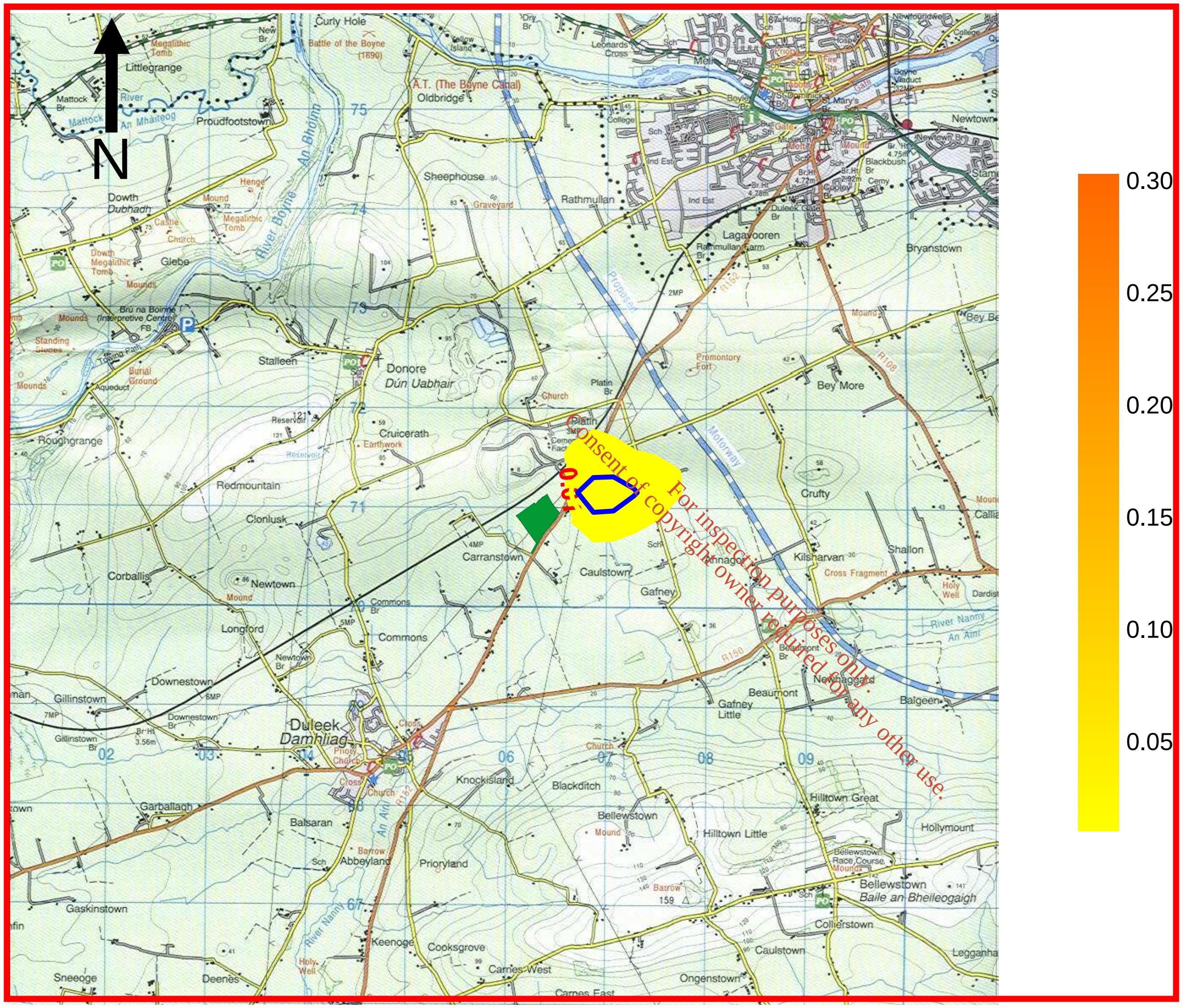
Figure 7.13

Predicted 98th%ile of HF 1-Hour Concentrations (µg/m^3)



Annual Average HF
Concentration
Blue Contour = 0.010 $\mu g/m^3$

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Scale 1:70,000 approx

Project
Carranstown WTE
Facility

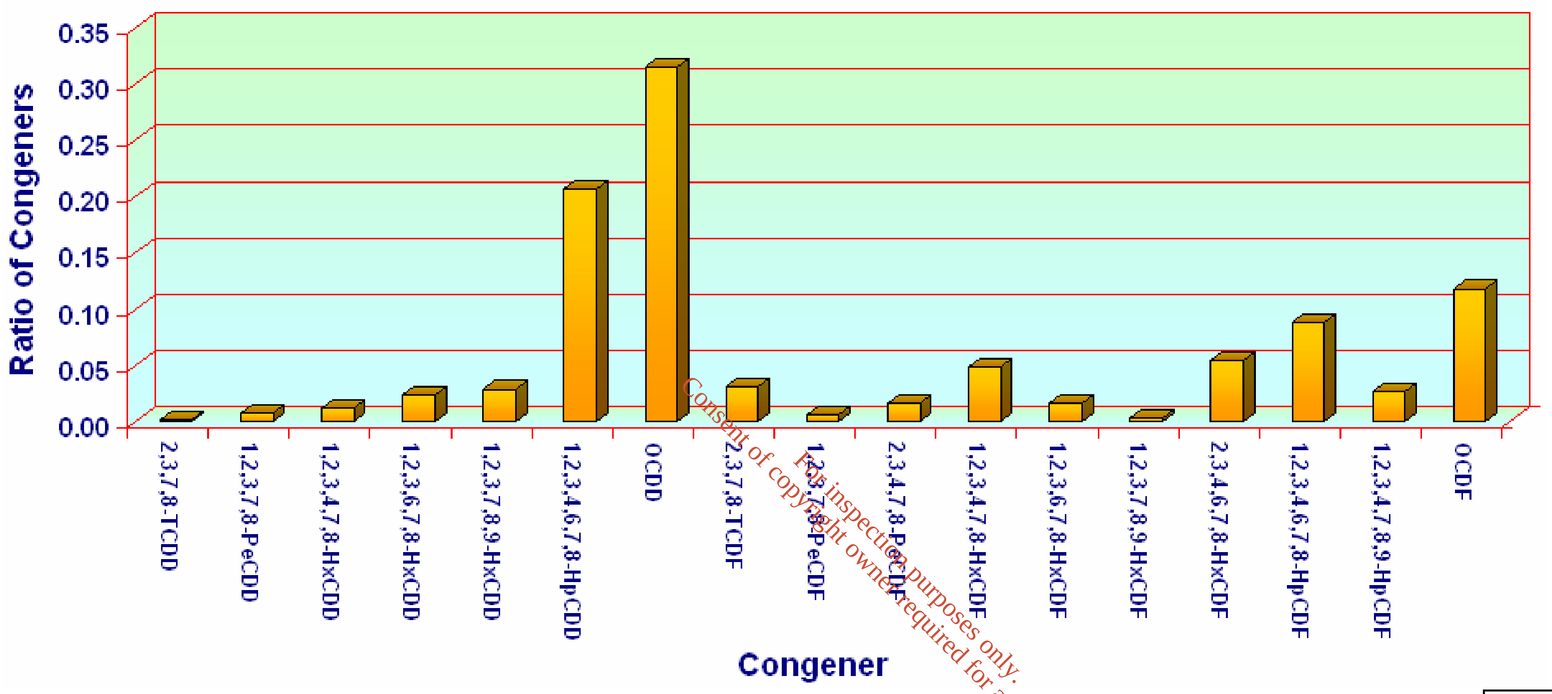
Reference
05_2624AR01

Figure 7.14
Predicted Annual
Average HF
Concentrations ($\mu g/m^3$)

awn
consulting

The Tecpro Building, Clonshaugh Industrial Estate, Dublin 17. Tel: +353 (0)1 847 4220 Fax: +353 (0)1 847 4257

Figure 7.15 - Default MWI (MS-Ref WS) Congener Profile



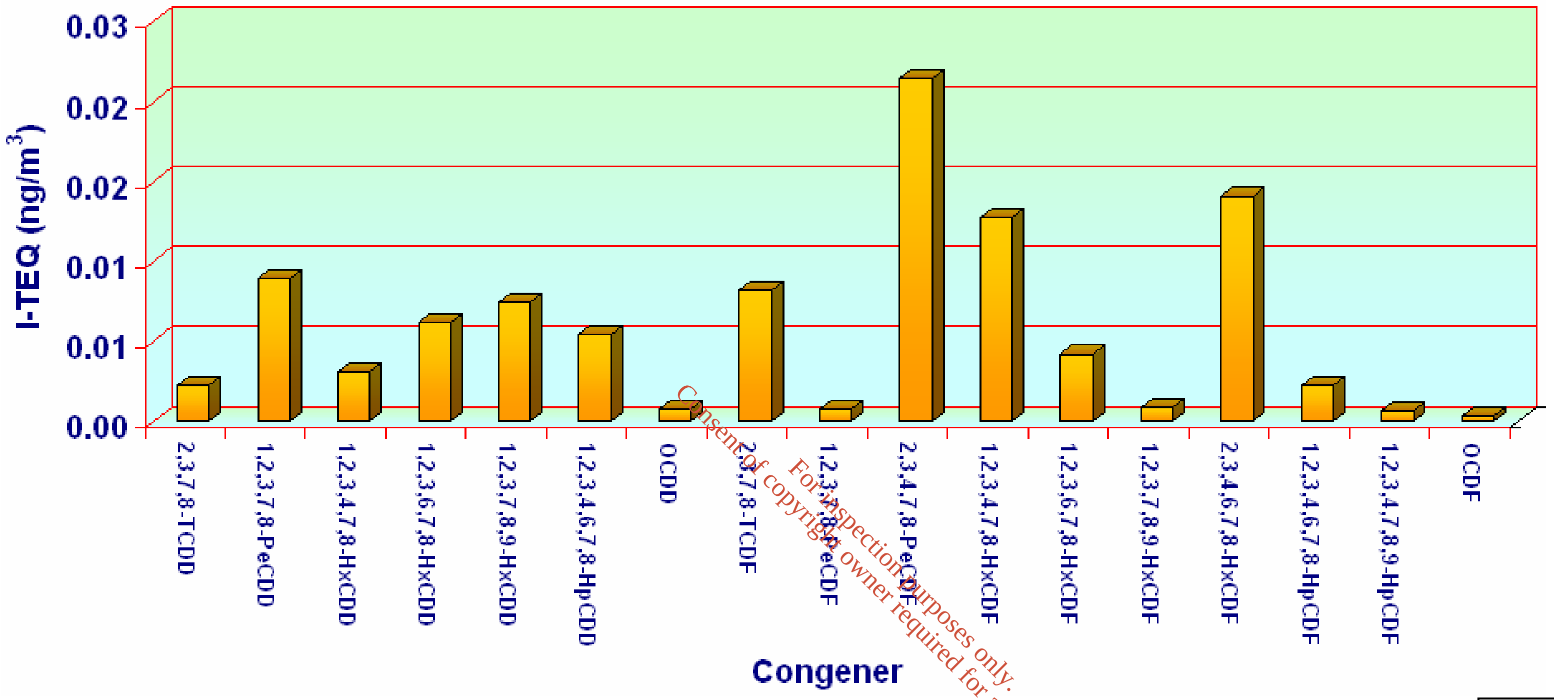
Project
Carranstown WTE Facility

Reference
05_2624AR01

Figure 7.15
Default MWI (MS-Ref WS) Dioxin Congener Profile

awn
consulting

Figure 7.16 - Default MWI TEQ Equivalent Release Corrected To 0.1 ng/m^3



Project
Carranstown WTE
Facility

Reference
05_2624AR01

Figure 7.16
Default MWI TEQ
Equivalent Release
Corrected to 0.1ng/m^3

awn
consulting

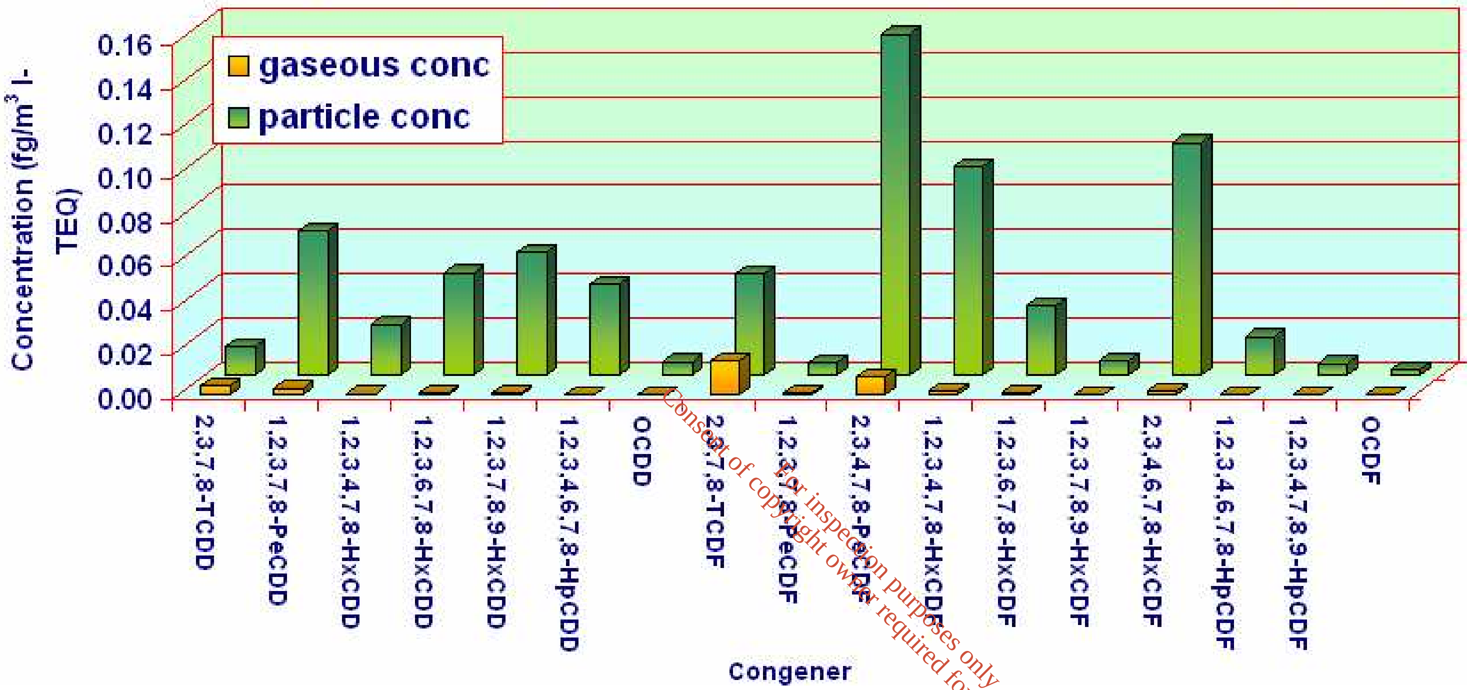


Figure 7.17 - Vapour and Particulate Congener Concentration (fg/m^3)

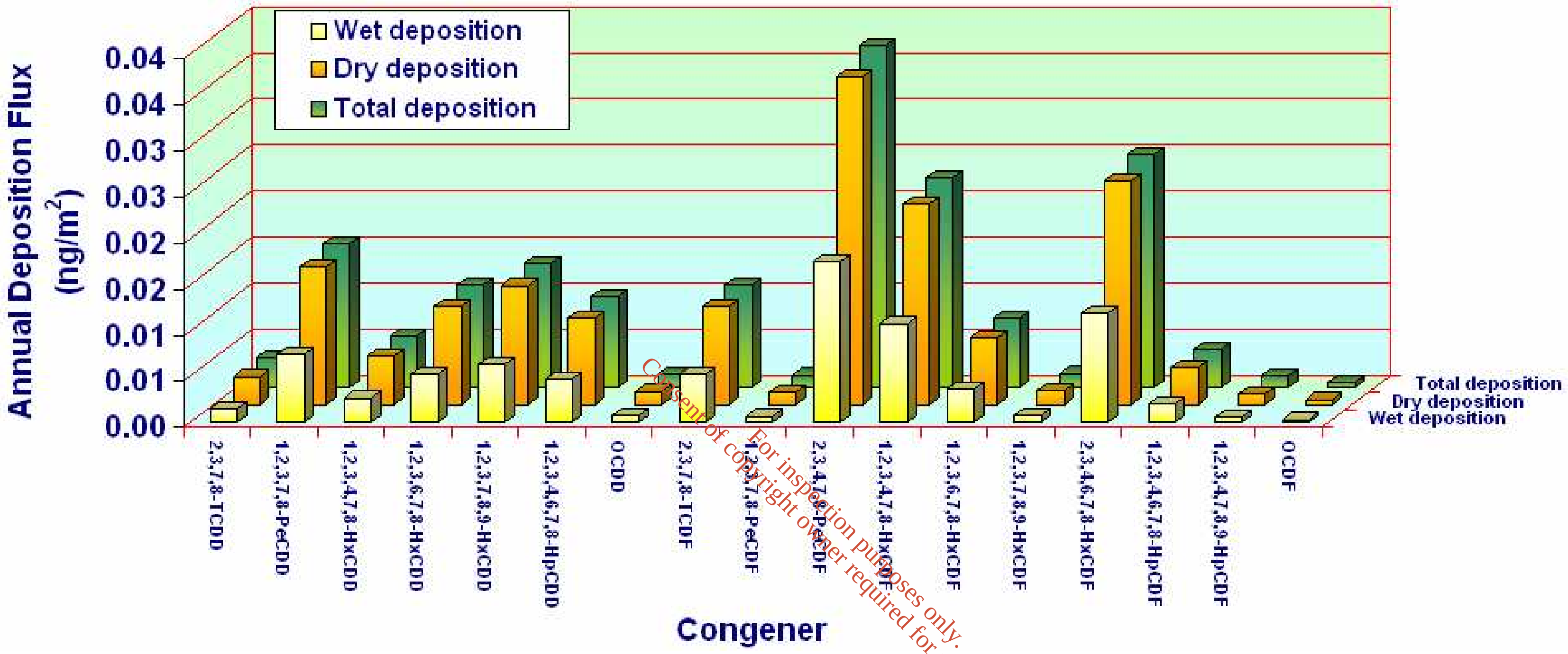
Project
Carranstown WTE Facility

Reference
05_2624AR01

Figure 7.17
Vapour & Particulate Congener Concentration (fg/m^3) Under Maximum Operations

