PART III

ENVIRONMENTAL ASSESSMENT

TEXT PRINTED ON RECYCLED PAPER

9.0 AIR & CLIMATE

SCOPE OF STUDY

9.1 This chapter provides an air and climate impact assessment for the proposed extension to the existing landfill site at Ballynacarrick.

9.2 The aim of this assessment is to estimate the extent of gas emissions and their potential impact on the surrounding environment in terms of lateral migration, atmospheric dispersion and global warming; and to propose appropriate mitigation measures.

9.3 This chapter consists of the following:

- Definition of the Potential Emission Sources that can occur from landfill site activities;
- Description of the existing environment in the vicinity of the proposed site in terms of climate, air quality, landfill gas emissions, dust and odour;
- Prediction of airborne emissions resulting form the proposed extension and an assessment of their impacts on the surrounding environment; and
- Identification of both short-term construction and long-term operational emission sources and mitigation measures that are to be employed to moderate air quality impacts.

POTENTIAL EMISSION SOURCES

9.4 This section provides background information on the potential emissions that can occur during landfill site activities. This will address aspects such as landfill gas, flare gas, traffic fumes, dust and odours.

Landfill Gas

9.5 Landfill gas is produced by the decomposition of the organic fraction of waste materials deposited in landfill sites. The main constituents of landfill gas are Methane (CH_4) and Carbon Dioxide (CO_2), with numerous trace gases also present in low concentrations. The majority of the trace gases are Non Methane Volatile Organic Compounds (NMVOC's).

9.6 The rate of decomposition varies from site to site, depending on the types of waste accepted and operational procedures. The speed and degradation of waste and the amount of landfill gas produced is a function of the physical dimensions of the site and conditions within the site, such as depth, temperature, moisture content, pH, waste density and nutrient content.

9.7 There are five stages in the decomposition of waste. Landfill gas will not be produced until the third stage is reached.

- **Phase I**: Aerobic decomposition of biodegradable materials; entrained atmospheric oxygen is converted to carbon dioxide.
- **Phase II**: Anaerobic decomposition commences as oxygen is used up; carbon dioxide concentration increases and some hydrogen is produced; no methane is produced at this stage.
- **Phase III**: Anaerobic methane production commences and rises to a peak; concentration as carbon dioxide declines; hydrogen production ceases.
- **Phase IV**: Steady methane and carbon dioxide generation in proportions of between 50-70% and 30-50% respectively.
- **Phase V**: Steady decline in generation of methane and carbon dioxide; gradual return to aerobic conditions.

9.8 The progression from Stage I to Stage III typically takes between 3 to 18 months and it is approximated that 50% of the available landfill gas will be generated within 5 to 15 years of the waste being deposited. However, traces of landfill gas may still be produced many decades after the closure of the landfill site.

9.9 Table 9.1 illustrates the typical landfill gas composition published by the Environmental Protection Agency.

Table 9.1 Typical Landfill Gas Composition

Component	Typical Volume (%)	Max Volume (%)
Methane	63.8	88.0
Carbon Dioxide	33.6	89.3
Oxygen	0.16	20.9
Nitrogen	2.4	87.0
Hydrogen	0.05	21.1
Carbon Monoxide	0.001	0.09
Ethane	0.005	0.0139
Ethene	0.018	
Acetaldehyde	0.005	
Propane	0.002	0.0171
Butanes	0.003	0.023
Helium	0.00005	
Higher Alkanes	<0.05	0.07
Unsaturated Hydrocarbons	0.009	0.048
Halogated Hydrocarbons	0.00002	0.032
Hydrogen Sulphide	0.00002	35.0
Organosulphur compounds	0.00001	0.028
Alcohols	0.00001	0.0127
Others	0.00005	0.023

Source: Environmental Protection Agency (EPA), Landfill Manuals, Landfill Site Design (2000)

Flare Gas

9.10 The purpose of a flare system is to burn landfill gas that might otherwise be vented into the atmosphere. This serves to reduce air emissions, control odours, and prevent off-site migration. A landfill gas flare can reduce the uncontrolled migration of landfill gas, decrease greenhouse gas emissions and contributes to the broader objectives of sustainable development. The main gas emissions that will need to be considered from the flaring system are as follows:

- **Carbon dioxide (CO_2)**

  The carbon dioxide is generated from the combustion of the methane, as illustrated to this reaction:

  $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

- **Hydrogen chloride/Hydrogen Fluoride (HCl/HF)**

  Landfill gas contains small amounts of halogenated organic compounds. When combusted these will generate acid gases, including hydrogen chloride. The concentration of this gas will depend upon the landfill gas composition.

- **Nitrogen oxides (NOx)**

  The principal oxide of nitrogen formed in combustion processes is nitric oxide (NO). Some NO may be converted to nitrogen dioxide (NO_2), the mixture being referred to as NOx.

- **Sulphur Oxides (SOx)**

  The oxides of sulphur are formed from the oxidation of trace quantities of sulphur compounds in landfill gas.

- **Carbon monoxide (CO)**

  Carbon monoxide is the primary product of hydrocarbon oxidation and its concentration decreases by a relatively slow reaction, which forms CO_2. This is the ultimate product of carbon fuel combustion and its formation can not be avoided. Carbon monoxide can also be emitted from combustion plant as a consequence of incomplete combustion.

Traffic Fumes

9.11 Traffic fumes arise from vehicles associated with the construction and operation of the site. The compounds released into the air by vehicles give rise to a variety of environmental effects over different geographical ranges and time periods. The combustion of a hydrocarbon fuel in air produces mainly carbon dioxide (CO_2) and water vapour. However combustion engines are not 100% efficient, and some of the fuel is not burnt or only partially burnt, which results in the formation of organic compounds, carbon monoxide (CO) and particulates. In addition, at the high temperatures and pressures found in the combustion chamber, some of the nitrogen in the air and fuel is oxidised, forming nitric oxide (NO) and nitrogen dioxide (NO_2). These compounds are covered by the Air Quality standards described in section 9.30.

Dust

9.12 Dust is generally described as particulate matter in the size range 1 – 75μm. PM_{10} (particulates of a 10μm diameter or less) have the greatest impact on health issues and is therefore considered in the Air Quality Standards applicable in Ireland. There are a number of activities on a landfill site that could give rise to dust emissions, as follows:

- construction works;
- depositing of waste;
- depositing of cover materials; and
- general vehicle traffic within the site.

Odour

9.13 The main source of odour in landfill sites is from landfill gas emissions, but can also arise from the storage and recirculation of leachate in landfill sites and the deposition of malodorous wastes.

9.14 The landfill gas composition includes a range of trace compounds, including oxygenated and sulphonated organics and inorganics such as hydrogen sulphide (0 – 2% dry volume), mercaptans, hydrocarbons and aliphatic organic acids. These compounds are indicative of the early anaerobic stages of the waste degradation process. Several of these components are odorous with varying odour threshold concentrations, producing unpleasant/nuisance odours in the vicinity of landfill sites.

9.15 Hydrogen sulphide is a flammable gas, with a characteristic odour of 'rotten eggs'. It is perceptible in air at concentrations greater than 0.47parts per billion (ppb) (0.66μg/m^3).

9.16 Mercaptans (thiols) is the collective name for group of compounds containing the functional group –SH (sulphur hydrogen), such as methyl mercaptans (methanethiol) (CH3SH). Each mercaptan has varying characteristics. Methyl mercaptan for example, is a flammable gas, with a characteristic odour of 'rotten cabbage'. It is perceptible in air at concentrations greater than 2.1ppb (4.2μg/m^3). Ethyl mercaptan, which has similar characteristics to methyl mercaptan, has an odour threshold concentration of 1ppb (2.5μg/m^3).

9.17 Odour threshold levels for odorous components, which indicate the lowest concentration of a vapour or gas in air that can be detected by smell, are summarised in Table 9.2.

9.18 Organic acids have varying characteristics. The most common, acetic acid, is perceptible in air at concentrations greater than 1,000 ppb (2,500μg/m^3).

Table 9.2 Odour thresholds of specific compounds of interest

Compound	Odour threshold
Hydrogen Sulphide (H_2S)	0.66 µg/m^3 (0.4 ppb)
Methyl mercaptan	0.04 µg/m^3 (0.02 ppb)
Butyric acid	1 µg/m^3 (0.27 ppb)

(Ruth, Jon H. (1986) Odour Thresholds and Irritation Levels of Several Chemical Substances: A Review. Am. Ind. Hyg. Assoc. J., 47, 142-151)

DESCRIPTION OF EXISTING ENVIRONMENT

9.19 The existing landfill site occupies an area of approximately 5.5 hectares and has an estimated lifespan of 25 years since it was opened in 1980. The site is situated in a rural area, approximately 3km south of Ballintra, Co Donegal and is bounded to the south and east by minor roads and on the remaining sides by rough and unimproved grassland. Housing density in the area is low with only eight occupied dwellings within 500 metres of the landfill site, as shown in Figure 9.1.