awn
consulting

Figure 7.18 - Particulate Congener Deposition (ng/m^2) Under Maximum Operations



Project

Carranstown WTE Facility

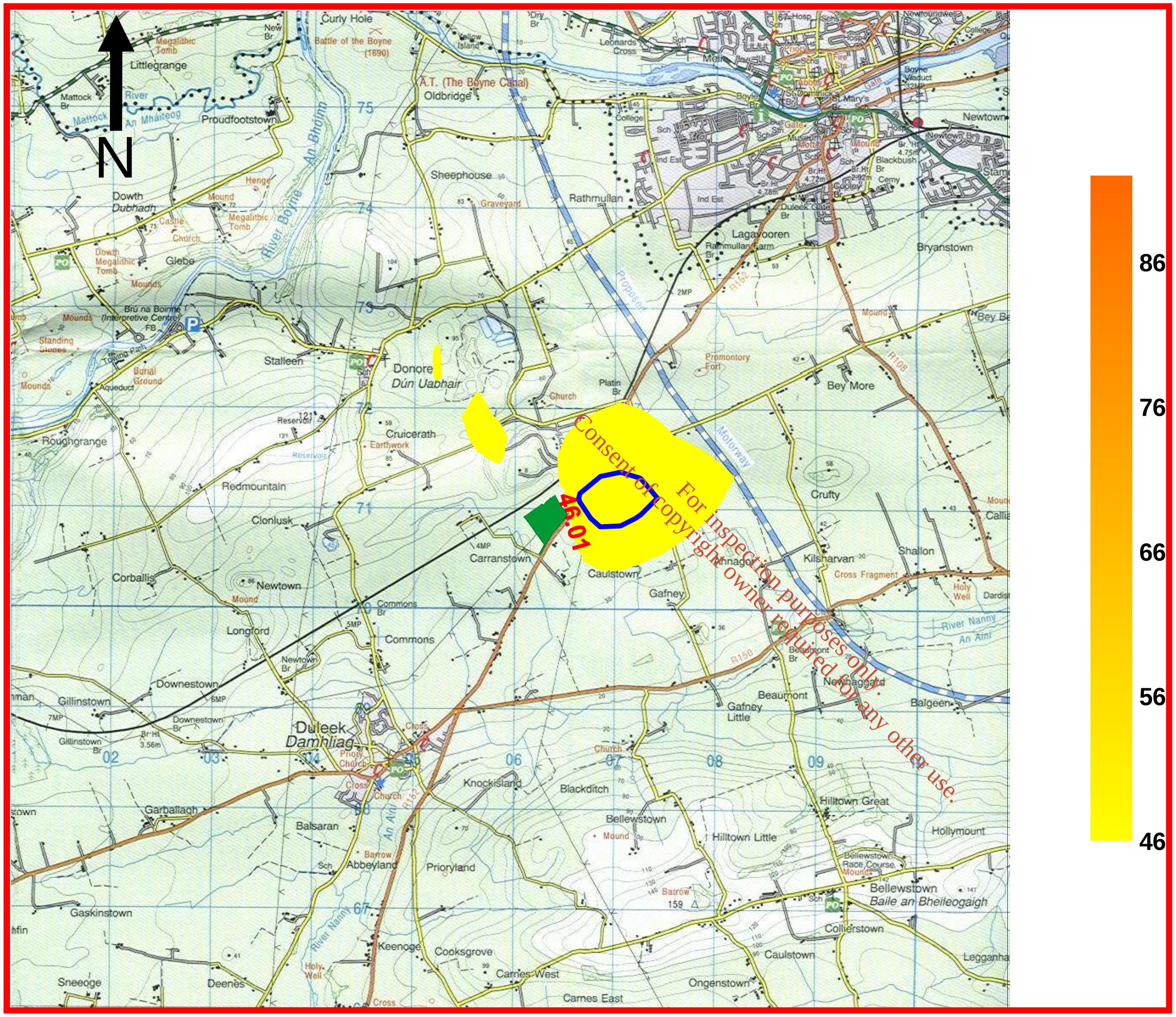
Reference

05_2624AR01

Figure 7.18

Particulate Congener Deposition (ng/m^2) Under Maximum Operations

awn consulting



Annual Average Dioxin
Vapour Concentration
Blue Contour = 46.02 fg/m^3

Reproduced from
Ordnance Survey
Ireland
Permit No: EN 7505

Scale 1:70,000 approx

Project

Carranstown WTE
Facility

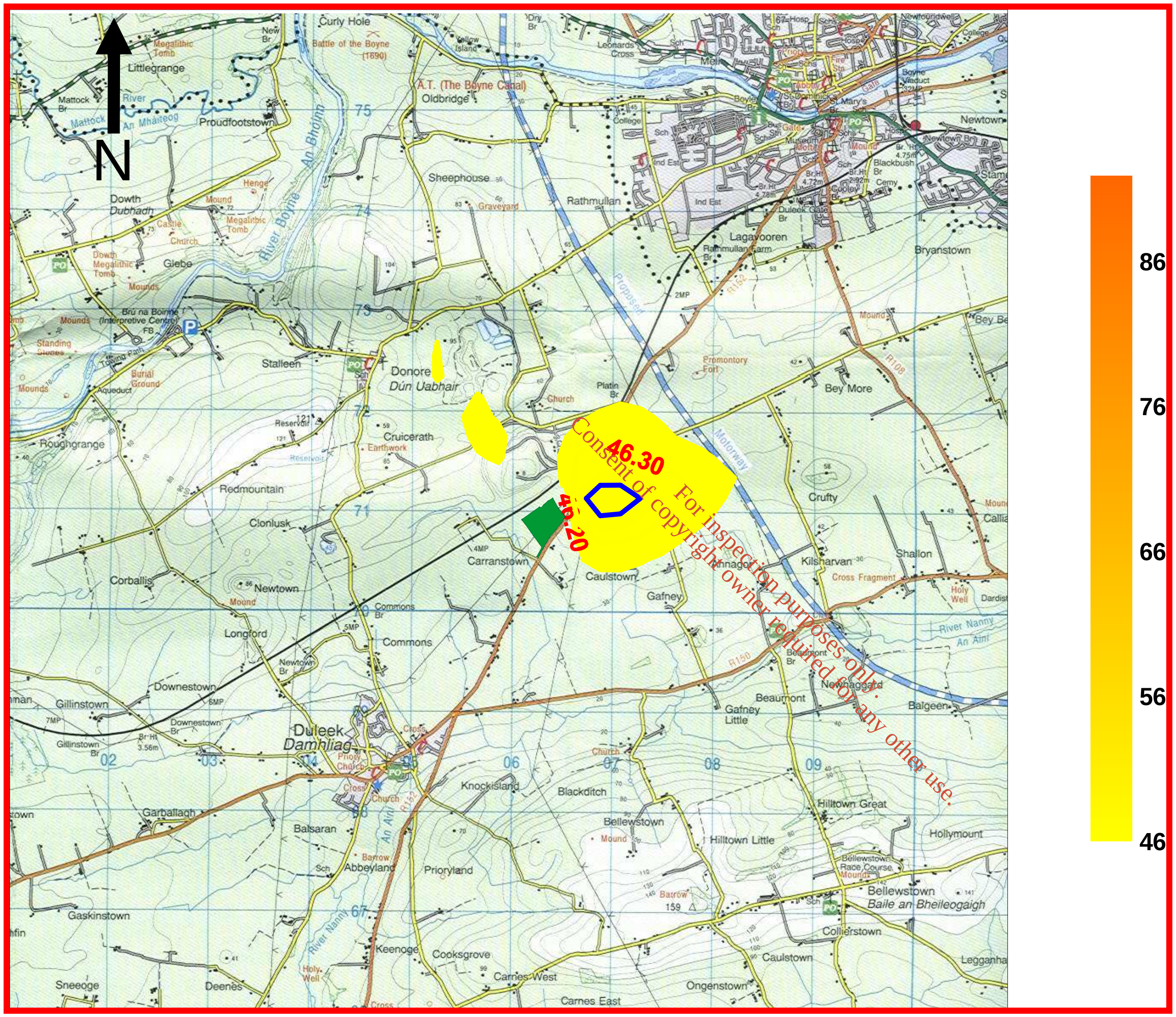
Reference

05_2624AR01

Figure 7.19

Predicted Annual
Average Dioxin Vapour
Concentrations (fg/m^3)

awn
consulting



Annual Average Dioxin Particulate Concentration
Blue Contour = 46.5 fg/m^3

Reproduced from Ordnance Survey Ireland
Permit No: EN 7505

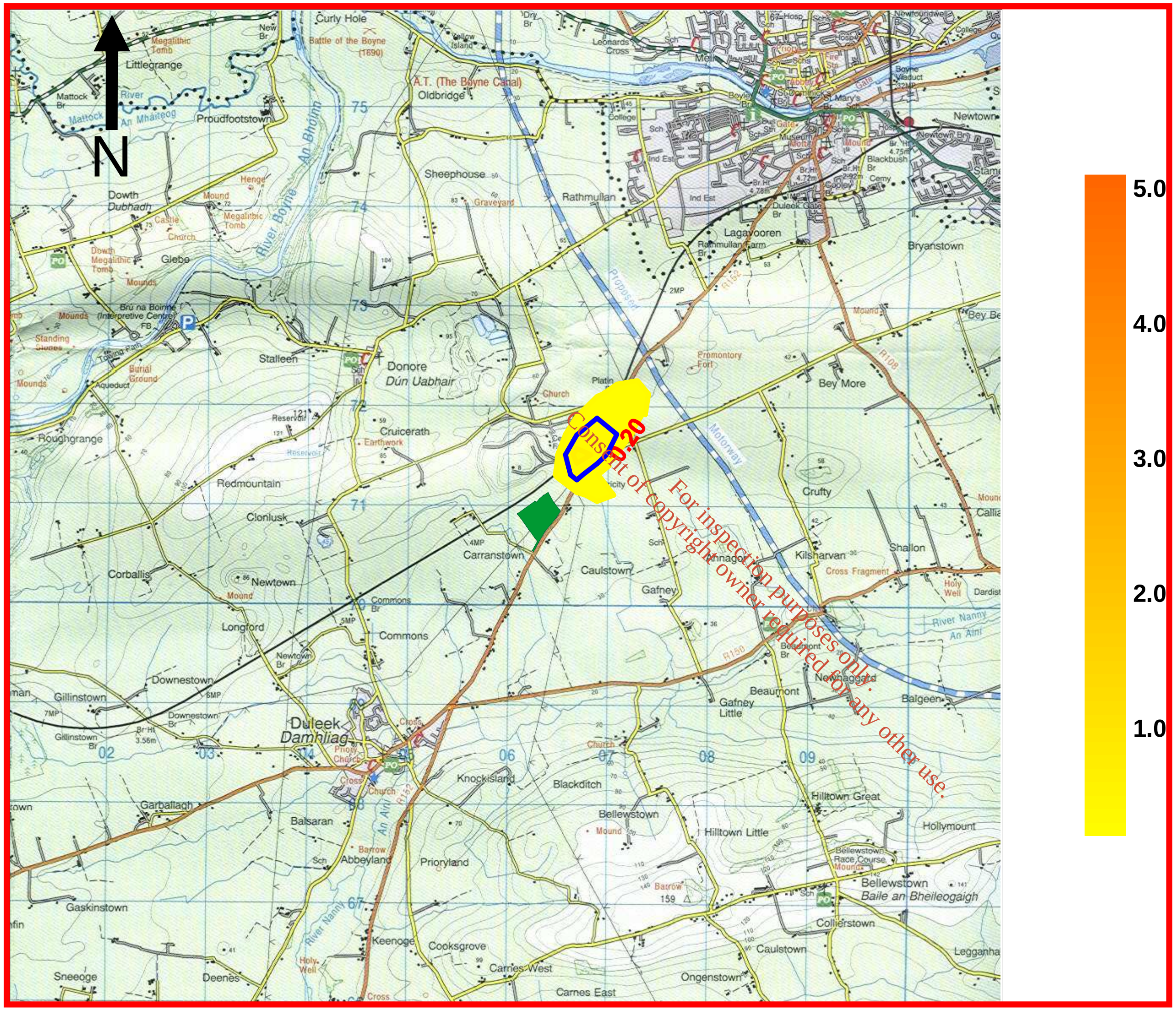
Scale 1:70,000 approx

Project
Carranstown WTE Facility

Reference
05_2624AR01

Figure 7.20
Predicted Annual Average Dioxin Particulate Concentrations (fg/m^3)

awn
consulting



Annual Average Dioxin Particulate Deposition Flux
Blue Contour = 0.3 pg/m²/day

Reproduced from Ordnance Survey Ireland
Permit No: EN 7505

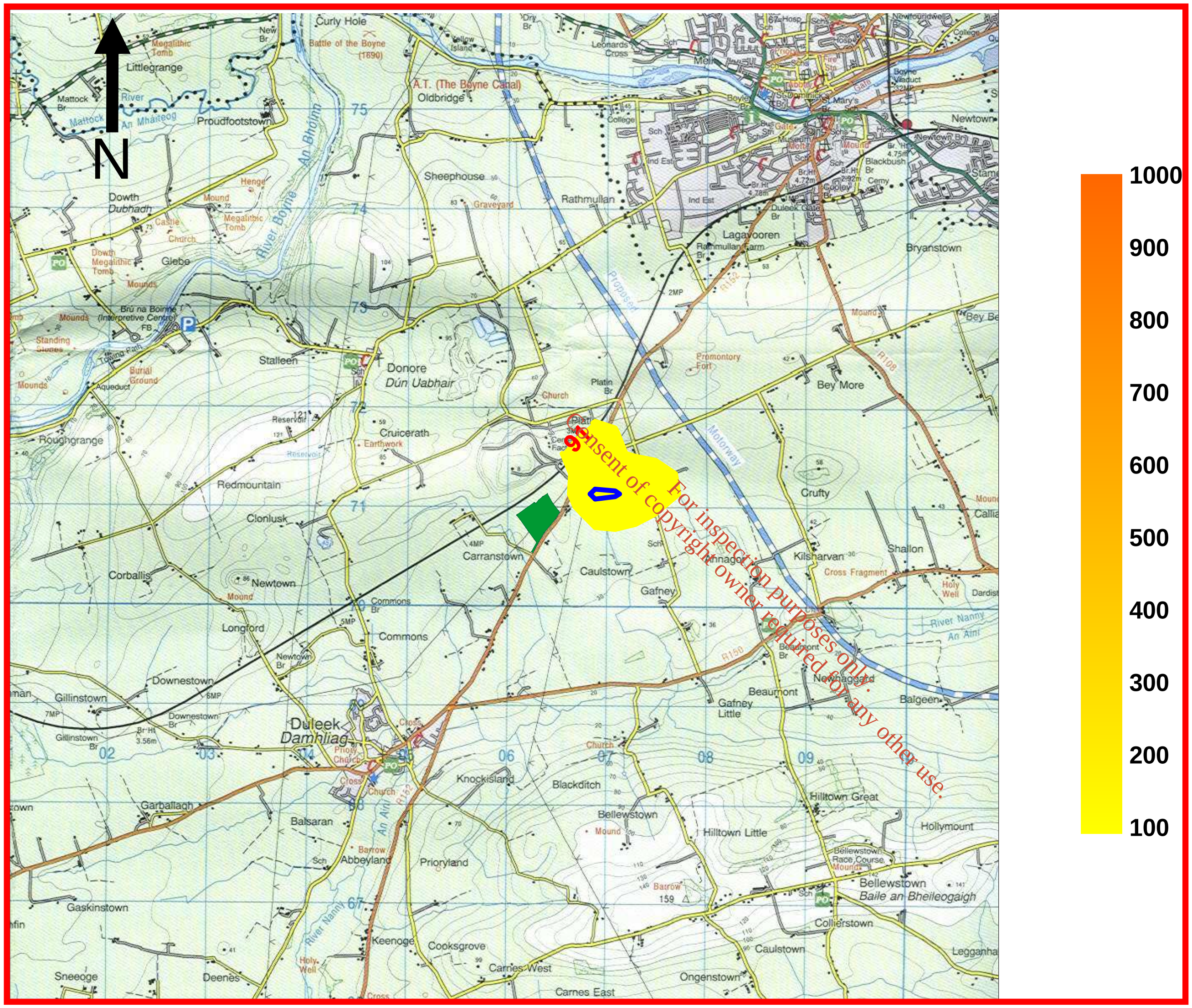
Scale 1:70,000 approx

Project
Carranstown WTE Facility

Reference
05_2624AR01

Figure 7.21
Predicted Annual Average Dioxin Particulate Deposition Flux (pg/m²/day)

awn consulting



Annual Average B[a]P
Particulate Concentration
Blue Contour = 92 pg/m^3

Reproduced from
Ordnance Survey
Ireland
Permit No: EN 7505

Scale 1:70,000 approx

Project

Carranstown WTE Facility

Reference

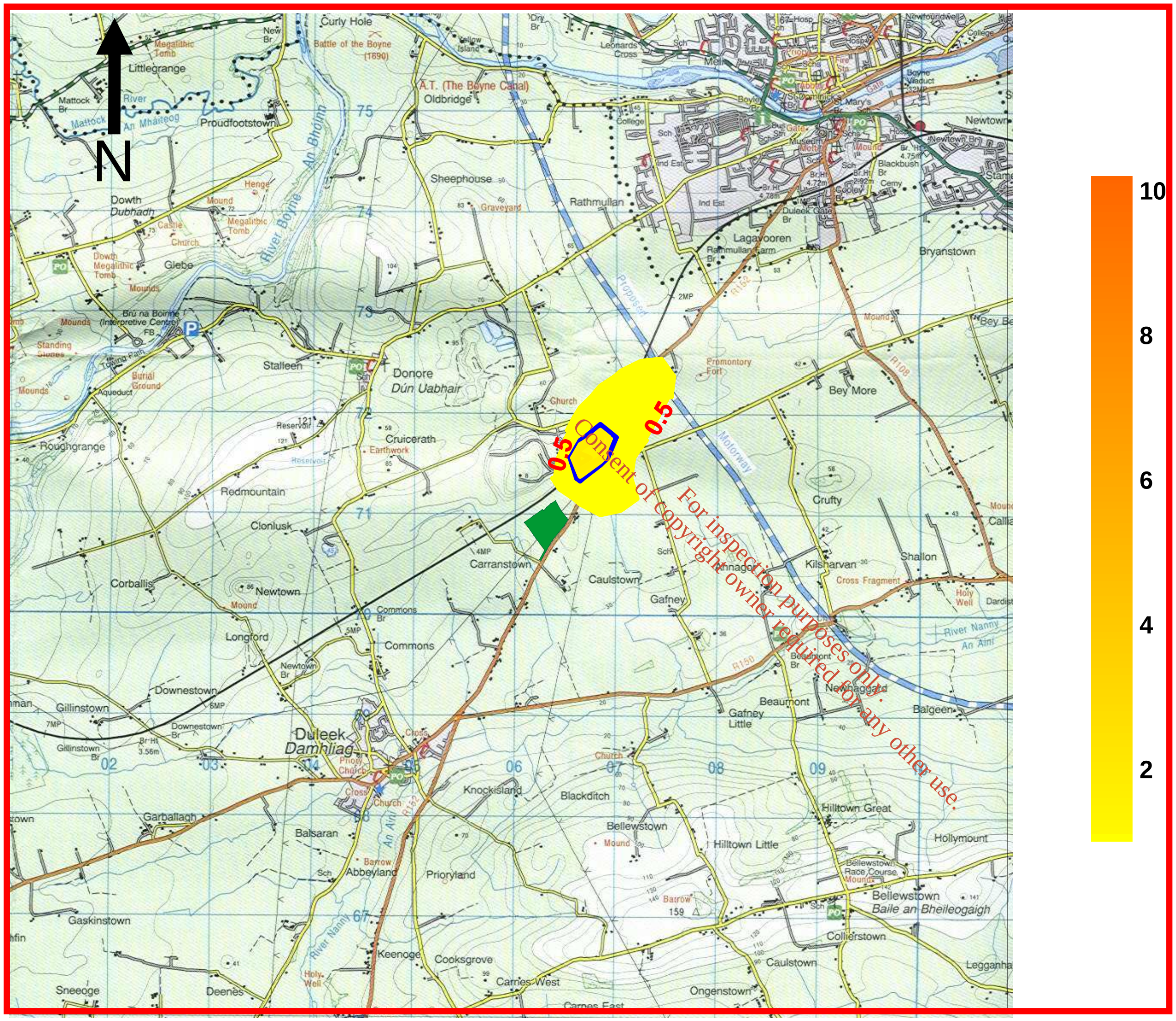
05_2624AR01

Figure 7.22

Predicted Annual Average B[a]P Particulate Concentration (pg/m^3)

awn
consulting

The Tecpro Building, Clonshaugh Industrial Estate, Dublin 17. Tel: +353 (0)1 847 4220 Fax: +353 (0)1 847 4257



Annual Average B[a]P
Particulate Deposition Flux
Blue Contour = 1.0 ng/m^2/day

Reproduced from
Ordnance Survey
Ireland
Permit No: EN 7505

Scale 1:70,000 approx

Project

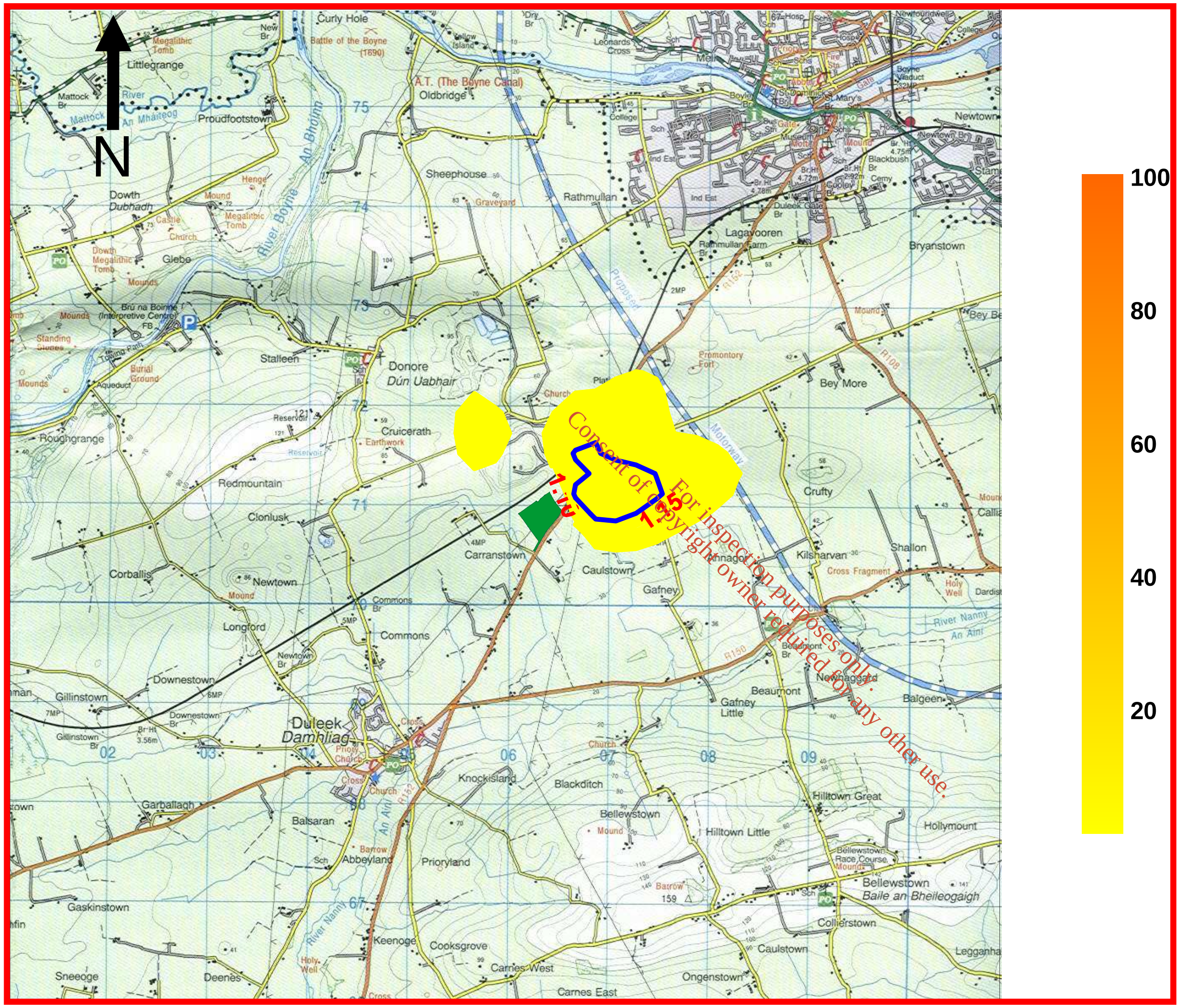
Carranstown WTE Facility

Reference

05_2624AR01

Figure 7.23

Predicted Annual Average Dioxin Particulate Deposition Flux (ng/m^2/day)



Annual Average Mercury
Concentration
Blue Contour = 1.2 ng/m^3

Reproduced from
Ordnance Survey
Ireland
Permit No: EN 7505

Scale 1:70,000 approx

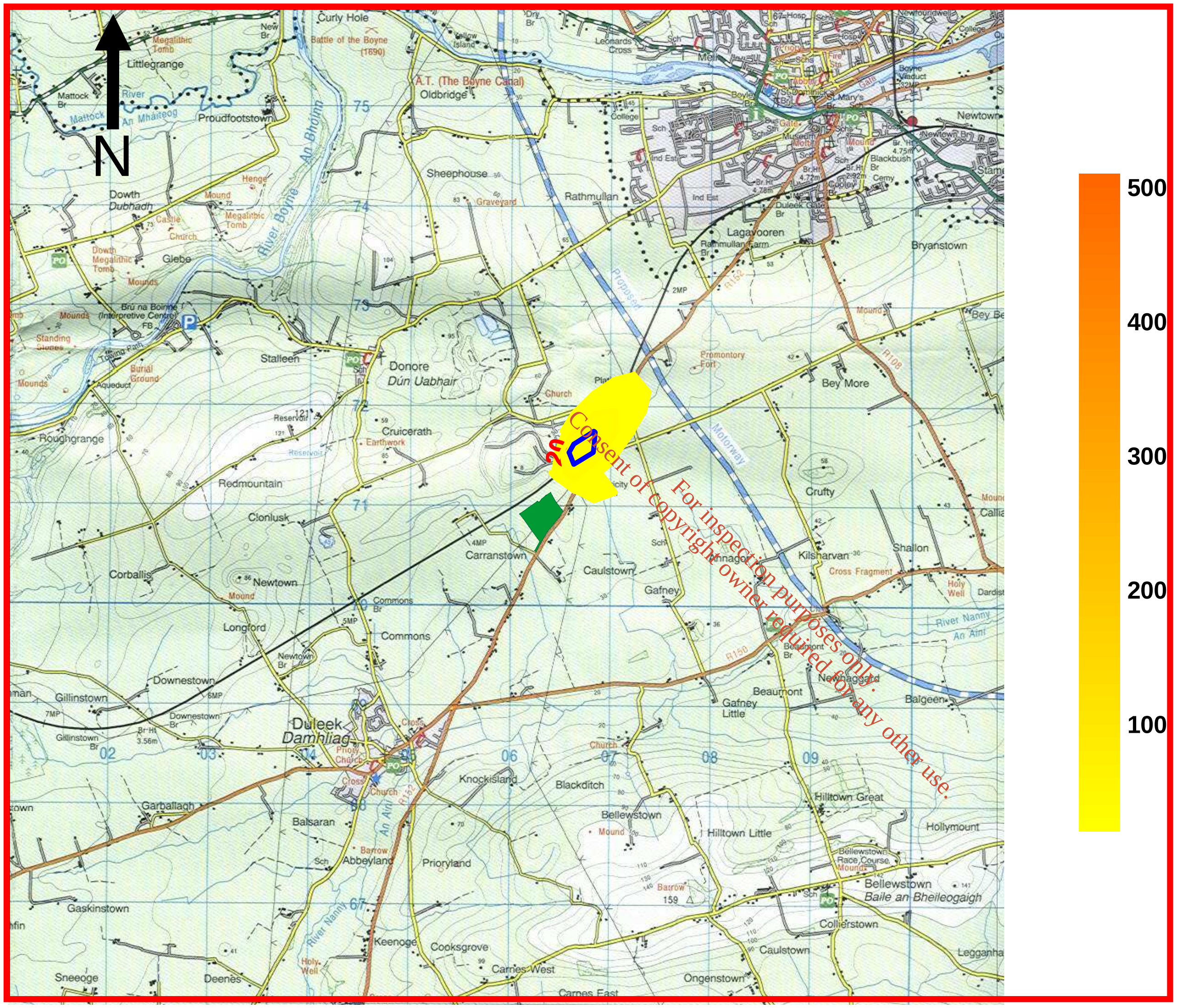
Project
Carranstown WTE
Facility

Reference
05_2624AR01

Figure 7.24
Predicted Annual
Average Mercury
Concentration (ng/m^3)

awn
consulting

The Tecpro Building, Clonshaugh Industrial Estate, Dublin 17. Tel: +353 (0)1 847 4220 Fax: +353 (0)1 847 4257



Annual Average Mercury Particulate Deposition Flux
Blue Contour = 40 ng/m^2/day

Reproduced from Ordnance Survey Ireland
Permit No: EN 7505

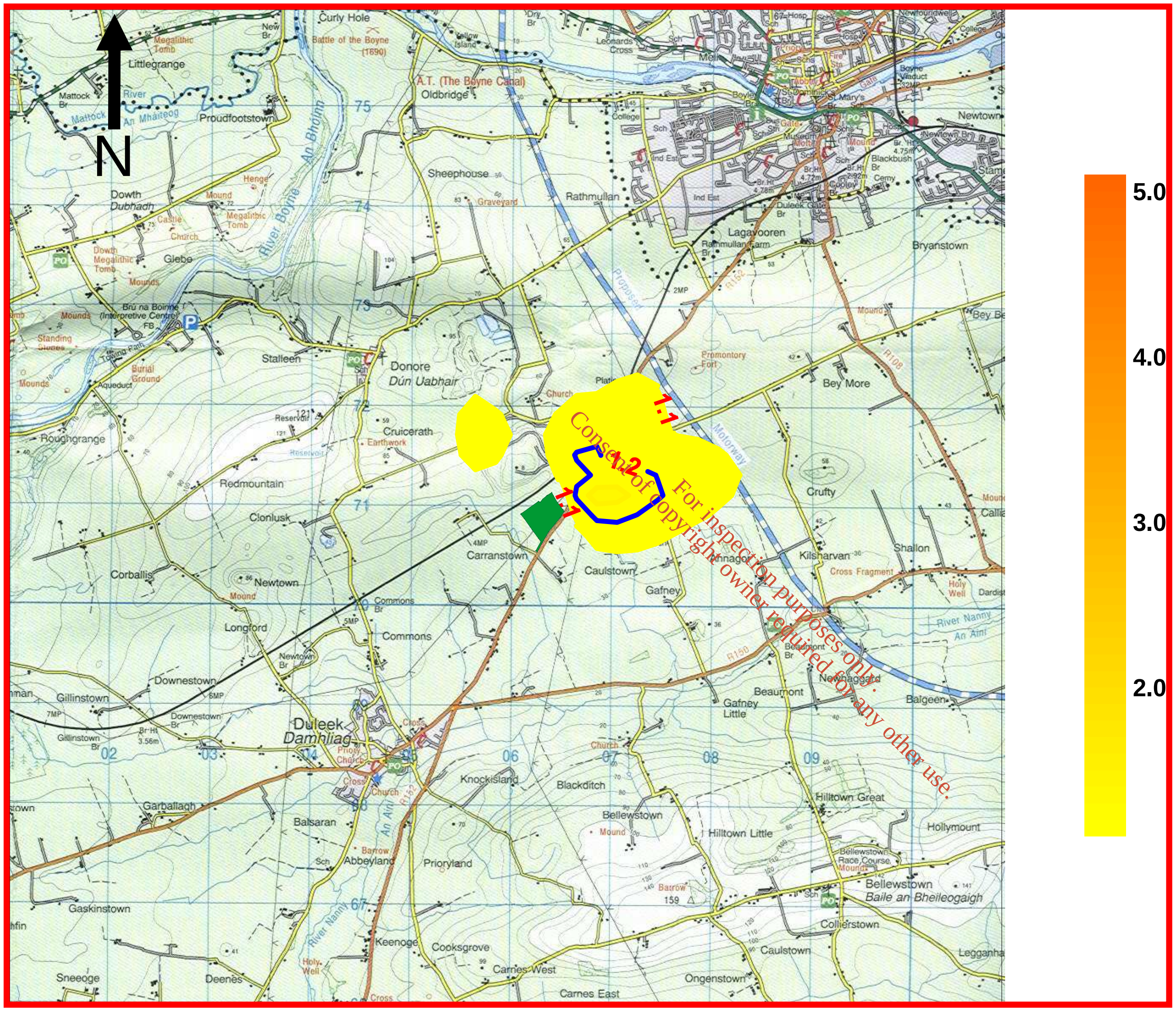
Scale 1:70,000 approx

Project
Carranstown WTE Facility

Reference
05_2624AR01

Figure 7.25
Predicted Annual Average Mercury Particulate Deposition Flux (ng/m^2/day)

awn consulting



Annual Average Cadmium Concentration
Blue Contour = 1.2 ng/m^3

Reproduced from Ordnance Survey Ireland
Permit No: EN 7505

Scale 1:70,000 approx

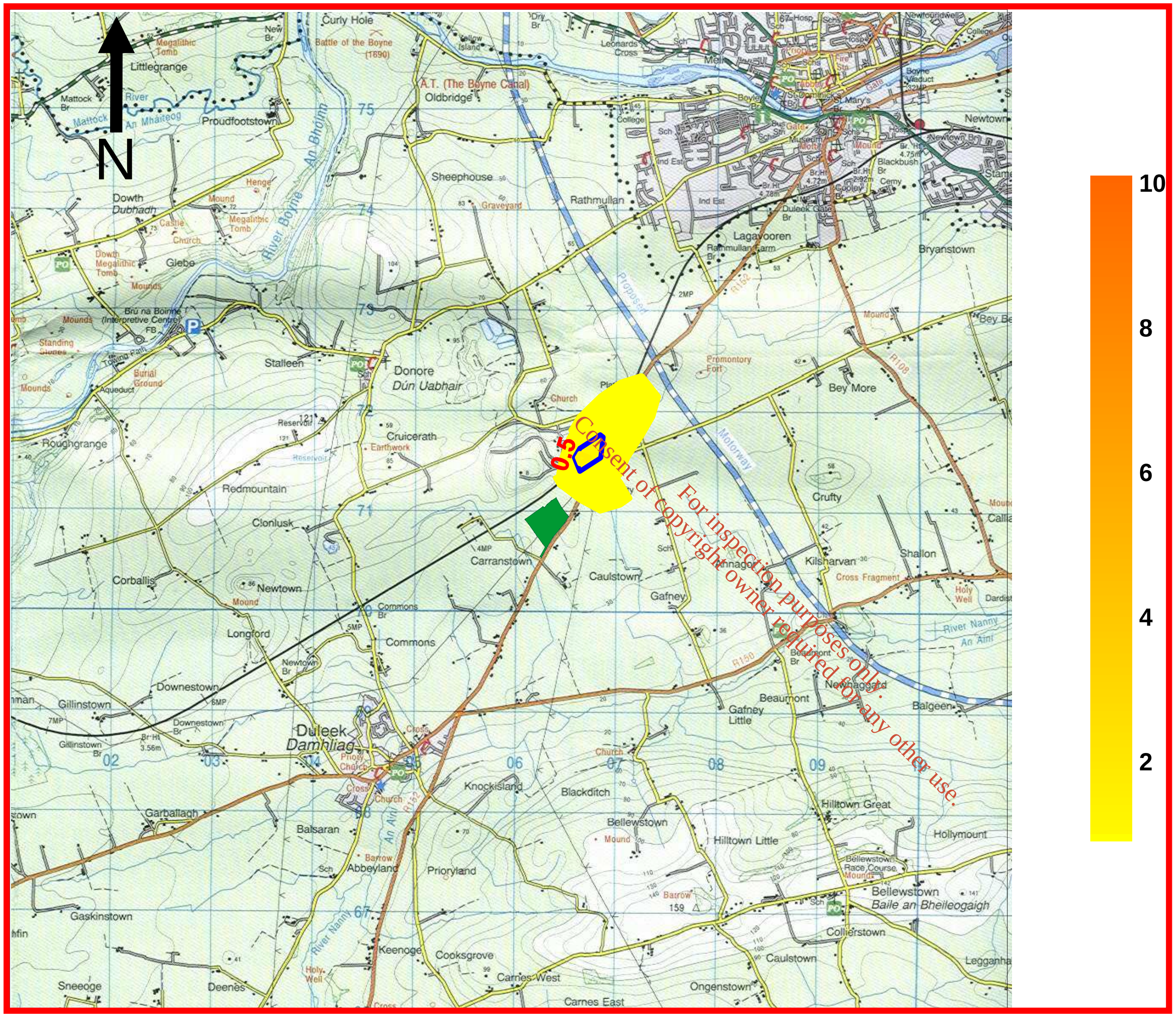
Project
Carranstown WTE Facility

Reference
05_2624AR01

Figure 7.26
Predicted Annual Average Cadmium Concentration (ng/m^3)

awn consulting

The Tecpro Building, Clonshaugh Industrial Estate, Dublin 17. Tel: +353 (0)1 847 4220 Fax: +353 (0)1 847 4257



Annual Average Cadmium
Deposition Flux
Blue Contour = 1.0 ng/m²/day

Reproduced from
Ordnance Survey
Ireland
Permit No: EN 7505

Scale 1:70,000 approx

Project

Carranstown WTE
Facility

Reference

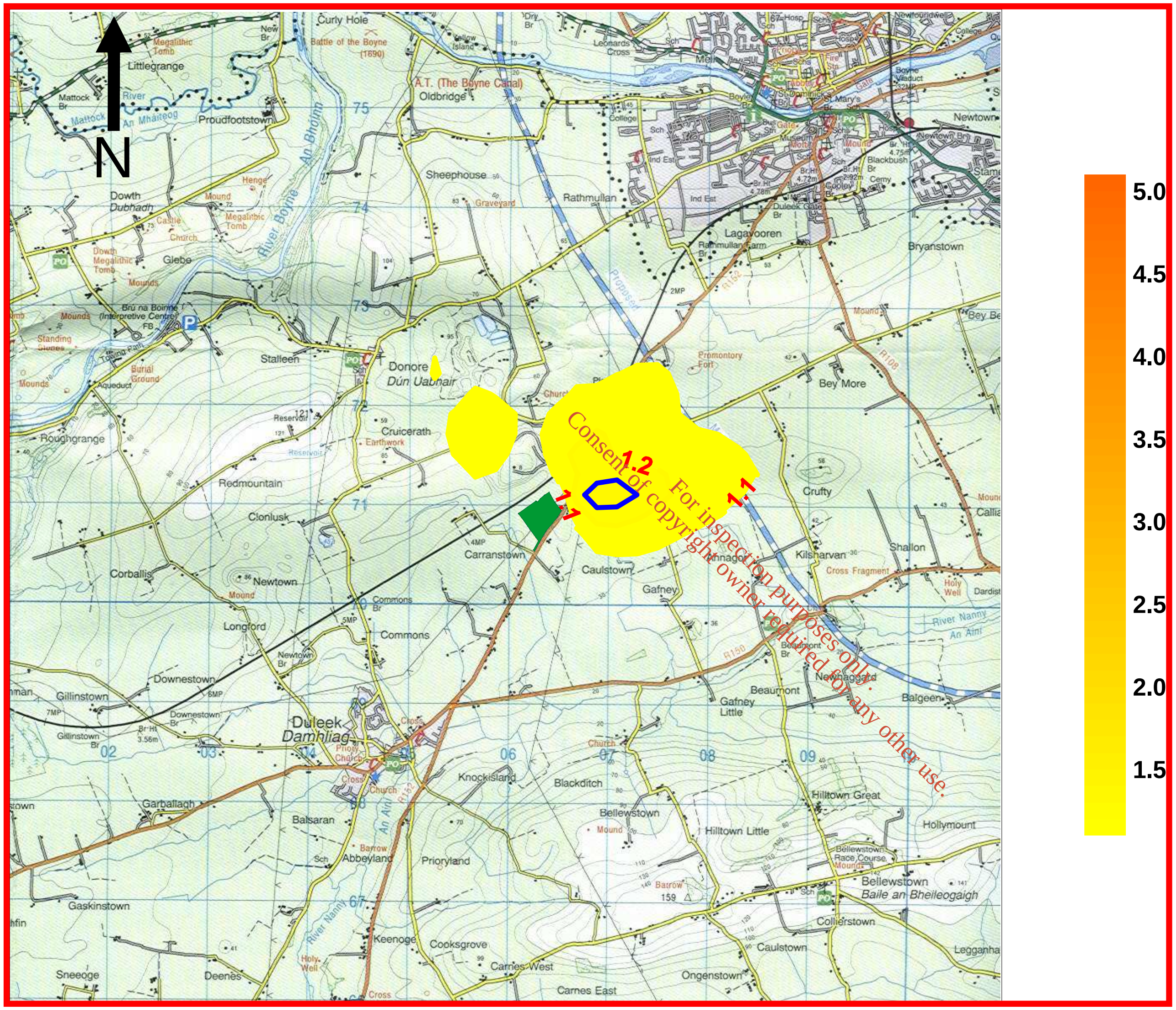
05_2624AR01

Figure 7.27

Predicted Annual
Average Cadmium
Deposition Flux
(ng/m²/day)

awn
consulting

The Tecpro Building, Clonshaugh Industrial Estate, Dublin 17. Tel: +353 (0)1 847 4220 Fax: +353 (0)1 847 4257