9.20 The site is licensed to take non-hazardous household wastes, commercial wastes, non-hazardous construction and demolition wastes. The existing site was licensed in 2000 by the Environment Protection Agency with a maximum tonnage of 24,000 tonnes. The following section highlights the existing conditions at the Ballynacarrick landfill site.

Existing Climate

9.21 The meteorology of the Ballintra area, where the landfill site is located, is typical of coastal sites on the western seaboard of Ireland. The weather is predominantly marine and characterised by mild conditions, with no extremes of wind, rain or temperature. The area in the immediate vicinity of the site is rural and there is no evidence of a significant microclimate.

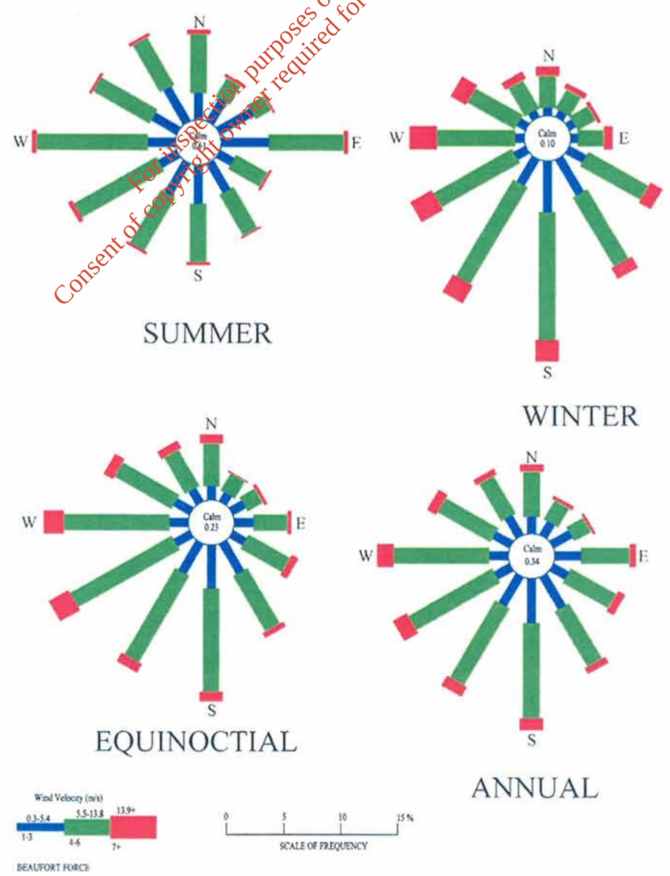
9.22 Rainfall data available from rainfall stations in south Donegal are summarised in Table 9.3.

9.23 The data illustrates that rainfall is distributed uniformly throughout the year. The months of October to January are the wettest with a mean rainfall of 107-140 mm/month, with April to July being the driest months with a mean rainfall of 57-89 mm/month. The annual rainfall at the site is likely to vary between 1,082 mm/yr and 1,264 mm/yr.

Table 9.3 Monthly and Annual Rainfall Averages (mm) 1961-1991

Location	Elevation (mOD – Malin Head Datum)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ballintra	40	129	85	104	67	75	86	85	113	123	140	132	123	1264
Ballyshannon (Cathleen's Fall)	38	109	75	88	57	68	74	73	99	103	118	111	107	1082
Ballyshannon (Cherrymount)	30	115	78	92	59	72	79	77	105	109	123	117	111	1136
Ballyshannon (Cliff House)	50	122	86	101	66	79	85	84	110	114	133	126	122	1227

9.24 The long-term patterns for wind direction and speed were obtained from the nationally verified meteorological data collected in Malin Head. The predominant winds m.easured at this site were from the south and south westerly directions and with speeds of 5.5 to 13.8 m/s. Annual wind roses for Malin Head are shown below.