Annual Average Arsenic Concentration
Blue Contour = 1.3 ng/m^3

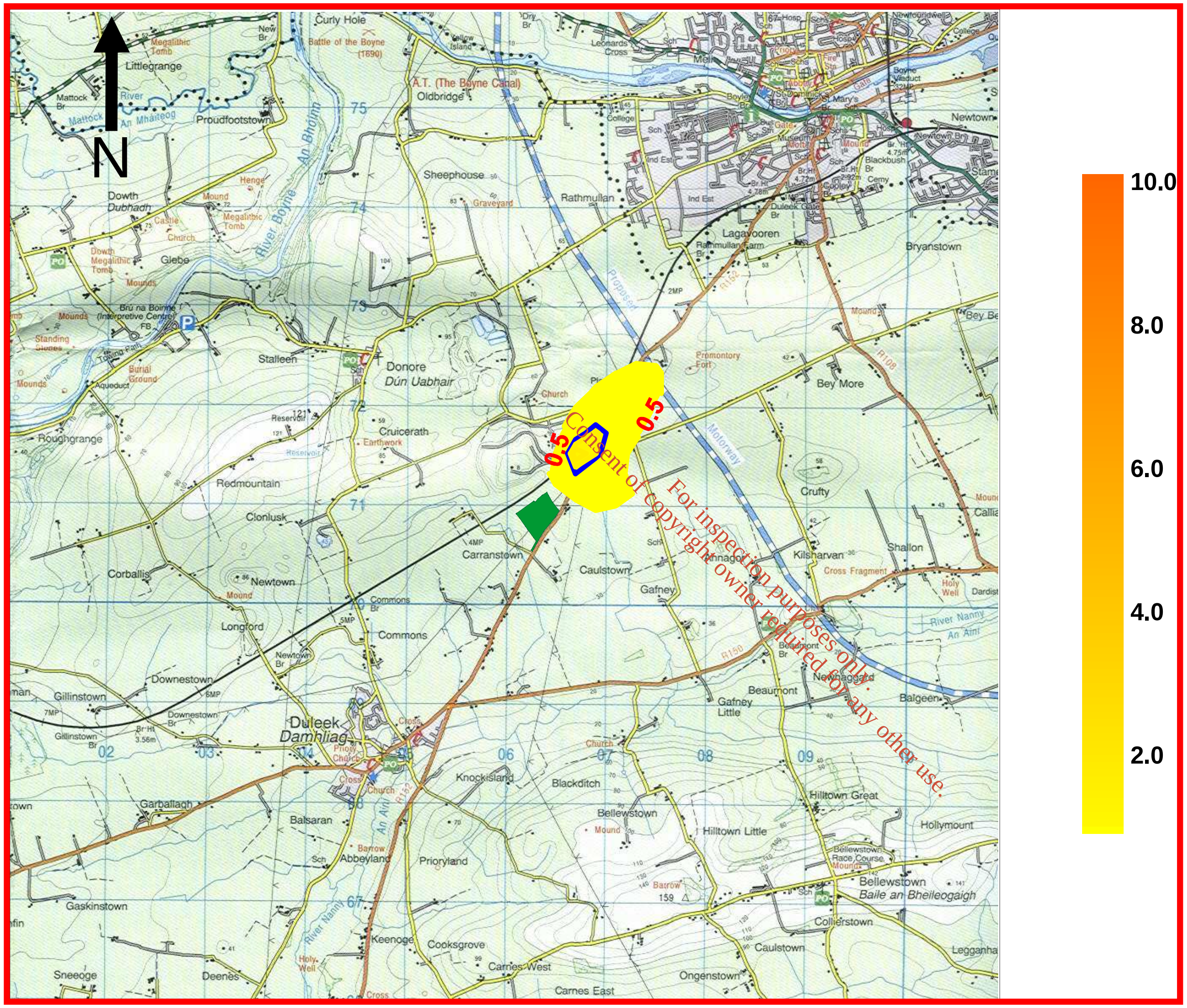
Reproduced from Ordnance Survey Ireland
Permit No: EN 7505

Scale 1:70,000 approx

Project
Carranstown WTE Facility

Reference
05_2624AR01

Figure 7.28
Predicted Annual Average Arsenic Concentration (ng/m^3)



Annual Average Arsenic
Deposition Flux
Blue Contour = 1.0 ng/m^2/day

Reproduced from
Ordnance Survey
Ireland
Permit No: EN 7505

Scale 1:70,000 approx

Project
Carranstown WTE
Facility

Reference
05_2624AR01

Figure 7.29
Predicted Annual
Average Arsenic
Deposition Flux
(ng/m^2/day)

Appendix 7.1

Description Of The Aermod Model

DESCRIPTION OF THE AERMOD MODEL

The AERMOD dispersion model has been recently developed in part by the U.S. Environmental Protection Agency (USEPA)(6). The model is a steady-state Gaussian model used to assess pollutant concentrations associated with industrial sources. The model is an enhancement on the Industrial Source Complex-Short Term 3 (ISCST3) model which has been widely used for emissions from industrial sources. The 2005 Federal Register Part II (Guidelines on Air Quality Models) has recently approved the replacement of ISCST3 by AERMOD as the preferred model for a refined analysis from industrial sources, in all terrains(1).

Improvements over the ISCST3 model include the treatment of the vertical distribution of concentration within the plume. ISCST3 assumes a Gaussian distribution in both the horizontal and vertical direction under all weather conditions. AERMOD with PRIME, however, treats the vertical distribution as non-Gaussian under convective (unstable) conditions while maintaining a Gaussian distribution in both the horizontal and vertical direction during stable conditions. This treatment reflects the fact that the plume is skewed upwards under convective conditions due to the greater intensity of turbulence above the plume than below. The result is a more accurate portrayal of actual conditions using the AERMOD model. AERMOD also enhances the turbulence of night-time urban boundary layers thus simulating the influence of the urban heat island.

In contrast to ISCST3, AERMOD is widely applicable in all types of terrain. Differentiation of the simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions. In the dividing-streamline concept, flow below this height remains horizontal, and flow above this height tends to rise up and over terrain. Extensive validation studies have found that AERMOD (precursor to AERMOD with PRIME) performs better than ISCST3 for many applications and as well or better than CTDMPLUS for several complex terrain data sets(5).

Due to the proximity to surrounding buildings, the PRIME (Plume Rise Model Enhancements) building downwash algorithm has been incorporated into the model to determine the influence (wake effects) of these buildings on dispersion in each direction considered. The PRIME algorithm takes into account the position of the stack relative to the building in calculating building downwash. In the absence of the building, the plume from the stack will rise due to momentum and/or buoyancy forces. Wind streamlines act on the plume leads to the bending over of the plume as it disperses. However, due to the presence of the building, wind streamlines are disrupted leading to a lowering of the plume centreline.

When there are multiple buildings, the building tier leading to the largest cavity height is used to determine building downwash. The cavity height calculation is an empirical formula based on building height, the length scale (which is a factor of building height & width) and the cavity length (which is based on building width, length and height). As the direction of the wind will lead to the identification of differing dominant tiers, calculations are carried out in intervals of 10 degrees.

In PRIME, the nature of the wind streamline disruption as it passes over the dominant building tier is a function of the exact dimensions of the building and the angle at which the wind approaches the building. Once the streamline encounters the zone of influence of the building, two forces act on the plume. Firstly, the disruption caused by the building leads to increased turbulence and enhances horizontal and vertical dispersion. Secondly, the streamline descends in the lee of the building due to the reduced pressure and drags the plume (or part of) nearer to the ground, leading to higher ground level concentrations. The model calculates the descent of the plume as a function of the building shape and, using a numerical plume rise model, calculates the change in the plume centreline location with distance downwind.

The immediate zone in the lee of the building is termed the cavity or near wake and is characterised by high intensity turbulence and an area of uniform low pressure. Plume mass captured by the cavity region is re-emitted to the far wake as a ground-level volume source. The volume source is located at the base of the lee wall of the building, but is only evaluated near the end of the near wake and beyond. In this region, the disruption caused by the building downwash gradually fades with distance to ambient values downwind of the building.

AERMOD has made substantial improvements in the area of plume growth rates in comparison to ISCST3(6). ISCST3 approximates turbulence using six Pasquill-Gifford-Turner Stability Classes and bases the resulting dispersion curves upon surface release experiments. This treatment, however, cannot explicitly account for turbulence in the formulation. AERMOD is based on the more realistic modern planetary boundary layer (PBL) theory which allows turbulence to vary with height. This use of turbulence-based plume growth with height leads to a substantial advancement over the ISCST3 treatment.

Improvements have also been made in relation to mixing height(6). The treatment of mixing height by ISCST3 is based on a single morning upper air sounding each day. AERMOD, however, calculates mixing height on an hourly basis based on the morning upper air sounding and the surface energy balance, accounting for the solar radiation, cloud cover, reflectivity of the ground and the latent heat due to evaporation from the ground cover. This more advanced formulation provides a more realistic sequence of the diurnal mixing height changes.

AERMOD also contains improved algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed may be less than 1 m/s, but still greater than the instrument threshold.

The AERMOD model incorporated the following features:

- Two receptor grids were created at which concentrations would be modelled. Receptors were mapped with sufficient resolution to ensure all localised "hot-spots" were identified without adding unduly to processing time. The receptor grids were based on Cartesian grids with the site at the centre. An outer grid extended to 9 km from the site with concentrations calculated at 1000m intervals. An inner grid extended to 5 km from the site with concentrations calculated at 50m intervals. Boundary receptor locations were also placed along the boundary of the site, at 100m intervals, giving a total of 10,551 calculation points for each model case.

- All on-site and nearby off-site buildings and significant process structures were mapped into the computer to create a three dimensional visualisation of the site and its emission points. Buildings and process structures can influence the passage of airflow over the emission stacks and draw plumes down towards the ground (termed building downwash). The stacks themselves can influence airflow in the same way as buildings by causing low pressure regions behind them (termed stack tip downwash). Both building and stack tip downwash were incorporated into the modelling.

- Hourly-sequenced meteorological information has been used in the model. The worst-case year of meteorological data over a five year period (Dublin Airport, 1998 - 2002) was selected for use in the model (worst-case years 1998 (gaseous) and 2000 (deposition)).

- Detailed terrain has been mapped into the model. The site is located on relatively flat terrain with gentle changes in terrain in the immediate environs of the site. The surrounding area is characterised by moderate terrain features north and south of the site, at which the terrain rises to 120-160m at a distance of approximately 2-5km. All terrain features have been mapped in detail into the model out to a diameter of 9km with the site at the centre using the terrain pre-processor AERMAP and using digital terrain data provided by Ordnance Survey Ireland.

AERMET PRO

AERMOD incorporates a meteorological pre-processor AERMET PRO(34). AERMET PRO allows AERMOD to account for changes in the plume behaviour with height. AERMET PRO calculates hourly boundary layer parameters for use by AERMOD, including friction velocity, Monin-Obukhov length, convective velocity scale, convective (CBL) and stable boundary layer (SBL) height and surface heat flux. AERMOD uses this information to calculate concentrations in a manner that accounts for changes in dispersion rate with height, allows for a non-Gaussian plume in convective conditions, and accounts for a dispersion rate that is a continuous function of meteorology.

The AERMET PRO meteorological pre-processor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. A morning sounding from a representative upper air station, latitude, longitude, time zone, and wind speed threshold are also required.

Two files are produced by AERMET PRO for input to the AERMOD dispersion model. The surface file contains observed and calculated surface variables, one record per hour. The profile file contains the observations made at each level of a meteorological tower, if available, or the one-level observations taken from other representative data, one record level per hour.

From the surface characteristics (i.e. surface roughness, albedo and amount of moisture available (Bowen Ratio)) AERMET PRO calculates several boundary layer parameters that are important in the evolution of the boundary layer, which, in turn, influences the dispersion of pollutants. These parameters include the surface friction velocity, which is a measure of the vertical transport of horizontal momentum; the sensible heat flux, which is the vertical transport of heat to/from the surface; the Monin-Obukhov length which is a stability parameter relating the surface friction velocity to the sensible heat flux; the daytime mixed layer height; the nocturnal surface layer height and the convective velocity scale which combines the daytime mixed layer height and the sensible heat flux. These parameters all depend on the underlying surface.

The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use type was carried out to a distance of 3km from the source location in line with USEPA recommendations(12). In relation to wind direction, a minimum sector arc of 30 degrees is recommended. In the current model, the surface characteristics for the site were assessed and four sectors identified with distinctly varying land use characteristics.

Surface roughness

Surface roughness length is the height above the ground at which the wind speed goes to zero. Surface roughness length is defined by the individual elements on the landscape such as trees and buildings. In order to determine surface roughness length, the USEPA recommends that a representative length be defined for each sector, based on an area-weighted average of the land use within the sector, by using the eight land use categories outlined by the USEPA. The area-weighted surface roughness length derived from the land use classification within a radius of 3km from the site is shown in Table A7.1.

Table A7.1 **Surface Roughness based on an area-weighted average of the land use within a 3km radius of Carranstown.**

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
325-45	0.75 (grassland) + 0.25 (urban)	0.2875	0.3250	0.2575	0.2575
45-200	1.0 (grassland)	0.0500	0.1000	0.0100	0.0100
200-230	0.7 (grassland) + 0.3 (urban)	0.3350	0.3700	0.3070	0.3070
230-325	1.0 (grassland)	0.0500	0.1000	0.0100	0.0100

Note 1: Winter defined as periods when surfaces covered permanently by snow whereas autumn is defined as periods when freezing conditions are common, deciduous trees are leafless and no snow is present (Iqbal (1983))(12). Thus for the current location autumn more accurately defines "winter" conditions at the proposed facility.

Albedo

Noon-time Albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. Albedo is used in calculating the hourly net heat balance at the surface for calculating hourly values of Monin-Obuklov length. The area-weighted albedo derived from the land use classification within a radius of 3km from the site is shown in Table A7.2.

Table A7.2 **Albedo based on an area-weighted average of the land use within a 3km radius of Carranstown.**

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
325-45	0.75 (grassland) + 0.25 (urban)	0.1700	0.1750	0.1950	0.1950
45-200	1.0 (grassland)	0.1800	0.1800	0.2000	0.2000
200-230	0.7 (grassland) + 0.3 (urban)	0.1680	0.1740	0.1940	0.1940
230-325	1.0 (grassland)	0.1800	0.1800	0.2000	0.2000

Note 1: For the current location autumn more accurately defines "winter" conditions at the proposed facility.

Bowen Ratio

The Bowen ratio is a measure of the amount of moisture at the surface of the earth. The presence of moisture affects the heat balance resulting from evaporative cooling which, in turn, affects the Monin-Obukhov length which is used in the formulation of the boundary layer. The area-weighted Bowen ratio derived from the land use classification within a radius of 3km from the site is shown in Table A7.3.

Table A7.3 **Bowen Ratio based on an area-weighted average of the land use within a 3km radius of Carranstown.**

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
325-45	0.75 (grassland) + 0.25 (urban)	0.5500	1.1000	1.2500	1.2500
45-200	1.0 (grassland)	0.4000	0.8000	1.0000	1.0000
200-230	0.7 (grassland) + 0.3 (urban)	0.5800	1.1600	1.3000	1.3000
230-325	1.0 (grassland)	0.4000	0.8000	1.0000	1.0000

Note 1: For the current location autumn more accurately defines “winter” conditions at the proposed facility.

APPENDIX 7.2

Cumulative Impact Assessment

CUMULATIVE IMPACT ASSESSMENT

As the region around Carranstown is partly industrialised and thus has several other potentially significant sources of air emissions, a detailed cumulative assessment has been carried out using the methodology outlined by the USEPA. Table 7.3 (see main report) outlined the recommended range of operating conditions to be assessed in the cumulative assessment. Full details are given below of the cumulative assessment carried out for the current study.

The impact of nearby sources should be examined where interactions between the plume of the point source under consideration and those of nearby sources can occur. These include:

a. the area of maximum impact of the point source,
b. the area of maximum impact of nearby sources,
c. the area where all sources combine to cause maximum impact(1,13).

The approach taken in the cumulative assessment followed the USEPA recommended Prevention of Significant Deterioration (PSD) Increment approach(13) as outlined in Section 7.2.

As previously discussed in Section 7.2, the current location would be considered a Class II area and thus the PSD applicable to Class II areas has been applied in the current case. Due to the variations in pollutant averaging times and standards between the USA and the EU, only relative PSD can be derived. The relative PSD, as a percentage of the respective National Ambient Air Quality Standards (NAAQS), is shown in Table 7.4 with the corresponding concentration as it would be applied to the EU ambient air quality standards. In the current context, the PSD increment has been applied to zones where significant overlap occurs between plumes from each of the sources. The PSD increment has not been applied per se, as existing facilities were not designed to this standard.

In the context of the cumulative assessment, all significant sources should be taken into account. The USEPA has defined “significance” in the current context as an impact leading to a 1 $\mu g/m^3$ annual increase in the annual average concentration of the applicable criteria pollutant. However, no significance ambient impact levels have been established for non-criteria pollutants (defined as all pollutants except PM_{10}, NO_2, SO_2, CO and lead). The USEPA does not require a full cumulative assessment for a particular pollutant when emissions of that pollutant from a proposed source would not increase ambient levels by more than the significant ambient impact level (annual average of 1 $\mu g/m^3$). A similar approach has been applied in the current assessment. A significance criterion of 2% of the ambient air quality standard or guideline has been applied for all non-criteria pollutants. Table A7.4 outlines the significant releases from Indaver Ireland. These releases consist of NO_2, HF, Dioxins, Cd & Tl, and the sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V. As emissions of SO_2, HCl, Total Dust (and PM_{10}), CO, TOC and Hg are not significant, no cumulative assessment need be carried out for these pollutants. However, due to the presence of Platin Cement, a cumulative impact assessment was conducted for SO_2, PM_{10} and $PM_{2.5}$ thus representing a worst-case appraoach.

The project's impact area is the geographical area for which the required air quality analysis for PSD increments are carried out. The USEPA has defined the "impact area" as a circular area with a radius extending from the source to the most distant point where dispersion modelling predicts a significant ambient impact will occur irrespective of pockets of insignificant impact occurring within it. Within this impact area, all nearby sources should be modelled, where "nearby" is defined as any point source expected to cause a significant concentration gradient in the vicinity of the proposed new source.

In order to determine compliance, the predicted ground level concentration (based on the full impact analysis and existing air quality data) at each model receptor is compared to the applicable ambient air quality limit value or PSD increment. If the predicted pollutant concentration increase over the baseline concentration is below the applicable increment, and the predicted total ground level concentrations are below the ambient air quality standards, then the applicant has successfully demonstrated compliance.

When an air quality standard or PSD increment is predicted to be exceeded at one or more receptor in the impact area, it should be determined whether the net emissions increase from the proposed source will result in a significant ambient impact at the point of each violation, and at the time the violation is predicted to occur. The source will not be considered to cause or contribute to the violation if its own impact is not significant at any violating receptor at the time of each violation.

In relation to nearby sources, several significant sources of releases were identified as outlined in Table A7.5. For each significant nearby source, an assessment was made of which pollutants from each source were significant. Due to the absence of any other significant sources of HF, Cd & Tl and the sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V in the nearby environment, no cumulative assessment need be carried out for these substances. The significant pollutants from each site have been outlined in Table A7.5.

Table A8.4 Assessment of Significant Releases from Indaver Ireland

Pollutant	Significance Criteria ($\mu g/m^3$ annual average)	Indaver Ireland GLC ($\mu g/m^3$ annual average)	Significance
NO_2	1	1	√
SO_2	1	0.35	√(2)
PM_{10}	1	0.1	√(2)
$PM_{2.5}$	1(1)	0.1	√(2)
TOC (Benzene)	0.1	0.07	-
HCl	2 (98th%ile of 1-hr)	0.8 (98th%ile of 1-hr)	-
HF	0.006	0.007	√
Dioxins	-	0.73E-9	√
Cd & Tl	0.0001	0.0004	√
Hg	0.002	0.0004	-
Sum of metals (Arsenic)	0.0001	0.0004	√

(1) Assumed to equivalent to PM_{10}

(2) Not strictly necessary based on the PSD significance criteria approach but conducted in any case as a worst-case.

Table A7.5 Assessment of Significant Releases From Nearby Sources

Pollutant	Plant 1	Plant 2
NO_2	√	√
SO_2	√	-
PM_{10}	-	√
$PM_{2.5}$	-	√
HF	-	-
Dioxins	-	√
Cd & Tl	-	-
Sum of metals	-	-

Plant 1 - Marathon Power

Plant 2 - Platin Cement

The cumulative impact assessment has been carried out to assess the impact of emissions from Indaver Ireland on the surrounding environment. As such, several conservative approximations have been made in regards to the operating details and physical characteristics of the surrounding sources. Furthermore, the guidance for assessing cumulative impacts includes assessing everywhere off-site, including within the site boundary of all nearby sources(13). Thus, the results outlined in this chapter, in regards to emissions from nearby sources, may apply to areas on-site within each source (and thus will not fall under the domain of ambient legislation) and will also most likely overestimate the impact of these sources in the surrounding environment.

Table A7.6 **Assessment of Cumulative Impact of Nitrogen Dioxide Emissions (µg/m^3)**

Pollutant	Plant 1	Plant 2	All Sources Except Indaver	Significance Criteria	All Sources	Limit Value[3]
Impact of each source at Indaver Maximum – 99.8th%ile[1]	7.2 (304000, 271750)	21.9 (304000, 271750)	26.3 (304000, 271750)	50[4]	86.5 (304000, 271750)	200
Impact of each source at Indaver Maximum – Annual Average[2]	0.24 (306950, 271050)	0.85 (306950, 271050)	1.09 (306950, 271050)	10[4]	22.2 (306950, 271050)	40
Indaver Impact At Maximum of Each Source – 99.8th%ile[1]	1.68 (298000, 280000)	8.0 (305900, 272300)	-	50[4]	85.0 (298000, 280000)	200
Indaver Impact At Maximum of Each Source – Annual Average[2]	0.51 (307500, 270900)	0.28 (307650, 271950)	-	10[4]	23.3 (307650, 271900)	40

(1) Conversion factor, following guidance from USEPA (Tier 3 analysis), based on empirically derived site-specific maximum 1-hour value for NO_2 / NO_X of 0.30

(2) Conversion factor following guidance from USEPA (Tier 2 analysis, annual average) based on a default ratio of 0.75 (worst-case).