Malin Head Wind Roses
(1980 -1999)

9.25 Mean monthly air temperatures were measured at Ballyshannon, 10 kilometres away from the site and are detailed in Table 9.4 below. The coldest months are December to February with mean temperatures varying from 4.8°C to 5.8°C while the warmest months are June to September with mean temperatures of 13.0°C to 15.0°C. The mean temperature for the year is 9.4°C.

Table 9.4 Mean Monthly Air Temperatures (1968-1997) at Ballyshannon, Co Donegal

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temp (°C)	4.8	4.8	6.3	8.0	10.6	13.0	15.0	14.8	12.7	10.2	7.1	5.8	9.4

9.26 The average relative humidity (%) at the site would be similar to coastal sites on the western or northern seaboard. Table 9.5 presents mean monthly humidity data for Finner Camp, Co Donegal, located near Ballyshannon and around 11 km away from the Ballynacarrick landfill site, for year 2001.

Table 9.5 Averages of Relative Humidity (%) at Finner Camp, Co Donegal (2001)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average % Humidity	83.8	82.7	80.4	82.4	82.7	79.5	86.8	83.0	83.0	86.1	83.3	82.0	83.0

Existing Air Quality

9.27 In order to predict the effects on air quality of the construction, operation and restoration of the proposed landfill extension, the existing levels of air quality were determined.

9.28 The local baseline air quality was assessed from on site sampling, information provided by the Environmental Protection Agency (EPA) and are summarised in Table 9.5. The monitoring undertaken by the EPA was based throughout Ireland, mainly in urban areas such as Dublin and Cork, which contain large volumes of traffic and which indicate that the mean concentrations of the pollutants are significantly higher than those in the vicinity of the existing landfill site.

9.29 However, baseline air quality in Ireland does not include the monitoring of gases in isolated areas, therefore rural background levels from the UK National Air Quality Information Archive were collected to evaluate the likely baseline air quality in the vicinity of the landfill site.

Table 9.6 Baseline Levels of Air Pollutants

Pollutant	Year	Annual Mean Concentration ($\mu g/m^3$)	Source
PM10	1996	12.0	Rural Location, UK
	1999	18.0	Rathmines Road, Dublin (Urban Background Concentration), EPA
NO_2	1996	9.6	Rural Location, UK
	1999	15.0	Rathmines Road, Dublin (Urban Background Concentration), EPA
SO_2	1996	5.4	Rural Location, UK
	1999	7.0	Wicklow
	1999	19	Dublin County
CO	1996	230	Rural Location, UK
Benzene	1996	0.23	Rural Location, UK

9.30 These baseline levels were compared with existing Irish Air Quality Standards, referenced in the EPA Air Quality Monitoring Annual Report (1999), and are listed below.

- **Sulphur Dioxide and Black Smoke**

  The air quality standards follow the EC Directive 80/779/EEC on air quality limit values for SO_2 and suspended particulates as black smoke, as shown in the Table 9.7

- **Particulates**

  The Irish standard for Particulate Matter PM_{10} is 50 $\mu g/m^3$, corresponding the daily mean limit value established in the Air Quality Daughter Directive 1999/30/EC, (CEC, 1999).

- **Nitrogen Dioxide**

  The EC Directive 85/203/EEC on air quality standards for nitrogen dioxide (NO_2) sets a limit value of 200 $\mu g/m^3$ in respect of the 98th percentile of hourly values in the calendar year. The Irish Air Quality standard for NO_2 was based on the European Directive (DoE, 1988). This Directive also prescribes guide values of 135 $\mu g/m^3$ for the 98th percentile limit of 50 $\mu g/m^3$ in respect of the annual median.

- **Carbon Monoxide**

  For carbon monoxide (CO), the European Commission (EC, 1998) has proposed a limit value of 10 mg/m^3 (8.7 ppm) applied to the maximum daily eight-hour mean selected by examining eight-hour running averages. However, there are currently no Irish or EU standards in force for carbon monoxide.

Table 9.7 Air Quality Standards for Sulphur Dioxide (SO_2) and Smoke

	Limit Value for SO_2 ($\mu g/m^3$)	Associated Smoke ($\mu g/m^3$)	Limit Value for Smoke ($\mu g/m^3$)
Annual Median of Daily Mean Values	80	>40	80
	120	= or <40	
Winter Median of Daily Mean Values	130	>60	130
	180	= or <60	
98-percentile of Daily Mean Values	250	>150	250
	350	= or <150	
Not more than three consecutive days	250	>150	250
	350	= or <150	

9.31 The main aim of these standards is to protect human health and the environment.

9.32 The perceived existing levels of air quality, particular, in terms of Particulates PM_{10}, Nitrogen Dioxide, Carbon Monoxide and Sulphur Dioxide concentrations, are well below the Irish Air Quality Standards in the vicinity of the existing landfill site.