(3) Directive 1999/30/EC

(4) PSD Class II Increment for Nitrogen Dioxide applicable in the current application (except for the All Sources scenario).

Note: Grid co-ordinates are National Grid co-ordinates and refer to the location of local maximum

Note: Refer to Appendix 7.4 for input information on nearby sources

Table A7.7 **Assessment of Cumulative Impact of Sulphur Dioxide Emissions (µg/m^3)**

Pollutant	Plant 1	All Sources Except Indaver	Significance Criteria	All Sources	Limit Value
Impact of each source at Indaver Maximum – 99.7th%ile of 1-Hr(1)	17.9 (303800, 271650)	17.9 (303800, 271650)	88(2)	32.6 (303800, 271650)	350
Indaver Impact At Maximum of Each Source – 99.7th%ile of 1-Hr(1)	0.41 (298000, 280000)	-	88(2)	71.7 (298000, 280000)	350
Impact of each source at Indaver Maximum – Annual Average(1)	0.38 (306950, 271050)	0.38 (306950, 271050)	5(2)	4.73 (306950, 271050)	20(3)

(1) Directive 1999/EU/30 – Maximum one-hour concentration not to be exceeded more than 24 times per year (99.7th%ile)

(2) PSD Increment for Sulphur Dioxide applicable in the current application (except for the All Sources scenario)

(3) Limit value not applicable in current location - modelling used as basis for baseline level of SO_2 in Table 7.12.

Note: Grid co-ordinates are National Grid co-ordinates and refer to the location of local maximum

Note: Refer to Appendix 7.4 for input information on nearby sources

Table A7.8 **Assessment of Cumulative Impact of PM_{10} Emissions (µg/m^3)**

Pollutant	Plant 2	All Sources Except Indaver	Significance Criteria	All Sources	Limit Value[1]
Impact of each source at Indaver Maximum – 90%ile of 24-hr values[1]	1.69 (306950, 271100)	1.69 (306950, 271100)	12.5[4]	21.7 (306950, 271100)	50
Impact of each source at Indaver Maximum – Annual Average[2]	0.40 (306950, 271050)	0.40 (306950, 271050)	10[4]	20.5 (306950, 271050)	40
Indaver Impact At Maximum of Each Source – 90%ile of 24-hr values[1]	0.025 (306800, 271850)	-	12.5[4]	40.2 (306800, 271850)	50
Indaver Impact At Maximum of Each Source – Annual Average[2]	0.022 (306800, 271850)	-	10[4]	28.2 (306800, 271850)	40

(1) Directive 1999/30/EC

(2) PSD Class II Increment for PM_{10} applicable in the current application (except for the All Sources scenario).

Note: Grid co-ordinates are National Grid co-ordinates and refer to the location of local maximum

Note: Refer to Appendix 7.4 for input information on nearby sources

Table A7.9 **Assessment of Cumulative Impact of $PM_{2.5}$ Emissions (µg/m^3)**

Pollutant	Plant 2	All Sources Except Indaver	Significance Criteria	All Sources	Limit Value(1)
Impact of each source at Indaver Maximum – Annual Average(2)	0.40 (306950, 271050)	0.40 (306950, 271050)	6.25(4)	12.5 (306950, 271050)	25
Indaver Impact At Maximum of Each Source – Annual Average(2)	0.022 (306800, 271850)	-	6.25(4)	20.2 (306800, 271850)	25

(1) Proposed Directive COM(2005) 447

(2) PSD Class II Increment for $PM_{2.5}$ applied in the current application (except for the All Sources scenario).

Note: Grid co-ordinates are National Grid co-ordinates and refer to the location of local maximum

Note: Refer to Appendix 7.4 for input information on nearby sources

Table A7.10 **Assessment of Cumulative Impact of Dioxins Emissions (pg/m^3)**

Pollutant	Plant 2	All Sources Except Indaver	Significance Criteria	All Sources	Limit Value
Impact of each source at Indaver Maximum – Annual Average	0.00004 (306950, 271100)	0.00004 (306950, 271100)	-	0.00080 (306950, 271100)	-
Indaver Impact At Maximum of Each Source – Annual Average	0.00015 (307600, 272850)	0.00015 (307600, 272850)	-	0.00080 (307000, 271100)	-

Note: Grid co-ordinates are National Grid co-ordinates and refer to the location of local maximum

Note: Refer to Appendix 7.4 for input information on nearby sources

NO_2

The cumulative impact of nitrogen dioxide has been assessed in Table A7.6. Each individual source has been modelled both separately and as part of the cumulative assessment.

The impact of nearby sources has been examined where interactions between the plume of the point source under consideration and those of nearby sources may occur. These locations were:

1) the area of maximum impact of the point source,
2) the area of maximum impact of nearby sources,
3) the area where all sources combine to cause maximum impact(13).

In the area of the maximum impact of Indaver Ireland (Grid Co-ordinate 304000, 271750), the impact from each source was minor. In relation to the 99.8th%ile of maximum one-hour concentrations, the cumulative impact at this point was 13% of the limit value in the absence of Indaver Ireland. However, in the presence of Indaver Ireland, the assessment indicated that the cumulative impact (not including background concentration) was 23% of the limit value at this point.

The annual average cumulative assessment was likewise minor at the area of the maximum impact of Indaver Ireland (Grid Co-ordinate 306950, 271050). The overall impact leads to an increase of 2.7% in the annual average levels leading to a cumulative level of 5.5% of the limit value (not including background concentration).

In the area of the maximum impact of each nearby source, the impact from Indaver Ireland was very small. In relation to the 99.8th%ile of maximum one-hour concentrations, the impact of Indaver Ireland at the point of maximum impact of each nearby source was always less than 4% of the limit value. Moreover, the maximum one-hour impact of Indaver Ireland at each nearby source was separated in time and thus did not lead to any significant increase in levels above the impact of each individual source separately.

The annual average cumulative assessment was likewise minor at the area of the maximum impact of each individual source. The overall impact leads to an increase of 1% in the annual average level of the worst-case nearby source. Indeed, in the region where all sources combine to cause the maximum impact, an examination of the impact of Indaver Ireland reveals an insignificant impact of the order of 0.25% of the limit value.

SO_2

The cumulative impact of sulphur dioxide has been assessed in Table A7.7. Each individual source has been modelled both separately and as part of the cumulative assessment.

In the area of the maximum impact of Indaver Ireland (Grid Co-ordinate 303800, 271650), the impact from the other main source was minor. In relation to the 99.7th%ile of maximum one-hour concentrations, the cumulative impact at this point was 5% of the limit value in the absence of Indaver Ireland. However, in the presence of Indaver Ireland, the assessment indicated that the cumulative impact was 7% of the limit value at this point (excluding background concentration). This was similar to the maximum concentration of Indaver Ireland alone and thus indicates that the contribution of the main nearby source was separated in time and thus did not lead to any significant increase in levels above the impact of Indaver Ireland alone.

In the area of the maximum impact of the main nearby source (Grid Co-ordinate 298000, 280000), the impact from Indaver Ireland was very small. In relation to the 99.7th%ile of maximum one-hour concentrations, the impact of Indaver Ireland at the point of maximum impact of the main nearby source was always less than 0.2% of the limit value. Moreover, the maximum one-hour impact of Indaver Ireland at the main nearby source was separated in time and thus did not lead to any significant increase in levels above the impact of each individual source separately.

PM_{10}

The cumulative impact of PM_{10} has been assessed in Table A7.8. Each individual source has been modelled both separately and as part of the cumulative assessment.

In the area of the maximum impact of Indaver Ireland (Grid Co-ordinate 306950, 271100), the impact from the other main source was minor. In relation to the 90th%ile of maximum 24-hour concentrations, the cumulative impact at this point was 3.4% of the limit value in the absence of Indaver Ireland. However, in the presence of Indaver Ireland, the assessment indicated that the cumulative impact was 3.5% of the limit value at this point. This was similar to the maximum concentration of Indaver Ireland alone and thus indicates that the contribution of the main nearby source was separated in time and thus did not lead to any significant increase in levels above the impact of Indaver Ireland alone.

The annual average cumulative assessment was likewise minor at the area of the maximum impact of Indaver Ireland (Grid Co-ordinate 306950, 271050). The overall impact leads to an increase of 1% in the annual average levels leading to a cumulative level of 1.2% of the limit value.

In the area of the maximum impact of the main nearby source (Grid Co-ordinate 306800, 271850), the impact from Indaver Ireland was very small. In relation to the 90th%ile of maximum 24-hour concentrations, the impact of Indaver Ireland at the point of maximum impact of the main nearby source was always less than 0.1% of the limit value.

The annual average cumulative assessment was likewise minor at the area of the maximum impact of the main nearby source (Grid Co-ordinate 306800, 271850). The overall impact leads to an increase of 0.1% in the annual average level of the worst-case nearby source.

PM$_{2.5}$

The cumulative impact of PM$_{2.5}$ has been assessed in Table A7.9. Each individual source has been modelled both separately and as part of the cumulative assessment.

In the area of the maximum impact of Indaver Ireland (Grid Co-ordinate 306950, 271050), the impact from the other main source was minor. In relation to the annual average, the cumulative impact at this point was 1.6% of the limit value in the absence of Indaver Ireland. However, in the presence of Indaver Ireland, the assessment indicated that the cumulative impact was 2% of the limit value at this point.

In the area of the maximum impact of the main nearby source (Grid Co-ordinate 3068050, 271850), the impact from Indaver Ireland was very small. In relation to the annual average, the impact of Indaver Ireland at the point of maximum impact of the main nearby source was less than 0.1% of the limit value.

Dioxins

The cumulative impact of Dioxins has been assessed in Table A7.10. Each individual source has been modelled both separately and as part of the cumulative assessment.

In the area of the maximum impact of Indaver Ireland (Grid Co-ordinate 306950, 271100), the impact from the other main source was minor. In relation to the annual average, the cumulative impact at this point was 0.1% of the baseline value in the absence of Indaver Ireland. However, in the presence of Indaver Ireland, the assessment indicated that the cumulative impact was 3% of the baseline level at this point.

In the area of the maximum impact of each nearby source, the impact from Indaver Ireland was small. In relation to the annual average, the impact of Indaver Ireland at the point of maximum impact of the nearby source was less than 0.6% of the baseline level.

APPENDIX 7.3

Air Quality Impact From Back-Up Generator

AIR QUALITY IMPACT FROM BACK-UP GENERATOR

The back-up generator is expected to run only when both the national grid and the Carranstown incinerator are down. A monthly "test run" of the back-up generator will be carried out for one hour per month. Therefore, the back-up generator is expected to run at most for 12 hours per year. Emissions of NO_X, SO_2 and HCl from the back-up generator are detailed in Table A7.11. Annual emissions from the back-up generator are negligible compared to those from the incinerator. In particular, annual emissions of NO_X from the back-up generator are only 0.007% of the incinerator NO_X emissions.

As a worst-case, modelling has been conducted based on the operation of the back-up generator one hour per week for the full year (52 hours per year compared to the more likely 12 hours per year). Ambient results are outlined in Table A7.12 and indicate that all impacts are less than 1% of the ambient limit values.

Table A7.11 Air Emission Values From Back-Up Generator

Daily Average Values	Back-up Generator	
	Emission Rate (g/s)	Emission Rate (tonnes/annum)[1]
Nitrogen Oxides (as NO_2)	0.366	0.016
Sulphur Dioxide	0.44	0.002
HCl	0.004	0.0002

(1) Tonnes per annum for back-up generator calculated based on operating conditions of 12 hours/annum.

Table A7.12 Dispersion Model Results – Back-Up Generator

Pollutant / Scenario	Annual Mean Background (µg/m^3)(1)	Averaging Period	Process Contribution (µg/m^3)	Predicted Emission Concentration (µg/Nm^3)	Standard (µg/Nm^3)	Indaver emissions as a % of ambient limit value
NO_2 / Back-Up Generator	20	Annual Mean(3)	0.03	20.03	40(2)	0.1%
		99.8th%ile of 1-hr means(4)	1.0	41.0	200(2	0.5%
SO_2 / Back-Up Generator	4	99.7th%ile of 1-hr means	0.18	8.18	350(2)	0.05%
		99.2th%ile of 24-hr means	0.21	4.2	125(2)	0.2%
HCl/ Back-Up Generator	0.01	98th%ile of 1-hr means	0.83(5)	0.84	100(6)	0.8%

(1) Includes contribution from traffic and background sources (based on results from diffusion tubes) and incorporating the cumulative assessment results.

(2) Directive 1999/30/EC

(3) Conversion factor following guidance from USEPA (Tier 2 analysis, annual average) based on the default ratio of 0.75 (worst-case).

(4) Conversion factor, following guidance from USEPA (Tier 3 analysis), based on empirically derived site-specific maximum 1-hour value for NO_2 / NO_X of 0.50

(5) Maximum value reported as 98th%ile is zero.

(6) TA Luft (2002).

APPENDIX 7.4

Air Quality Impact From Traffic Sources

AIR QUALITY IMPACT FROM TRAFFIC SOURCES

The impact of the operational traffic accessing the site has been assessed using the UK DMRB Screening Model. The worst-case operational impact in the region of the site has been assessed and is outlined in Table A7.13. Peak contributions to ambient air quality concentration tend not to overlap between traffic sources and industrial releases both temporally and spatially as these peak contributions from each source often occur under different weather conditions. However, for the purposes of this assessment, the maximum ambient levels due to traffic sources and process emissions have been combined to derive the worst-case cumulative impact from the site. The results indicate that the cumulative impact from operational traffic and process emissions at the worst-case roadside location leads to an increase in ambient levels (compared to baseline traffic and process levels) of up to 3% of the ambient limit values.

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TABLE A7.13 Summary Of Predicted Traffic Derived Pollutant Levels At Worst-Case Receptors Located Near The Proposed Facility.

Scenarios	Traffic Speed	Carbon Monoxide (mg/m^3)		Benzene (µg/m^3)		Nitrogen Dioxide (µg/m^3)			Particulates (PM_{10}) (µg/m^3)	
	(km/hr)	Annual Mean	Maximum 8-hour	Annual mean benzene	Rolling annual mean benzene	Annual average NO_x	Annual average NO_2	Maximum 1-Hour NO_2	Annual average	No of Days > 50 µg/m^3
2008 No change	80	0.04	0.4	0.04	0.05	25.7	7.9	39.5	2.1	0
2008 With Development	80	0.04	0.4	0.04	0.05	29.7	8.8	44.2	2.4	0
2008 Difference	80	<0.01	<0.1	<0.01	<0.01	4.0	1.1	4.7	0.3	0
Standards			10(1)		5(1)	-	40(2)	200(2,3)	40^2	35(2,4)

(1) EU Council Directive 2000/69/EC (S.I. 271 of 2002)

(2) EU Council Directive 1999/30/EC (S.I. 271 of 2002)

(3) 1-hr limit of 200 µg/m^3 not to be exceeded > 18 times/year (99.8th %ile)

(4) 24-Hr limit of 50 µg/m^3 not to be exceeded > 35 times/year (90.1th %ile)

APPENDIX 7.5

Summary of Source Emission Data

SUMMARY OF SOURCE EMISSION DATA

Plant 1 Marathon Power Plant 2 Platin Cement

Table A7.14: Source Emission Data for Emissions of Indaver Ireland

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temperature (K)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm^3)	Mass Emission (g/s)
Stack - Maximum Operation	65	2.0	3.14	373	147000	17.8	NO_2 – 200 SO_2 – 50 PM_{10} – 10 CO – 100 TOC – 10 HCl – 10 HF – 1.0 Dioxins – 0.1 ng/m^3 Cd & Tl – 0.05 Hg – 0.05 Sum of Metals – 0.5	NO_2 – 8.17 SO_2 – 2.04 PM_{10} – 0.41 CO – 4.1 TOC – 0.41 HCl – 0.41 HF – 0.041 Dioxins – 4.1E-9 Cd & Tl – 0.0020 Hg – 0.0020 Sum of Metals – 0.020
Stack - Abnormal Operation	65	2.0	3.14	373	147000	17.8	NO_2 – 400 SO_2 – 200 PM_{10} – 30.0 CO – 200 TOC – 30.0 HCl – 60.0 HF – 4.0 Dioxins – 0.5 ng/m^3 Cd & Tl – 1.0 Hg – 1.0 Sum of Metals – 30.0	NO_2 – 16.3 SO_2 – 8.2 PM_{10} – 1.2 CO – 8.2 TOC – 1.2 HCl – 2.45 HF – 0.16 Dioxins – 2.0E-8 Cd & Tl – 0.041 Hg – 0.041 Sum of Metals – 1.23
Bac-Up Generator	3	0.25	0.049	423	3656	20.7	NO_2 – 360 SO_2 – 44 HCl – 4	NO_2 – 0.366 SO_2 – 0.045 HCl – 0.0041

Table A7.15: Source Emission Data For Emissions of Plant 1(1)

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temperature (K)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm^3)	Mass Emission (g/s)
Stack	49.9	7.0	38.5	369	1810800	17.7	NO_2 – 120 SO_2 - 140	60.4 70.4

(1) Taken from IPC Licence Application for the site.

Table A7.16: Source Emission Data For Emissions of Plant 2[1]

Stack Reference	Stack Height (m)	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temperature (K)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm^3)	Mass Emission (g/s)
Kiln 2	103.0	3.7	10.8	393.15	440678	10.8	NO_2 – 700 PM_{10} – 25.0 $PM_{2.5}$ – 25.0 Dioxins(3) - 0.063 ng/m^3	59.5 PM_{10} – 2.1 $PM_{2.5}$ – 2.1 Dioxins - 5.25 ng/s
Kiln 3	125	3.2	8.0	371.15	611538	21.8	NO_2 – 700 PM_{10} – 25 $PM_{2.5}$ – 25 Dioxins - 0.063 ng/m^3	87.5 PM_{10} – 3.1 $PM_{2.5}$ – 3.1 Dioxins - 8.14 ng/s
Raw Mill 1	32.4	1.20	1.1	356	58727	14.4	PM_{10} – 25.0 $PM_{2.5}$ – 25.0	PM_{10} – 0.3 $PM_{2.5}$ – 0.3
Coal Mill 2	48.1	1.00	0.79	354	32874	11.6	PM_{10} – 25.0 $PM_{2.5}$ – 25.0	PM_{10} – 0.09 $PM_{2.5}$ – 0.09
CM1 EF	28.6	0.71	0.40	372	16785	12.0	PM_{10} – 25.0 $PM_{2.5}$ – 25.0	PM_{10} – 0.10 $PM_{2.5}$ – 0.10
CM3 BF	26.4	2.0	3.1	352	124518	11.1	PM_{10} – 25.0 $PM_{2.5}$ – 25.0	PM_{10} – 0.67 $PM_{2.5}$ – 0.67
K2 Grate Cooler	30.4	3.6	9.9	531	310057	8.7	PM_{10} – 25.0 $PM_{2.5}$ – 25.0	PM_{10} – 1.1 $PM_{2.5}$ – 1.1
CM2 BF	34.8	1.9	2.9	353	114106	11.2	PM_{10} – 25.0 $PM_{2.5}$ – 25.0	PM_{10} – 0.6 $PM_{2.5}$ – 0.6
K3 Grate Cooler	36.2	3.0	7.1	520	314286	12.4	PM_{10} – 25.0 $PM_{2.5}$ – 25.0	PM_{10} – 1.2 $PM_{2.5}$ – 1.2
CM4 BF	35.4	2.0	3.1	353	122839	10.9	PM_{10} – 25.0 $PM_{2.5}$ – 25.0	PM_{10} – 0.7 $PM_{2.5}$ – 0.7

(1) Taken from EIS for the site (2005), and also IPC Licence No.268.

(2) Concentrations and mass emissions based on EIS which refers to PM_{10}. As a worst case, all particulates are assumed to be in the form of $PM_{2.5}$ for the present assessment.

(3) Based on default emission rate outlined in EPA Report "Inventory of Dioxin & Furan Released to Air, Land & W ater 2000 and 2010 - (2000-DS-2-M1) (2002)" of 0.15 □g TEQ/tonne of cement (Page 49) and based on a production capacity of 2.8 million tonnes/annum of cement as outlined in Platin Cement EIS (2005).

8 NOISE AND VIBRATION

8.1 INTRODUCTION

The European Commission acknowledges that populations are suffering from an increasing level of noise nuisance. The Commission's 6th EU Environment Action Programme states that:

> *"Noise affects the health and quality of life of at least one quarter of the European Union population. It raises stress, disrupts sleep and can increase the risk of heart disease. New legislation will oblige public authorities to draw up 'noise maps' and set noise objectives when they make planning decisions."*

This chapter assesses the impact of the anticipated noise and vibration associated with the proposed development at nearby sensitive locations on the environment.