Existing Landfill Gas Emissions

9.33 Landfill gas emissions were monitored at Ballynacarrick, as part of a gas control measure, to quantify the landfill gas composition and assess the landfill gas lateral migration on the site. The landfill gas composition at Ballynacarrick was measured in 2001 and 2002 at different gas monitoring points placed at the existing landfill site. The locations of the landfill gas monitoring points are shown in Figure 9.3 with the associated results summarised in Table 9.8 below.

Table 9.8 Landfill Gas Monitoring Results – Existing Landfill Site

2001						
Parameters	**LG1**	**LG3**	**LG4**	**LG5**	**LG6**	**LG7**
Methane (% v/v)	58.45	64.72	61.65	53.41	64.71	58.54
Carbon Dioxide (%v/v)	40.30	31.90	36.14	36.47	32.25	37.54
2002						
Parameters	**LG1**	**LG2**	**LG4**	**G5**	**LG6**	**LG7**
Methane (% v/v)	62.63	57.8	62.45	62.1	62.88	60.3
Carbon Dioxide (%v/v)	37.3	37.9	36.5	38.17	36.8	36.6

9.34 All wells are actively producing landfill gas and the results are within the parameters of an active landfill. The composition of landfill gas in terms of methane and carbon dioxide emissions at the existing Ballynacarrick landfill site is similar to a typical landfill gas composition as shown in Table 9.1.

9.35 There are no regulations regarding the landfill gas emissions from landfills. However, the Environmental Protection Agency (EPA) imposes limits for landfill gas concentrations measured in any building on or adjacent to the facility and are as follows:

Table 9.9 Landfill Gas Concentration at Receptor Points

Methane (CH_4)	Carbon Dioxide (CO_2)
20% LEL (1% v/v)	1.5% v/v

9.36 Landfill gas levels are continuously monitored at the site office as a safety measure. Considering the above limits, no landfill gas has been detected at the site office during the operational activities of the existing landfill site.

Existing Landfill Gas Management

9.37 **Lining System**: The majority of the existing landfill site has no lining system. However, the last phase of the existing site to be filled and completed by 2005 is a fully engineered phase that contains a composite lining system.

9.38 **Capping System**: Prior to October 2002, landfill gas was vented trough the temporary clay cap. However, a temporary passive venting system was installed in October 2002 on the existing landfill site. The passive venting system, shown in Figure 9.2 will be a temporary solution to control the surface migration of landfill gas as it is planned to install in 2004 an active-gas extraction system. The collected gas will be piped from the wells to a gas flare stack in the south-eastern corner of the site.

9.39 A permanent capping system is due to be installed on the site and this will result in a reduction in the emissions of methane and carbon dioxide through the surface. The cap will comprise a gas collection barrier layer and a surface water collection layer and will be restored as detailed in section 8.0.

Existing Dust Emissions

9.40 Dust monitoring on the landfill site has been carried out at one location of the site three times per year at the required times between May and September. Additional monitoring points were later included over the whole landfill site, as shown in Figure 9.3, including the proposed location of the extended landfill area. The results, shown in Table 9.10 are generally within the dust deposition limit of 350 mg/m^2/day as set out in of the licence except for monitoring point DG1 in 2002. The high level of dust deposition at this specific location is mainly due to the prevailing south and southerly winds and should be reduced by implementation of appropriate mitigation measures detailed in this chapter.

Table 9.10 Dust Monitoring Results at Ballynacarrick Landfill Site

Date	Monitoring Point	mg/m^2/day
1 June 2001	DG1	74
6 July 2001	DG1	317
3 August 2001	DG1	140
25 October 2002	DG1	482
	DG2	24
	DG3	20
	DG4	29

Existing Odour Emissions

9.41 The types of compounds associated with malodours include methane, hydrogen sulphide and organic sulphides (mercaptans). It is possible that during prevailing wind directions, especially on warm summer days, malodours may extend beyond the boundary and may be detected some distance downwind from the filling operation.

9.42 Measurements assessing the concentrations of trace gases, including hydrogen sulphide, mercaptans and aliphatic acids, were undertaken by Bord Na Móna from the 20 November to 4 December 2002. The sampling locations on the Ballynacarrick landfill site (AM-01 to AM-04), as illustrated in Figure 9.3, were established considering the site layout, local meteorological conditions (prevailing winds are south to south westerly in direction) and the location of the nearest dwellings from the landfill site. A brief description of each location is provided in Table 9.11 and Table 9.12 summarise the results.

Table 9.11 Monitoring Locations

SAMPLING LOCATIONS	
Location	**Description**
AM-01	North-eastern corner of existing site, adjacent permanent dust gauge DG2 and close to dwellings
AM-02	East of Current infill area on existing site, close to the end of internal site road.
AM-03	Immediately west of current infill area
AM-04	Centre of proposed site extension area – green field west of existing site

Table 9.12 Trace Gas Monitoring Results

Contaminant	AM-01	AM-02	AM-03	AM-04	Limit Value1	Threshold Value
H_2S (ppb)	0.554	<0.163	<0.163	<0.163	0.66	0.4
Total Mercaptans (ppb)	<0.8	<0.8	<0.8	<0.8	-	0.02
2-Propanethiol (ppb)	<0.05	<0.05	0.07	0.05	0.06	-
Total Organic Acids (ppb)	0.069	0.006	0.069	0.44	-	-

Notes: 1. In the absence of Irish/EU/international air quality limit value for H_2S in ambient air, comparison of the concentration obtained is made to the Danish EPA Industrial Air Pollution Control Guidelines C-Values, which stipulate maximum ground level concentrations for a number of pollutants based on their knowledge of how each substance can be injurious to health and environment with long-term exposure.
2. Of those organic acids detected at concentrations greater than the analytical limit of detection, a C-value of 100µg/m3 (40ppb) exists for acetic acid only.

9.43 The hydrogen sulphide level at location AM-01 is below limit value . However, if the odour threshold concentrations summarised in Table 9.2 are considered, the hydrogen sulphide level at AM-01 is slightly higher than the odour threshold concentration of 0.4 ppb. Hydrogen sulphide may therefore be perceptible to the human nose at this location under favourable meteorological conditions.

IMPACT OF THE PROPOSED EXTENSION ON EXISTING AIR EMISSIONS

Introduction

9.44 The proposed extension will have an approximate area of 3.5 hectares. It will contain four cells with a lifespan estimated to be 8 and a half years and will increase the capacity of the landfill site with an annual waste input of around 24,000 tonnes per annum. The active gas extraction system, planned to be installed on the existing site in 2004, should be extended into the extension site once the cells are completed.

9.45 The proposed extension will be a contained site, including a composite lining system and a permanent capping system with a gas collection layer.

Landfill Gas Emissions

9.46 The generation of landfill gas emitted from the existing site and the proposed extension was calculated using GasSim, a computer-modelling package developed by Golder Associates and Land Quality Management on behalf of the Environment Agency. GasSim has been developed as a management tool to provide probabilistic quantitative assessment of the performance of a specific landfill site. The calculations considered the tonnage, the mix (breakdown), composition and moisture content of wastes in the landfill site. The model also takes account of the degradation rates of the different types of waste on a landfill site.

9.47 The model is based on degradation following a first-decay equation that calculates the landfill gas generation for up to 200 years. The model takes this output and uses it to calculate landfill gas emissions in terms of bulk and trace gases to the environment after allowing for landfill gas collection, flaring, utilisation (energy recovery) and biological methane oxidation. This is undertaken by using information on the site gas collection system, flare, engine and engineered barriers (cap and liner).

9.48 GasSim is designed to simulate landfills for risk assessments based on the use of Probability Density Functions that allow the model to show the full range of possible results and combinations of different input ranges. The results of air emissions calculated in this model are therefore shown in terms of percentile. The Environment Agency commonly considers the 95% to be a reasonable assessment level in the GasSim Assessment. This percentile will be considered in the results for this impact assessment.

9.49 The production of landfill gas was assessed for the existing site, the proposed extended area and the whole landfill site (including the existing site and the extension) with the use of different parameter inputs, regarding the infiltration, the landfill site and the waste characteristics.