Typical noise sources associated with the planned development will be short-term construction noise and, once developed, process and plant noise from the proposed waste management facility.

8.2 STUDY METHODOLOGY

The methodology adopted for this noise and vibration assessment is as follows:

- Characterisation of the receiving environment;
- Characterisation of the proposed development;
- Prediction of the noise and vibration impact associated with the proposed development;
- Evaluation of noise and vibration impacts.

In all cases, we have undertaken predictions and the impact assessment at the nearest noise sensitive residential locations surrounding the proposed site. Due to the nature of noise propagation, there is significant attenuation of noise as it travels away from the source, hence noise levels at more remote noise sensitive locations will be lower than noise levels predicted at the nearest residential locations. Therefore, noise impacts predicted at the nearest residential locations can be considered the "worst-case" scenario.

8.2.1 Environmental Noise Survey

A series of environmental noise surveys were conducted in order to quantify the existing noise environment. The surveys were conducted in accordance with ISO 1996: *Acoustics – Description and measurement of environmental noise*: 1982. Specific details are set out overleaf.

8.2.2 Choice of Measurement Locations

Four measurement locations were selected. Three locations were used for the short-term attended noise surveys. One location was used for the installation of the long-term unattended noise monitoring equipment; refer to Figure 8.1 for their approximate positions. Each is discussed in turn below.

Location 1	Is located to the west of the proposed site. The position is located in the vicinity of a group of dwellings located approximately 700 metres from the R152 regional road.
Location 2	Is located to the east of the proposed site. The position is located adjacent to a group of dwellings on the R152 regional road and the microphone was located approximately 10 metres from the R152 regional road.
Location 3	Is located to the south of the proposed site. The position is located opposite a group of dwellings on the R152 regional road approximately 300 metres from the proposed site. The microphone was located approximately 10 metres from the R152 regional road.
Location 4	Is located within the proposed site boundary at the southern corner of the proposed site. The microphone was located approximately 20 metres from the R152 regional road. This is the location of the long-term unattended monitoring equipment.

8.2.3 Survey Periods

Measurements were conducted over the course of the following survey periods:

- Daytime 4 October 2005 (Tue) between 11:45 – 14:25hrs;
  6 November 2005 (Sun) between 09:55 – 12:55hrs;
  17 November 2005 (Thu) between 15:15 – 16:30hrs;
- Night-time 3 – 4 October 2005 (Mon – Tue) between 23:15 – 01:55hrs;
  5 – 6 November 2005 (Sat – Sun) between 23:30 – 02:20hrs;
- Unattended monitoring 12 October 2005 (Wed) to 16 October 2005 (Sun)

The proposed facility will operate continuously (i.e. 24 hours per day, seven days a week). The measurement periods therefore cover typical busy and off-peak periods during the weekday and weekend periods. These measurement periods were selected in order to provide a typical snapshot of the noise climate, with the primary purpose being to ensure that the proposed development noise criteria are commensurate with the prevailing environment. We note that additional measurements were undertaken at Location 1 during the day period on 17 November 2005 to quantify noise emissions from Platin Cement quarry that is in close proximity to dwellings at this location.

The weather throughout both the daytime and night-time survey periods on 3 and 4 October 2005 was dry with light (wind speed not exceeding 1m/s).

The weather throughout both the daytime and night-time survey periods on 5 and 6 November 2005 was dry with moderate winds form the south-east (wind speed not exceeding 3m/s).

The weather throughout the daytime survey period on 17 November 2005 was dry with and calm.

8.2.4 Instrumentation

The noise measurements were performed using a Brüel & Kjær Type 2260 Sound Level Analysers. The measurement apparatus was check calibrated before and after the surveys using a Brüel & Kjær type 4231 Sound Level Calibrator. No significant deviation was observed.

8.2.5 Procedure

The short-term attended measurements were conducted at the three locations on a cyclical basis. Sample periods were 15-minutes. The results were noted onto a Survey Record Sheet immediately following each sample, and were also saved to the instrument memory for later analysis where appropriate. Survey personnel noted all primary noise sources contributing to noise build-up.

The long-term unattended noise monitoring was undertaken at a single fixed location over a six-day period. Equipment was configured to measure with sample periods of 15-minutes.

8.2.6 Measurement Parameters

The noise survey results are presented in terms of the following five parameters:

L_{Aeq}	is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period. This parameter is representative of the specific noise from plant when plant is the dominant noise source, i.e. there is no extraneous noise from sources such as traffic.
L_{Amax}	is the instantaneous maximum sound level measured during the sample period.

L_{Amin}	is the instantaneous minimum sound level measured during the sample period. This parameter is representative of the specific noise from plant when there is extraneous noise from almost continuous sources such as fairly continuous traffic.
L_{A10}	is the sound level that is exceeded for 10% of the sample period. It is typically used as a descriptor for traffic noise.
L_{A90}	is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise. This parameter is representative of the specific noise from plant when there is extraneous noise from intermittent noise sources such as intermittent traffic.

The “A” suffix denotes the fact that the sound levels have been “A-weighted” in order to account for the non-linear nature of human hearing. All sound levels in this report are expressed in terms of decibels (dB) relative to 2×10^{-5} Pa.

8.3 RECEIVING ENVIRONMENT

8.3.1 General Description

Lands surrounding the proposed site are a mix of agricultural farmland and residential housing. The majority of private residences are located to the south and east along the R152 regional road with the density of housing increasing on the approach to the township of Duleek. Lands to the west of the site are predominantly agricultural farmland with isolated private residences. Lands to the north of the proposed site are a mixture of agricultural farmland and commercial (Platin Cement works and quarry).

8.3.2 Results and Discussion

<u>Location 1</u>

The results for Location 1 are summarised in Table 8.1 below.

Table 8.1 Summary of results for Location 1

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)				
		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
Daytime 4 Oct 2005	11:45 – 12:00	49	59	41	51	45
	12:39 – 12:54	47	63	41	49	43
	13:32 – 13:47	49	61	40	50	44
Daytime 6 Nov 2005	09:55 – 10:10	44	64	31	47	35
	09:53 – 11:08	47	63	33	51	36
	11:57 – 12:12	57	77	32	49	36
Daytime 17 Nov 2005	15:15 – 15:30	56	74	39	56	43
	15:30 – 15:45	50	68	42	52	45
	15:45 – 16:00	50	70	42	52	45
	16:00 – 16:15	50	64	43	51	46
	16:15 – 16:30	48	59	45	50	46
Night-time 3-4 Oct 2005	23:15 – 23:30	39	60	23	43	27
	00:08 – 00:23	38	53	23	42	28
	01:01 – 01:16	39	54	22	43	26
Night-time 5-6 Nov 2005	23:30 – 23:45	45	55	33	47	38
	00:35 – 00:50	47	75	38	49	42
	01:28 – 01:43	45	68	35	48	40

Daytime noise levels at this monitoring location were dominated by distant traffic noise from the M1 motorway and R152 regional road. During the weekday survey periods, there was also noise from equipment operating at the Platin Cement site with quarry equipment the dominant noise source from this site. We note that the higher measured noise level during the surveys on 6 and 17 November 2005 (57dB and 56dB L_{Aeq}) were dominated by farm machinery operating in the vicinity of the measurement location. Excluding these samples, noise levels during the weekday daytime periods were in the range 47 to 50dB L_{Aeq} and 43 to 46dB L_{A90} Noise levels during the weekend daytime periods were in the range 44 to 47dB L_{Aeq} and 35 to 36dB L_{A90}. These surveys give an indication of the contribution due to noise from the Platin Cement works.

Night-time noise levels at this monitoring location were dominated by distant traffic noise from the M1 motorway and R152 regional road. Noise levels during this period were in the range 38 to 47dB L_{Aeq} and 26 to 42dB L_{A90}. We note that noise levels measured during the second night survey period (i.e. 5 – 6 November 2005) were higher than the first survey period due to increased wind generated noise in trees and foliage adjacent to the survey position.

These noise levels are typical of what would be expected in the type of environment under consideration. No significant sources of vibration were observed.

Location 2

The results for Location 2 are summarised in Table 8.2 below.

Table 8.2 Summary of results for Location 2

Time		Measured Noise Levels (dB re. 2x10^{-5} Pa)				
		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
Daytime 4 Oct 2005	12:21 – 12:36	75	90	43	80	50
	13:15 – 13:30	76	88	40	80	50
	14:10 – 14:25	76	89	42	81	51
Daytime 6 Nov 2005	10:35 – 10:50	72	85	46	78	52
	11:34 – 11:49	72	87	38	77	51
	12:40 – 12:55	72	84	45	77	51
Night-time 3-4 Oct 2005	23:51 – 00:06	63	83	23	61	31
	00:44 – 00:59	60	85	21	54	25
	01:40 – 01:55	59	85	21	47	25
Night-time 5-6 Nov 2005	00:15 – 00:30	71	89	34	73	41
	01:09 – 01:24	68	87	29	65	33
	02:05 – 02:20	66	87	26	61	30

Traffic movements on the R152 regional road dominated daytime noise levels at this monitoring location. Plant and process noise from the nearby cement factory facility was also audible at this location during lulls in the traffic. Noise levels during daytime periods were in the range 72 to 76dB L_{Aeq} and 50 to 52dB L_{A90}. These noise levels are typical of what would be expected adjacent to a moderately busy regional road.

Occasional traffic movements on the R152 regional road dominated night-time noise levels at this monitoring location. Noise levels during this period were in the range 59 to 71dB L_{Aeq} and 25 to 33 L_{A90}.

No significant sources of vibration were observed.

Location 3

The results for Location 3 are summarised in Table 8.3 below.

Table 8.3 Summary of results for Location 3

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)				
		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
Daytime 4 Oct 2005	12:04 – 12:19	71	86	36	76	48
	12:57 – 13:12	73	89	36	78	51
	13:52 – 14:07	72	89	37	77	48
Daytime 6 Nov 2005	10:16 – 10:31	67	83	43	72	50
	11:13 – 11:28	65	78	41	70	51
	12:18 – 12:33	66	81	45	70	53
Night-time 3-4 Oct 2005	23:34 – 23:49	67	90	23	64	28
	00:26 – 00:41	64	87	19	59	26
	01:20 – 01:35	63	89	22	56	25
Night-time 5-6 Nov 2005	23:50 – 00:05	60	77	34	63	38
	00:52 – 01:07	62	77	29	66	33
	01:47 – 02:02	62	79	30	65	36

Traffic movements on the R152 regional road dominated daytime noise levels at this monitoring location. Plant and process noise from the nearby cement factory facility was also audible at this location during lulls in the traffic. Noise levels during daytime periods were in the range 65 to 73dB L_{Aeq} and 48 to 53dB L_{A90}. These noise levels are typical of what would be expected adjacent to a moderately busy regional road.

Occasional traffic movements on the R152 regional road dominated night-time noise levels at this monitoring location. Noise levels during this period were in the range 60 to 67dB L_{Aeq} and 25 to 38 L_{A90}.

No significant sources of vibration were observed.

Location 4

Long term unattended noise monitoring was conducted at Location 4 during the weekday and weekend periods and the results are summarised in Appendix 8.1.

Noise measurements during the weekday period indicate that daytime noise levels were in the range of 61 to 70dB L_{Aeq} and 40 to 60dB L_{A90}. During night-time, noise levels were in the range of 48 to 67dB L_{Aeq} and 34 to 52dB L_{A90}.

Noise measurements during the weekend period indicate that daytime noise levels were in the range of 56 to 68dB L_{Aeq} and 36 to 57dB L_{A90}. During night-time, noise levels were in the range of 53 to 64dB L_{Aeq} and 31 to 46dB L_{A90}.

The results of the unattended noise monitoring show a larger range of measured noise levels when compared to the short-term attended survey. This is attributable to the larger time period over which the unattended noise monitoring was undertaken.

8.4 CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

The proposed development comprises the construction of a new waste management facility. The potential noise elements of the facility are process machinery and plant located internally and externally. The major noise sources include condensers, turbines furnaces, boilers and discharge stack.

When considering a development of this nature, the potential noise and vibration impact on the surrounding environment must be considered for each of two distinct stages: the short term impact of the construction phase and the longer term impact of the operational phase.

The primary sources of noise during the construction phase will be temporary and include:

- Ground preparation phase – excavators, dump trucks and dozers for ground excavation, spreading fill and levelling;
- Structural phase – installation of foundations and erection of new buildings involving the use of equipment such as compressors, generators, pneumatic tools, hand-held power tools and mobile/fixed cranes;
- Additional vehicular traffic on public roads.

The primary sources of noise during the operational phase of the proposed development will be long-term and are listed below:

- Process and building services plant;
- Car parking on site;
- Vehicle movements on site;
- Additional vehicular traffic on public roads.

The primary sources of vibration during the construction phase of the proposed development will be short-term and are listed below:

- Piling operations;
- Ground excavation works;
- Truck movements on uneven road surfaces.

No significant sources of vibration will be present during the operational phase.

8.5 POTENTIAL IMPACT OF THE PROPOSED DEVELOPMENT

8.5.1 Noise Criteria

Construction Phase

There is no published Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. In order to reduce the potential for noise nuisance at residential properties in the vicinity of the proposed development, we recommend the following noise limits for construction noise.

During the construction phase of the proposed development, noise levels at the site when measured at noise sensitive locations in the vicinity shall not exceed 65dB(A) between 0700 and 1900 hours Monday to Saturday inclusive, excluding public holidays and Sunday, and 45dB(A) at any other time.

Table 8.4 summarises the construction noise limits applicable at the facade of dwellings during the construction period.

Table 8.4 Maximum Permissible Noise Levels at the Facade of Dwellings During Construction

Days and Times	Noise Levels $L_{Aeq,1hr}$ (dB re. $2x10^{-5}$ Pa)
Monday to Saturday 07:00 to 19:00hrs	65
Monday to Saturday 19:00 to 07:00hrs	45

Operational Phase

Due consideration must be given to the nature of the primary noise sources when setting criteria. In this instance, there are four primary sources of noise associated with the development once operational as outlined above. Criteria for noise from process and building services plant, car parking and vehicle movements on the site will be set in terms of L_{Aeq} the equivalent continuous sound level. However, given that vehicle movements on public roads are assessed using a different parameter (i.e. L_{A10}), it is appropriate to consider the degree by which the noise level due to the additional traffic exceeds the existing traffic noise level in the area.

For such a facility as that proposed, the Environmental Protection Agency would typically specify the following noise limits at the façades of residential properties closest to the development:

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

Whilst the application of absolute noise limits to a development ensures that overall impact is kept within acceptable margins, it does not assist with the assignation of relative impacts. In order to do this, it is appropriate to consider the likely change in ambient noise level as a result of the scheme under consideration. Table 8.5 offers guidance as to the likely impact on the surrounding environment associated with a change in ambient noise level.

Table 8.5 Significance criteria associated with change in noise level

Change in Ambient Noise Level (dB L_{Aeq})	**Subjective Reaction**	**Impact**
< 3	Imperceptible	Negligible
3 – 5	Perceptible	Slight
6 – 10	Up to a doubling of loudness	Moderate
11 – 15	Over a doubling of loudness	Significant
> 15		Profound

8.5.2 Vibration Guidelines

There are two varieties of criteria for vibration, the first relates to human comfort and the second relates to damage to buildings. In both instances, it is appropriate to consider the magnitude of vibration in terms of Peak Particle Velocity (PPV).

It is acknowledged that humans are particularly sensitive to vibration stimuli and that any perception of vibration may lead to concern. In the case of road traffic, vibration is perceptible at around 0.5mm/s and may become disturbing or annoying at higher magnitudes. However, higher levels of vibration are typically tolerated for single events or events of short duration. For example, blasting, piling and rock-breaking, some of the primary sources of vibration during construction, are typically tolerated at vibration levels up to 12mm/s, 5mm/s and 5mm/s respectively.

Guidance relevant to human response to vibration is contained within British Standard BS 6472 - *Evaluation of human exposure to vibration in buildings (1Hz to 80Hz).*

BS 6472 provides advice on vibration due to blasting and recommends vibration magnitudes below which the probability of adverse comment from building occupants is low. The standard recommends vibration levels of less than 8.5mm/s for at least 90% of all blasts over the frequency range 8Hz and above. This vibration limit assumes that there are no more than three blasts occurring on any one day. No individual blast should give rise to vibration which exceeds the satisfactory magnitude by more than 50% i.e. 12mms^{-1}. This criteria applies to vibration as measured in three mutually orthogonal directions about a fixed point.

Guidance relevant to acceptable *transient* vibration levels at the foundation of buildings is contained within British Standard BS 7385 - *Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration*.

The potential damaging effects of ground vibration on buildings are greatest at low frequencies. For residential buildings, BS 7385 recommends that there should be no cosmetic (i.e. non-structural) damage if transient vibration does not exceed 15mm/s at low frequencies rising to 20mm/s at 15Hz and 50mm/s at 40Hz and above.

Guidance relevant to acceptable *continuous* vibration levels at the foundation of buildings is contained within British Standard BS 5228 - *Noise Control on Construction and open sites Part 4: Code of Practice for noise and vibration control applicable to piling operations.*

For residential buildings, BS 5228 states that there should be no cosmetic (i.e. non-structural) damage if continuous vibration does not exceed 5mm/s over the frequency range 10Hz to 50Hz. Below these vibration magnitudes cosmetic damage is unlikely, although where there is existing damage these limits may be reduced by up to 50%.

This guidance is applicable to the daytime only; it is unreasonable to expect people to be tolerant of such activities during the night-time.

8.5.3 Construction Phase

There are two primary sources of noise during the construction phase of the proposed development.

- On site plant and machinery;
- Additional vehicular traffic on public roads.

Each of these primary noise sources is addressed in turn

<u>On-Site Plant and Machinery</u>

During the construction phase of the proposed development, a variety of items of plant will be in use, such as excavators, lifting equipment, dumper trucks, compressors and generators.

Due to the nature of the activities undertaken on a large construction site, there is potential for generation of significant levels of noise. The flow of vehicular traffic to and from a construction site is also a potential source of relatively high noise levels. The potential for vibration at neighbouring sensitive locations during construction is typically limited to piling, excavation works and truck movements on uneven road surfaces. Due to the proximity of sensitive locations to potential site access points, the more significant of these is likely to be uneven road surfaces. However, there is little likelihood of structural or cosmetic damage to existing neighbouring dwellings.

Due to the fact that the construction programme has been established in outline form only, it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, Table 8.6 indicates typical noise levels that would be expected from the proposed construction site during the various phases of the construction project. Noise levels have been predicted at the noise sensitive locations located on the east side of the R152, adjacent to the proposed entrance to the waste management facility site.

For the purposes of the calculation, it is assumed that equipment will be operating at the south eastern boundary at a distance of 50 metres from the nearest residential dwelling during the construction of the proposed earth bund along the south eastern boundary of the site and at a distance of 80 metres for other phases of the construction programme.

It should be stated that for most of the time, plant and equipment will be a greater distance from the nearest residential dwelling than that used for the calculations in Table 8.6 and consequently will have lesser impact on local residents. Our assessment is therefore representative of a “worst-case” scenario.

For the purposes of the assessment we have assumed that standard good practice measures for the control of noise from construction sites will be implemented. These issues are commented upon in further detail in the mitigation section of this chapter.

Table 8.6 Typical Noise Levels at nearest noise sensitive property during Construction Phases

Phase	Item of Plant *(BS5228 Ref)*	L_{Aeq} at 10m[1] (dB)	L_{Aeq} at NSL (dB)
Bund Construction	Wheeled Loader Lorry *(C3 51)*[2]	84	68
	Track Excavator *(C2 25)*[4]	85	
Site clearance/ excavation	Wheeled Loader Lorry *(C3 51)*[4]	84	60
	Track Excavator *(C2 25)*[4]	85	
Foundations	Compressor *(C6 43)*	77	64
	Poker Vibrator *(C6 29)*	86	

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[1] Sound Pressure Level data from BS5228: *Noise control on construction and open sites – Part 1: 1997.*

[2] Assume a noise control measure as outline in Table B1 of the standard i.e. Fit more efficient exhaust sound reduction equipment and manufacture's enclosure panels should be kept closed - 5 to 10dB reduction

Phase	Item of Plant *(BS5228 Ref)*	L_{Aeq} at 10m[1] (dB)	L_{Aeq} at NSL (dB)
Steel Erection	Crane operations *(C7.105)*	80	62
	Articulated lorry *(C7.121)*	70	
General Construction	Surfacing *(C8 26)*	80	57
	Pneumatic Circular Saw (C7.79)	70	
	Internal fit – out	70	
Road Works/Landscaping	Surfacing *(C8 26)*	80	57

The predictions indicate that the daytime construction noise limit of 65dB L_{Aeq} may be exceeded during the construction of the earth bund at the south-eastern corner of the site. Potential mitigation measures are commented upon in further detail in the mitigation section of this chapter.