9.50 The infiltration is defined as the effective rainfall entering the waste (i.e. rainfall less runoff, evaporation and transpiration). The infiltration rate depends on the proportion of the landfill that is capped, the nature and age of the cap. A low infiltration rate of 68mm/year, as 10% of the effective rainfall, was considered for this study, assuming that the whole landfill site was a fully restored capped area, which is mostly the case during the 70-year simulation period.

9.51 The characteristics of the site were used in the model, including the landfill geometry and the engineering systems.

9.52 Inputs of waste tonnage deposited for each operational year, were also taken into account in the model.

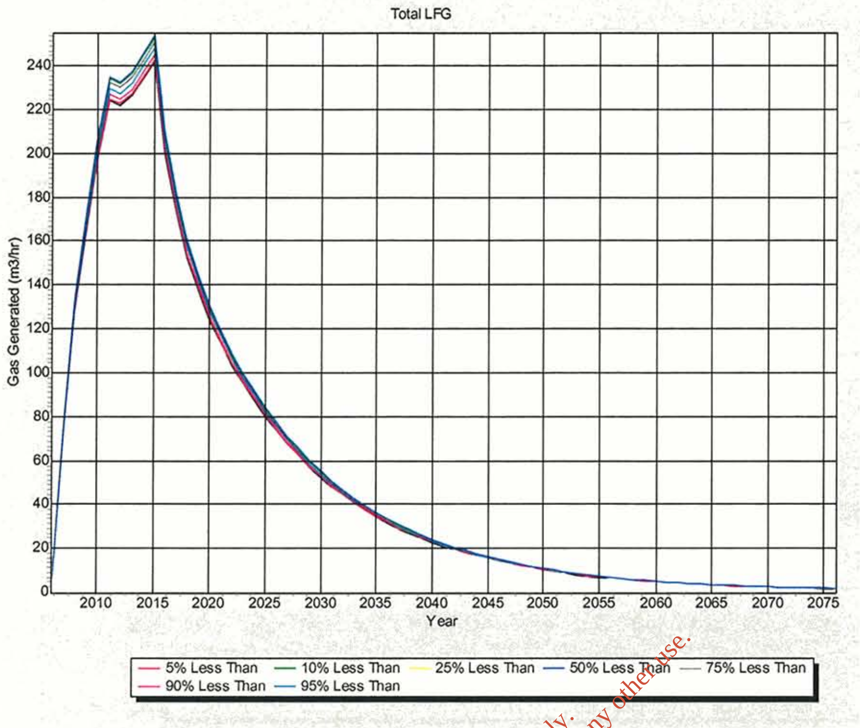
9.53 Table 9.13 summarises the parameters used in the analysis.

Table 9.13 GasSim Parameters for the calculation of landfill gas emissions

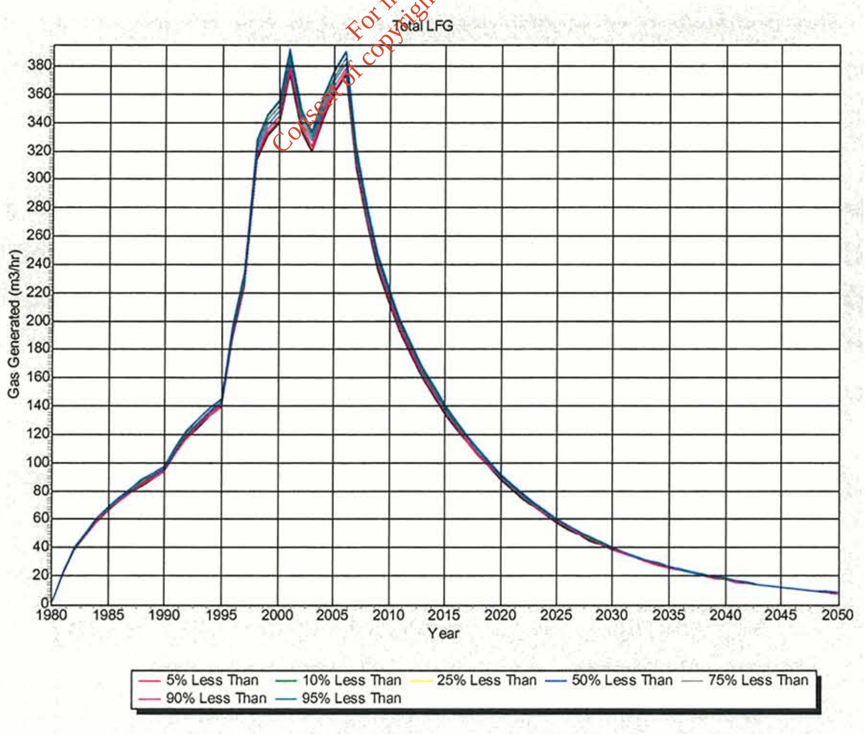
	Existing landfill site	Proposed Extension	Proposed Landfill site (existing + extension)
Year of Opening	1980	2006	1980
Year of Closure	2005	2012	2012
Operational Period	25 years	7 years	32 years
Simulation Period	70 years	70 years	70 years
Infiltration Rate	50 mm/year		
Waste Input	24,000 tonnes/year	24,000 tonnes/year	24,000 tonnes/year
Waste Composition	71% Domestic 27% Commercial 2% Inert		
Site Area	46,000 m^2	32,800 m^2	78,800 m^2
Landfill gas composition	% CO_2 = 36.5%< <38.2% % CH_4 = 57.8%< <62.9% Average of Landfill Gas Monitoring Results 2002		
Lining System	None	Composite basal lining system including: 2 mm HDPE Membrane 500 mm bentonite soil, k $\leq 1 \times 10^{-10}$ m/s	Combination
Capping System	Permanent capping system Geosynthetic Clay Liner (GCL) and Geonet Gas Collection Layer		