During all other operations, there are no items of plant that would be expected to give rise to noise levels that exceed the noise limits outlined in Table 8.4 for the daytime period (Monday to Saturday 07:00 to 19:00hrs). It would not be feasible to achieve the night-time noise limit of 45dB L_{Aeq} outlined in Table 8.4 and construction should not occur between 19:00 to 07:00 hours Monday to Saturday (inclusive), Sunday and Public Holidays.

The impact on the noise environment due to construction activities will be transient in nature and mitigation measures will be implemented to minimise the impact of noise from construction activities on the surrounding environment.

Additional Construction Traffic on Public Roads

The traffic assessment prepared by Roughan & O'Donovan Consulting Engineers has been used to determine the predicted noise levels in the vicinity of the major road adjoining the proposed development (i.e. R152).

When considering traffic noise, the parameter considered here is the $L_{A10(1hour)}$ expressed in terms of decibels (dB). The value of $L_{A10(1hour)}$ is the noise level exceeded for just 10% of the time over the period of one hour. $L_{A10(1hour)}$ is a parameter typically used in Ireland for the purposes of assessing traffic noise.

The anticipated peak period (06:00 – 07:00hrs) traffic generated during the construction phase is 236 vehicle movements.

Traffic volumes with and without the construction traffic from the proposed development are detailed in Table 8.7. The predicted increases in traffic noise levels are also detailed.

Table 8.7 Summary of Construction traffic flows and relative change in traffic noise levels

Route	**Peak period (06:00-07:00hrs)**		**Relative change in traffic noise level, dB(A)**
	Do Minimum	Do Something	
R152	803	1,045	+1

In summary, the predicted increase in noise levels arising from additional vehicular traffic due to the construction phase is 1dB. Reference to Table 8.5 confirms that such an increase is negligible and the associated noise impact is imperceptible. Therefore, noise from construction traffic will not impact on the surrounding environment.

8.5.4 Operational Phase

The operation of the proposed development is not anticipated to create any significant vibration impacts.

There are four primary sources of noise in the operational context of the proposed development.

- Process and building services plant;
- Car parking on site;
- Vehicle movements on site;
- Additional vehicular traffic on public roads.

Each of these primary noise sources is addressed in turn.

Process and Building Services Plant

Preparation of the Noise Model

Proprietary noise calculation software was used for the purposes of this impact assessment. The selected software, Brüel & Kjær Type 7810 *Predictor*, calculates noise levels in accordance with ISO9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation*, 1996.

Brüel & Kjær Type 7810 Predictor

Brüel & Kjær Type 7810 *Predictor* is a proprietary noise calculation package for computing noise levels in the vicinity of noise sources. *Predictor* predicts noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated taking into account a range of factors affecting the propagation of sound, including:

- The magnitude of the noise source in terms of sound power;
- The distance between the source and receiver;

  The presence of obstacles such as screens or barriers in the propagation path;
- The presence of reflecting surfaces;

  The hardness of the ground between the source and receiver;

  Attenuation due to atmospheric absorption;

  Meteorological effects such as wind gradient, temperature gradient and humidity (these have significant impact at distances greater than approximately 400m).

Prediction Calculations

Prediction calculations have been performed using *Predictor* in accordance with ISO9613, assuming 10^{o}C and 80% humidity. The degree of accuracy associated with this prediction method is shown in the Table 8.8.

Table 8.8 Estimated accuracy for broadband noise of L_{AT}(DW)

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

Where: h is the mean height of the source and receiver;
d is the mean distance between the source and receiver.

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

Input Data

Sound power data for each item of plant considered in the noise model is given in Table 8.9. This data is typical of noise levels measured for similar items of plant at the Indaver facility at Beveren, Flanders, Belgium.

Building layouts and heights have been taken from drawings supplied by McElroy Associates.

Ground topography, geographical features and location data for noise-sensitive locations have been taken from survey drawings supplied by McElroy Associates and Ordnance Survey maps.

Table 8.9 Equipment Sound Power Levels utilised in noise model

Description	Octave Band Centre Frequency (Hz)								dB(A)
	63	125	250	500	1k	2k	4k	8k	
Fan Turbine Building (N façade)	72	78	88	87	82	76	72	64	91
Fan Turbine Building (S façade)	72	78	88	87	82	76	72	64	91
Fan Turbine Building (E façade)	72	78	88	87	82	76	72	64	91
Fan Turbine Building (W façade)	72	78	88	87	82	76	72	64	91
Turbine Cooling No. 1	64	69	72	83	80	77	72	64	86
Turbine Cooling No. 2	64	69	72	83	80	77	72	64	86
Air Condensers No. 1	82	87	88	88	93	91	83	80	98
Air Condensers No. 2	82	87	88	88	93	91	83	80	98
Air Condensers No. 3	82	87	88	88	93	91	83	80	98
Air Condensers No. 4	82	87	88	88	93	91	83	80	98
Grid Compressor No. 1	74	73	78	82	76	70	65	64	85
Grid Compressor No. 2	74	73	78	82	76	70	65	64	85
Grid Compressor No. 3	74	73	78	82	76	70	65	64	85
Cooling Grid Oven No. 1	69	74	77	81	80	76	71	63	86
Cooling Grid Oven No. 2	69	74	77	81	80	76	71	63	86
Chimney stack	82	89	92	79	75	69	70	70	94

Output Data

Predictor calculates noise levels for a set of receiver locations specified by the user. The results include an overall level in dB(A) and a frequency spectrum for each of the noise sources contributing to noise build-up at the receiver point. The items in the list can be ranked in order of their contribution, and thus the noisiest items can be readily identified.

For the purposes of this assessment, we have predicted noise levels at the façade of the nearest noise-sensitive locations and at a variety of other locations along proposed boundaries.

Results of the Noise Model

Noise levels have been predicted at a total of five noise sensitive residential locations as summarised in Table 8.10 and shown in Figure 8.1.

Table 8.10 Details of Receiver Locations

Receiver Location Ref.	Description of Receiver Location
R1	Is located to the west of the proposed development site near a group of residential dwellings at the end of a private access road. The position was located at the façade of the closest residential dwelling to the development site. This receiver location is equivalent to survey Location 1.
R2	Is located at the residential dwellings near the north-east corner of the proposed development site. The position was located at the façade of the closest residential dwelling on the west side of the R152 regional road. This receiver location is in the vicinity of survey Location 2.
R3	Is located immediately adjacent to the proposed entrance of the development site near a pair of residential dwellings. The position was located at the façade of the closest residential dwelling on the east side of the R152 regional road.
R4	Is located to the south of the proposed development site near a single residential dwelling located on the west side of the R152, approximately 200 metres from the proposed site entrance.
R5	Is located to the south-east of the proposed development site near a single residential dwelling located on a private access road on the east side of the R152.

Table 8.11 compares predicted noise levels with the adopted criterion at the five noise sensitive locations under consideration.

Table 8.11 Predicted Noise Levels at Noise Sensitive Locations

Location	Daytime Predicted L_{Aeq} (dB)	Daytime Criterion L_{Aeq} (dB)	Complies	Daytime Predicted L_{Aeq} (dB)	Night Time Criterion L_{Aeq} (dB)	Complies
R1	33	55	Yes	33	45	Yes
R2	37		Yes	37		Yes
R3	34		Yes	34		Yes
R4	33		Yes	33		Yes
R5	30		Yes	30		Yes

Table 8.11 shows that the predicted noise levels at noise sensitive residential locations are within typical EPA Waste Licence daytime and night-time criteria of 55dB $L_{Aeq,30min}$ and 45dB $L_{Aeq,30min}$ respectively.

As previously stated in Section 8.5.1, the application of an absolute noise limits to a development ensures that overall impact on the local community is kept within acceptable margins, it does not assist with the assignation of relative impacts. In order to do this, it is appropriate to consider the likely change in ambient noise level as a result of the scheme under consideration.

At this development, the residential dwellings located at receptor reference R1 currently experience the lowest daytime and night-time ambient noise levels due to their remote proximity to major roads. It is therefore appropriate to undertake an assessment of the cumulative effects of noise from the proposed development at this location.

Reference to Table 8.1 shows that the lowest measured daytime noise levels at Location 1 were of the order of 47dB L_{Aeq} during the week and 44dB L_{Aeq} during the weekend. The lower measured noise levels during the weekend can be attributed to the absence of noise from Platin Cement quarry and lower traffic volumes on major roads in the vicinity.

Reference to Table 8.1 also shows that the lowest measured night-time noise levels were 38dB L_{Aeq} during the week and 45dB L_{Aeq} during the weekend. The elevated measured level during the weekend period was due to wind-generated noise in trees and foliage adjacent to the survey position. However, we do not expect night-time ambient noise to differ significantly between the weekend and weekday and on that basis 38dB L_{Aeq} is representative of ambient noise level during the night period.

Table 8.12 Predicted Noise Levels and Summary of Impacts at Receptor R1

Period		Predicted/Measured Noise Levels, L_{Aeq} (dB)				Impact
		Predicted noise level from site	Existing ambient level	Cumulative level	Change	
Daytime	Weekday	33	47	47	0	Negligible
	Weekend	33	44	44	0	Negligible
Night-time	Weekday	33	38	39	+1	Negligible
	Weekend	33	38	39	+1	Negligible

An increase in ambient noise levels of 1dB(A) is predicted during the night period at receptor location R1. Reference to Table 8.5 indicates that subjectively, this is an Imperceptible increase in noise levels and the resulting impact on this resident is negligible. No increase in ambient noise levels is predicted for the day period.

We note that for the remaining assessment locations have significantly higher ambient noise levels due to their closer proximity to the R152 regional road. Undertaking a similar assessment of cumulative impacts results in negligible impact on these residential locations.

Car Parking on Site

The proposed development will have the main surface car park area located at the south-eastern corner of the site, near the main entrance.

Noise level measurements have previously been conducted in the vicinity of car parks in support of other planning applications. The typical noise level at 10 metres beyond the boundary of car parks during busy daytime periods has been found to be of the order 48dB $L_{Aeq,1hr}$

The closest residential property to the proposed car park is located on the east side of the R152, adjacent to the site entrance (receiver reference R3). This property is located approximately 80 metres from the car park. Taking into account the attenuation due to distance, the predicted noise level at the nearest residential property is 30dB $L_{Aeq,1hr}$, This is significantly lower than the daytime noise limit of 55dB $L_{Aeq,30\ min}$.

Vehicle Movements on Site

The noise level associated with an event of short duration, such as a vehicle drive-by, may be expressed in terms of its Sound Exposure Level (SEL), defined as being the “A-weighted” equivalent continuous sound level which, when maintained for one second, contains the same quantity of sound energy as the actual time varying level of one event. The SEL can be used to calculate the contribution of an event or series of events to the overall noise level in a given period. The appropriate formula is given below.

$$L_{Aeq,T} = SEL + 10\log_{10}(N) - 10\log_{10}(T) + 20\log_{10}(r_1/r_2) \quad dB$$

where: $\mathbf{L_{Aeq,T}}$ is the equivalent continuous sound level over the time period T;

SEL is the “A-weighted” Sound Exposure Level of the event under consideration (dB);

N is the number of events over the course of time period T;

$\mathbf{r_1}$ is the distance at which SEL is expressed;

$\mathbf{r_2}$ is the distance to the assessment location.

The mean value of Sound Exposure Level for a heavy truck movement, at low to moderate speeds, is of the order of 78dB(A) at a distance of 5 metres from the edge of the road. These figures are based on a series of measurements conducted under controlled conditions.

The time period of interest is one hour (3,600 seconds). In this instance, the nearest noise sensitive location is the residential property located adjacent to the site entrance (receiver reference R3). This property is located approximately 60 metres from the internal site roads at the closest point.

The traffic assessment undertaken by Roughan & O'Donovan Consulting Engineers predicts that there will be 17 truck movements to the site during the peak period (08:00 – 09:00hrs).

The "worst-case" noise level due to additional vehicle movements along the site access road may therefore be calculated as follows:

$$L_{Aeq,1hr} = 78 + 10\log_{10}(17) - 10\log_{10}(3600) + 20\log_{10}(5/60) \quad \text{dB}$$
$$= 33\text{dB}$$

The resultant noise level at the assessment location is 33dB $L_{Aeq,1hr}$. The predicted noise level is within the typical EPA Waste Licence daytime and night-time criteria of 55dB $L_{Aeq,30min}$ and 45dB $L_{Aeq,30min}$ respectively. Therefore, vehicular movements on-site will not impact on local residents or the surrounding environment.

Additional Operational Traffic on Public Roads

The anticipated peak period (08:00 – 09:00hrs) traffic generated by the site is 17 truck movements (inclusive of waste delivery, consumables delivery and residual waste removal).

Traffic volumes with and without the proposed development for peak hours in the Opening Year are detailed in Table 8.13. The predicted increases in traffic noise levels are also detailed.

Table 8.13 Summary of traffic flows for Opening Year & calculated relative change in traffic noise levels

Route	Opening Year Peak period (09:00-10:00hrs)		Relative change in traffic noise level, dB(A)
	Do Minimum	Do Something	
R152	1,108	1,142	+0.1

In summary, the predicted increase in noise levels due to additional vehicular traffic due to the proposed development is less than 1dB. Reference to Table 8.56 confirms that such an increase is negligible and the associated noise impact on local residents is imperceptible.

Vibration Impact on Indaver Site From Existing Sources

Blasting has been carried out at the Platin Quarry site over the last 30 years at a maximum frequency of two blasts per week. The IPC licence for the Platin site specifies a peak particle velocity limit of 12mm/s for ground-borne vibration at the nearest noise sensitive location. This location is a house situated south-east of the quarry at a distance of approximately 300 metres from the quarry face.

The proposed turbine hall and condensers at the Indaver site are located approximately 300 metres from the nearest face of the Platin quarry. Therefore, it anticipated that that "worst-case" vibration levels at the foundation of the proposed buildings will be of the order of 12mm/s. This assumes that geological ground conditions are consistent between the quarry and receptor locations around the site.

With regards to possible damage to Indaver buildings due to blasting, reference to Section 8.5.2 shows that the potential damaging effects of ground vibration on buildings are greatest at low frequencies. There is typically no cosmetic (i.e. non-structural) damage if transient vibration does not exceed 15mm/s at low frequencies. In addition, the design of the waste-to-energy facility will include appropriate seismic design of the buildings foundations. On this basis, we do not anticipate any cosmetic or structural damage to buildings at the Indaver site due to "worst-case" vibration levels from the Platin site.

With regard to vibration sensitive equipment (i.e. laboratory equipment) to be installed at the Indaver site, we note that manufacturers of this type of equipment typically specify vibration limits. If equipment is to be installed where the manufacturers vibration limits are likely to be exceeded, then the manufacturer can specify suitable vibration isolating systems to be incorporated into the equipment installation. This is standard practice with regards to vibration sensitive equipment.

8.6 MITIGATION MEASURES

In order to sufficiently ameliorate the likely noise impact on the local community, a schedule of noise control measures has been formulated for both construction and operational phases associated with the proposed development.

8.6.1 Construction Phase

The assessment of construction noise in Section 8.5.3 indicates that the noise criterion may be exceeded during the construction of the earth bund at the southeast corner of the site. Special consideration should be given to the erection a temporary 2.4 metre high timber hoarding to block line-of-sight between earthmoving equipment and the residential properties on the eastern side of the R152 (receiver reference R3).

With regard to general construction activities, reference will be made to BS5228: *Noise control on construction and open sites*, which offers detailed guidance on the control of noise and vibration from demolition and construction activities. Various mitigation measures can be considered and applied during the construction of the proposed development, such as:

- Limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- Establishing channels of communication between the contractor/developer, Local Authority and residents;
- Appointing a site representative responsible for matters relating to noise and vibration;
- Monitoring levels of noise during critical periods and at sensitive locations;
- All site access roads will be kept even so as to mitigate the potential for vibration from lorries.

Furthermore, it is envisaged that a variety of practicable noise control measures will be employed. These may include:

- Selection of plant with low inherent potential for generation of noise and/ or vibration;
- Erection of barriers as necessary around items such as generators or high duty compressors;
- Situate any noisy plant as far away from sensitive properties as permitted by site constraints and the use of vibration isolated support structures where necessary.

Vibration from construction activities is not anticipated to be significant. Assimilating the guidance in the Vibration Guidelines section above, it is recommend that the allowable transient vibration during construction (in terms of peak particle velocity in mm/s) at the closest foundation of any building structure should normally be limited to the values set out in Table 8.14. It should be noted that these limits are not absolute, but provide guidance as to magnitudes of vibration that are very unlikely to cause cosmetic damage. Magnitudes of vibration slightly greater than those in the table are normally unlikely to cause cosmetic damage, but, in the interest of protecting the local community, construction work creating such magnitudes should proceed with caution. Where there is existing damage, these limits may need to be reduced by up to 50%.

Table 8.14 Construction Phase Vibration Limits to avoid cosmetic building damage

Type of structure	Allowable vibration level (in terms of frequency range)		
	Less than 10Hz	10 to 50Hz	50 to 100Hz (and above)
Particularly sensitive / listed building	3 mm/s	3 to 8 mm/s	8 to 10 mm/s
Dwellings	5 mm/s	5 to 15 mm/s	15 to 20 mm/s
Light & flexible industrial/commercial	10 mm/s	10 to 30 mm/s	30 to 40 mm/s
Heavy and stiff buildings	20 mm/s	20 to 40 mm/s	40 to 50 mm/s

With regard to piling operations, the contractor will be required to ensure that the specific peak particle velocity for the specified frequency band in Table 8.14 is not exceeded. The Contractor will be obliged to take abatement measures complying with the recommendations of BS 5228. This may include the selection of suitable piling methods to minimize vibration emissions such as “auger” type piling that has significantly lower vibration emissions when compared to traditional “impactive” type piling.

8.6.2 Operational Phase

Process and Building Services Plant

Noise predictions indicate that noise levels from the proposed development will be within typical EPA Waste Licence noise limits at noise sensitive locations beyond the southern and northern boundaries of the site and therefore should not impact on local residents.

Proven noise control techniques will be employed to ensure that the total noise emissions from new process equipment and building services plant is minimised. These include:

- selection of equipment with low inherent noise emission levels;
- where practicable, noisy equipment has been located inside process buildings;
- where noisy equipment must be located externally (i.e. air condensers), plant will be sited as far away from noise sensitive locations as is practicable and will be sited to gain maximum screening from process buildings;
- installation of duct mounted attenuators on the atmosphere side of all air moving plant;
- installation of splitter attenuators or acoustic louvres providing free ventilation to internal plant and process areas;
- installation of anti-vibration mounts on all plant with the potential to generate significant levels of vibration (i.e. reciprocating plant).

Car Parking on Site

The noise impact assessment outlined in Section 8.5.4 has demonstrated that mitigation measures are not required.

Vehicle Movements on Site

The noise impact assessment outlined in Section 8.5.4 has demonstrated that mitigation measures are not required.

Additional Vehicular Traffic on Public Roads

The noise impact assessment outlined in Section 8.5.4 has demonstrated that mitigation measures are not required.

8.7 PREDICTED IMPACTS OF THE PROPOSED DEVELOPMENT

This section summarises the likely noise impact associated with the proposed development, taking into account the mitigation measures that will be implemented.

8.7.1 Construction Phase

During the construction phase of the project, there may be some impact on nearby residential properties due to noise emissions from site traffic and other construction activities. The proposed development site is in a semi-rural location with moderately high daytime ambient noise levels due to existing traffic. It is considered that the various noise sources will not be excessively intrusive on the local community.

It is predicted that construction noise related impacts would be short-term and not significant. Furthermore, the anticipated application of limits for hours of operation and the implementation of appropriate noise and vibration control measures as outlined in section 8.6.1, will ensure that noise and vibration impact is kept to a minimum.

8.7.2 Operational Phase

Process and Building Services Plant

As outlined in Section 8.6.2, mitigation measures will be employed to ensure that activities on site will not give rise to noise levels off site which exceed typical EPA Waste Licence daytime and night-time criteria of 55dB and 45dB L_{Aeq} respectively. The resultant noise impact from the proposed development on the local community will therefore not be significant.

Car Parking on Site

The predicted noise level associated with proposed car parking facilities is within the recommended criteria; therefore the impact is not significant and will not negatively affect the local community.

Vehicle Movements on Site

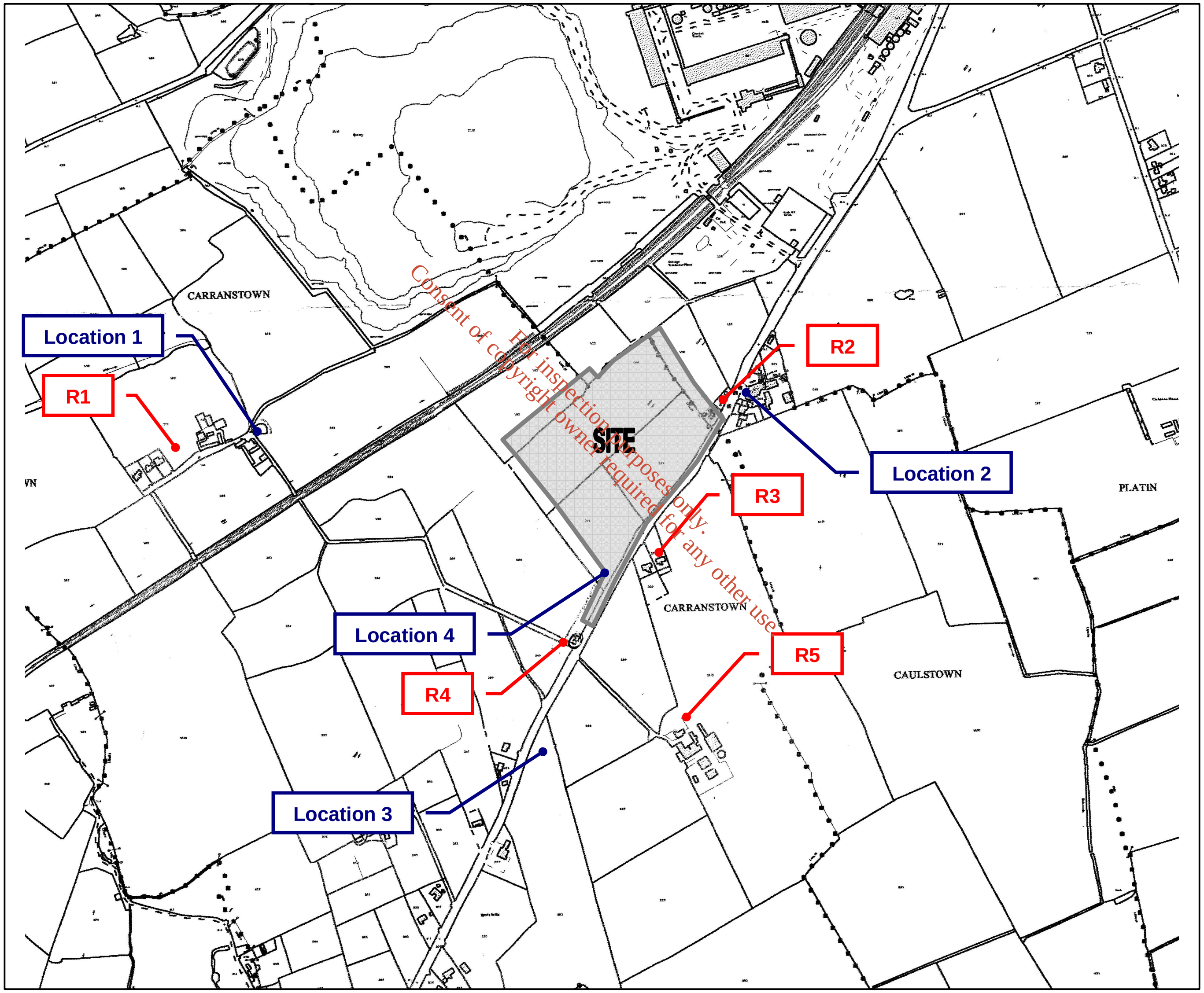
The predicted noise level associated with proposed vehicle movements on is within the recommended criteria; therefore the impact is not significant and will not negatively affect the local community.

Additional Vehicular Traffic on Public Roads

The increase in the level of road traffic noise adjacent to the majority of existing roads will be less than 1dB. The resultant noise impact is not significant and will not negatively affect the local community.

FIGURE 8.1

Site Layout Showing Noise Survey Locations and Noise Sensitive Locations Assessed



Appendix 8.1

Unattended Noise Monitoring results – Location 4

Day 1

Wednesday 12 October 2005

Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)					Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)				
	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
0:00	58	75	39	60	42	12:00	67	82	45	72	51
0:15	58	78	39	57	42	12:15	67	84	44	72	51
0:30	56	77	38	52	41	12:30	67	83	41	72	47
0:45	56	76	38	55	41	12:45	67	80	41	72	49
1:00	57	81	38	53	40	13:00	67	79	44	72	50
1:15	57	80	38	51	40	13:15	67	80	40	71	50
1:30	56	77	38	52	41	13:30	66	78	42	71	47
1:45	57	77	39	54	41	13:45	68	80	42	72	51
2:00	56	79	39	49	42	14:00	67	80	40	72	48
2:15	56	81	39	49	40	14:15	67	80	46	72	53
2:30	58	80	39	50	42	14:30	67	80	42	71	49
2:45	55	77	38	49	40	14:45	67	83	41	72	48
3:00	52	78	39	47	41	15:00	67	83	46	72	52
3:15	57	79	40	52	42	15:15	68	81	43	72	50
3:30	54	75	38	50	41	15:30	68	80	44	72	52
3:45	56	78	38	52	40	15:45	68	81	41	72	51
4:00	58	79	38	53	40	16:00	67	78	45	72	50
4:15	58	78	38	54	40	16:15	67	80	46	72	52
4:30	59	79	38	54	40	16:30	69	82	46	72	55
4:45	57	80	38	54	40	16:45	68	81	47	72	54
5:00	61	79	38	61	41	17:00	68	80	49	72	54
5:15	60	78	40	60	42	17:15	68	78	46	72	57
5:30	62	78	41	64	43	17:30	69	79	48	72	55
5:45	64	82	40	68	42	17:45	68	80	46	72	53
6:00	63	78	39	68	42	18:00	68	78	47	72	54
6:15	65	83	42	70	45	18:15	68	80	47	72	54
6:30	66	80	42	71	48	18:30	67	78	49	72	53
6:45	67	81	44	72	50	18:45	67	84	46	71	51
7:00	67	81	44	71	51	19:00	66	79	44	71	50
7:15	69	80	45	73	54	19:15	66	78	47	70	52
7:30	69	82	48	73	56	19:30	66	80	42	70	49
7:45	70	81	50	73	57	19:45	64	78	42	70	48
8:00	69	79	47	73	56	20:00	64	78	43	69	49
8:15	70	85	49	73	58	20:15	64	81	42	69	46
8:30	70	85	49	73	56	20:30	63	78	41	68	44
8:45	69	85	49	73	57	20:45	64	81	38	69	44
9:00	69	86	48	73	54	21:00	63	79	41	68	45
9:15	69	81	47	73	53	21:15	62	79	39	66	42
9:30	68	80	48	72	53	21:30	62	78	40	66	43
9:45	68	85	46	73	51	21:45	63	79	41	68	45
10:00	67	79	44	72	51	22:00	63	78	41	68	45
10:15	67	79	45	72	51	22:15	63	81	42	68	46
10:30	67	80	45	72	50	22:30	62	79	41	68	45
10:45	67	82	43	72	51	22:45	61	79	41	65	44
11:00	67	82	46	72	51	23:00	62	79	39	66	42
11:15	67	79	44	71	50	23:15	61	79	39	65	42
11:30	67	80	46	72	51	23:30	60	77	39	65	41
11:45	67	82	47	72	52	23:45	57	77	36	55	38

Day 2

Thursday 13 October 2005

Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)					Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)				
	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
0:00	58	79	34	58	37	12:00	67	83	41	71	49
0:15	60	80	36	60	38	12:15	67	80	42	71	49
0:30	58	79	36	59	39	12:30	66	78	43	71	49
0:45	57	76	37	56	40	12:45	67	81	44	72	51
1:00	60	80	38	59	40	13:00	67	81	41	71	48
1:15	56	77	35	54	38	13:15	68	81	41	72	49
1:30	55	77	36	52	38	13:30	67	82	40	71	50
1:45	54	75	33	51	36	13:45	67	81	42	71	49
2:00	57	79	34	51	36	14:00	66	78	42	71	50
2:15	54	77	34	46	36	14:15	67	80	42	72	50
2:30	53	78	34	43	35	14:30	67	80	39	71	50
2:45	48	74	35	43	37	14:45	67	82	40	71	50
3:00	55	78	34	48	36	15:00	68	81	42	72	50
3:15	50	78	34	42	36	15:15	67	79	39	71	50
3:30	55	79	33	50	35	15:30	67	79	42	72	51
3:45	53	77	33	45	35	15:45	67	82	41	72	49
4:00	56	78	34	50	36	16:00	67	81	43	72	50
4:15	56	77	35	48	37	16:15	68	81	45	72	53
4:30	57	78	36	50	38	16:30	67	81	43	71	50
4:45	57	79	34	53	37	16:45	68	82	41	72	51
5:00	60	79	36	60	39	17:00	68	80	46	72	54
5:15	61	79	37	59	40	17:15	68	79	47	72	55
5:30	63	80	41	64	43	17:30	69	84	46	72	56
5:45	64	80	42	68	44	17:45	69	81	48	73	58
6:00	62	79	42	66	45	18:00	69	92	49	72	56
6:15	65	78	44	70	48	18:15	69	92	41	73	53
6:30	66	83	44	71	48	18:30	68	81	46	72	53
6:45	67	81	47	71	51	18:45	68	82	50	72	56
7:00	67	80	48	72	53	19:00	68	79	46	72	54
7:15	68	80	47	73	53	19:15	67	79	47	71	55
7:30	69	85	49	73	55	19:30	66	78	48	71	53
7:45	70	84	52	73	58	19:45	66	78	46	71	52
8:00	70	86	49	73	57	20:00	66	81	47	70	53
8:15	69	81	49	73	56	20:15	66	79	45	71	52
8:30	69	79	49	73	55	20:30	65	82	46	70	50
8:45	70	82	53	73	58	20:45	65	78	46	70	51
9:00	68	79	48	72	54	21:00	66	79	47	71	51
9:15	69	81	49	73	54	21:15	66	78	47	70	52
9:30	69	82	51	73	54	21:30	65	81	48	70	51
9:45	67	80	47	72	52	21:45	65	78	47	70	51
10:00	68	82	44	73	52	22:00	64	80	45	69	49
10:15	67	81	42	72	50	22:15	64	77	45	69	49
10:30	68	84	45	72	49	22:30	62	77	46	68	49
10:45	67	79	44	72	50	22:45	63	78	45	68	48
11:00	67	80	45	72	51	23:00	63	79	45	67	47
11:15	67	84	41	71	49	23:15	63	79	45	67	48
11:30	67	82	39	71	49	23:30	61	79	46	64	48
11:45	67	81	43	72	51	23:45	62	79	41	65	47

Day 3

Friday 14 October 2005

Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)					Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)				
	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
0:00	60	78	41	63	44	12:00	67	85	40	71	48
0:15	59	75	43	61	46	12:15	66	82	40	71	47
0:30	59	79	41	58	43	12:30	67	80	41	71	48
0:45	60	79	43	60	46	12:45	68	89	42	72	51
1:00	58	79	42	57	44	13:00	67	80	40	71	50
1:15	57	75	42	54	44	13:15	67	82	42	72	47
1:30	59	79	41	60	44	13:30	68	80	44	72	51
1:45	57	78	44	55	46	13:45	68	79	47	72	52
2:00	58	79	41	54	44	14:00	67	80	42	71	51
2:15	56	78	42	52	44	14:15	68	79	42	72	51
2:30	56	78	38	54	42	14:30	66	80	43	71	49
2:45	56	76	39	51	40	14:45	67	79	43	72	50
3:00	58	79	38	56	40	15:00	68	81	46	72	52
3:15	59	80	41	58	43	15:15	69	81	44	72	53
3:30	54	77	41	49	42	15:30	68	80	47	72	52
3:45	58	80	40	53	42	15:45	69	80	46	72	54
4:00	57	79	41	54	43	16:00	69	81	46	73	53
4:15	56	78	41	52	43	16:15	67	78	42	70	53
4:30	59	78	40	58	43	16:30	68	82	49	72	55
4:45	60	79	39	58	41	16:45	68	80	45	72	55
5:00	61	80	41	61	43	17:00	69	78	47	72	55
5:15	62	80	42	63	44	17:15	69	83	45	73	56
5:30	63	81	41	66	46	17:30	69	79	47	72	57
5:45	63	79	41	66	45	17:45	69	81	47	72	55
6:00	63	79	43	68	47	18:00	68	79	45	72	54
6:15	66	79	45	71	50	18:15	67	80	43	72	51
6:30	66	80	40	71	49	18:30	67	79	40	71	52
6:45	67	79	43	72	52	18:45	67	81	45	71	52
7:00	68	89	50	72	55	19:00	66	90	44	71	52
7:15	68	83	48	72	56	19:15	66	78	42	71	51
7:30	70	83	53	74	59	19:30	66	82	43	70	50
7:45	70	81	48	73	60	19:45	65	77	41	70	50
8:00	70	86	54	74	59	20:00	65	81	39	70	46
8:15	70	83	50	74	59	20:15	65	90	37	69	48
8:30	70	85	51	74	57	20:30	65	83	38	70	46
8:45	69	79	48	73	55	20:45	64	77	42	69	49
9:00	69	80	44	73	52	21:00	65	77	40	70	47
9:15	68	81	43	72	50	21:15	64	80	38	69	46
9:30	68	84	42	72	49	21:30	65	81	39	69	46
9:45	67	79	39	71	49	21:45	64	80	40	69	46
10:00	68	84	44	72	49	22:00	64	80	39	69	49
10:15	67	81	43	72	51	22:15	62	81	39	67	47
10:30	67	81	43	71	50	22:30	63	79	38	68	43
10:45	68	79	44	72	52	22:45	63	82	36	67	40
11:00	67	89	36	72	48	23:00	61	78	34	65	38
11:15	68	80	44	72	51	23:15	61	79	32	66	38
11:30	67	79	43	72	49	23:30	60	79	35	64	39
11:45	67	83	42	72	50	23:45	59	76	31	63	34

Day 4

Saturday 15 October 2005

Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)					Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)				
	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
0:00	59	80	29	62	31	12:00	67	82	48	71	54
0:15	57	75	28	59	31	12:15	67	89	51	72	57
0:30	60	78	30	62	34	12:30	68	78	50	72	56
0:45	58	76	30	60	35	12:45	67	80	50	71	55
1:00	60	77	33	63	37	13:00	67	80	50	71	55
1:15	59	80	30	59	32	13:15	66	80	48	71	53
1:30	59	78	32	62	37	13:30	67	77	45	71	53
1:45	58	78	33	59	36	13:45	67	82	45	71	52
2:00	60	77	35	63	39	14:00	67	78	43	71	50
2:15	56	75	32	56	35	14:15	67	78	46	71	53
2:30	54	74	32	52	34	14:30	67	82	46	71	52
2:45	57	75	33	56	37	14:45	67	77	49	72	55
3:00	58	78	38	59	41	15:00	67	78	51	71	57
3:15	56	76	38	55	41	15:15	67	83	49	71	54
3:30	59	78	34	58	38	15:30	66	84	44	71	52
3:45	57	77	37	56	39	15:45	67	79	47	71	52
4:00	57	79	32	53	36	16:00	67	81	46	71	52
4:15	55	73	37	54	40	16:15	66	81	46	71	51
4:30	57	77	42	55	44	16:30	67	84	46	71	53
4:45	57	75	34	57	38	16:45	67	77	46	71	53
5:00	58	79	32	56	35	17:00	66	77	44	71	49
5:15	60	78	39	59	42	17:15	66	79	44	71	51
5:30	58	78	33	55	39	17:30	66	78	43	71	51
5:45	59	77	30	60	32	17:45	66	80	42	71	51
6:00	60	78	33	62	36	18:00	67	77	45	71	51
6:15	63	80	40	67	46	18:15	66	77	43	71	51
6:30	62	78	37	66	42	18:30	66	80	42	71	51
6:45	64	79	38	68	43	18:45	65	79	42	70	48
7:00	65	82	39	69	46	19:00	65	79	43	70	49
7:15	65	80	42	70	48	19:15	65	76	43	70	49
7:30	65	79	39	70	48	19:30	65	80	41	70	46
7:45	65	78	41	70	48	19:45	65	80	40	69	47
8:00	66	80	38	70	45	20:00	64	76	40	70	46
8:15	65	79	42	70	49	20:15	65	80	41	69	47
8:30	66	81	40	71	49	20:30	64	76	38	69	44
8:45	67	83	41	71	49	20:45	64	79	36	69	44
9:00	66	85	40	71	46	21:00	63	75	37	69	44
9:15	66	80	43	71	49	21:15	63	78	40	68	44
9:30	67	80	43	71	51	21:30	62	76	37	68	45
9:45	67	80	42	71	49	21:45	62	80	34	68	43
10:00	66	79	43	70	49	22:00	62	79	36	67	43
10:15	67	81	40	71	48	22:15	61	75	34	66	39
10:30	66	79	42	71	50	22:30	62	77	35	67	41
10:45	66	78	44	71	51	22:45	62	77	34	67	39
11:00	67	88	43	71	52	23:00	61	76	35	66	39
11:15	66	81	45	71	52	23:15	63	78	34	68	41
11:30	66	83	47	71	52	23:30	61	77	32	66	36
11:45	67	80	49	71	54	23:45	60	77	32	64	36

Day 5

Sunday 16 October 2005

Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)					Start Time (hh:mm)	Measured Noise Levels (dB re. 2x10^{-5} Pa)				
	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
0:00	60	77	34	64	38	12:00	66	91	39	70	49
0:15	61	78	36	64	41	12:15	65	78	41	70	49
0:30	60	77	37	64	40	12:30	65	76	42	70	49
0:45	60	76	35	65	40	12:45	65	79	41	70	49
1:00	58	79	36	58	39	13:00	66	90	44	70	50
1:15	60	76	35	63	37	13:15	66	77	41	70	49
1:30	59	79	35	61	37	13:30	66	78	42	71	50
1:45	60	79	34	63	37	13:45	67	79	43	71	51
2:00	59	79	33	59	36	14:00	66	77	41	71	50
2:15	59	76	33	61	35	14:15	66	77	43	71	51
2:30	56	74	33	56	36	14:30	66	79	40	70	49
2:45	56	76	34	55	36	14:45	66	78	42	71	48
3:00	57	76	34	54	36	15:00	66	77	40	71	52
3:15	60	76	36	63	38	15:15	66	78	43	71	50
3:30	59	77	35	60	37	15:30	66	76	45	71	51
3:45	60	77	35	64	38	15:45	66	76	43	71	50
4:00	59	80	34	61	36	16:00	66	83	43	70	50
4:15	57	75	34	58	36	16:15	66	76	40	71	51
4:30	58	77	33	58	36	16:30	66	76	43	71	50
4:45	55	74	33	51	35	16:45	66	87	40	70	48
5:00	56	74	35	55	36	17:00	65	75	41	70	50
5:15	55	76	34	51	36	17:15	66	76	41	70	47
5:30	53	72	33	49	36	17:30	66	80	41	70	48
5:45	53	76	33	45	35	17:45	66	76	43	70	49
6:00	54	74	33	51	35	18:00	66	75	41	70	49
6:15	58	77	35	59	36	18:15	65	75	44	70	48
6:30	59	85	35	56	38	18:30	65	79	42	70	49
6:45	59	78	33	60	36	18:45	66	89	44	70	48
7:00	56	77	34	53	36	19:00	65	76	43	70	49
7:15	59	77	36	62	38	19:15	65	78	42	69	47
7:30	61	77	36	65	40	19:30	64	76	45	69	49
7:45	62	77	38	66	42	19:45	64	75	44	69	48
8:00	62	77	38	66	44	20:00	64	80	42	69	47
8:15	59	76	36	62	41	20:15	64	79	43	69	48
8:30	60	76	36	63	42	20:30	63	77	43	68	46
8:45	61	77	35	65	41	20:45	63	77	43	68	46
9:00	60	78	32	62	36	21:00	63	77	42	69	46
9:15	60	77	33	64	37	21:15	62	78	40	67	44
9:30	62	77	34	67	40	21:30	63	79	41	68	45
9:45	62	75	35	67	41	21:45	62	79	36	67	41
10:00	62	76	34	68	41	22:00	60	81	34	65	37
10:15	64	78	37	69	43	22:15	61	79	37	66	42
10:30	64	81	36	69	43	22:30	60	75	34	65	39
10:45	64	82	35	69	44	22:45	61	75	35	66	38
11:00	64	76	38	69	45	23:00	60	78	35	63	37
11:15	65	90	35	69	44	23:15	60	79	33	62	36
11:30	65	78	37	70	45	23:30	59	76	35	61	38
11:45	65	79	39	70	46	23:45	60	77	32	64	36