9.54 Graphs 9.1, 9.2 and 9.3 illustrate the landfill gas emissions (m^3/hr) from the proposed extension, the existing and proposed landfill sites, calculated with the GasSim model. The results from the simulation show that the production of landfill gas increases by up to **7.5%** if the extension is included compared to the existing site. Considering the worst-case scenario, the landfill gas emission peak for the existing site is around 380m^3/hr in 2006. However, if the extension is included, the landfill gas emission peak is predicted to be in 2010, with a rate of 430m^3/hr. The landfill gas emissions decrease by 13% in 2003, which corresponds to the installation of the permanent capping system on the existing landfill site.

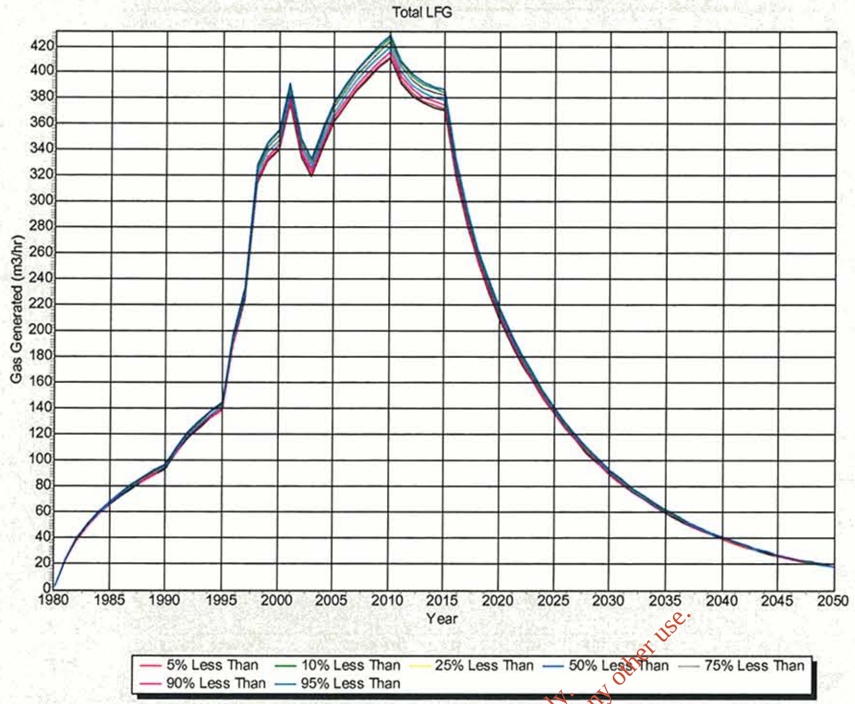
Graph 9.1 Production of Landfill Gas from the Proposed Extended Area



Graph 9.2 Production of Landfill Gas for the Existing Site (Without proposed Extension)



Graph 9.3 Production of Landfill Gas for the Proposed Site (Including Proposed Extension)



Gas Flare Emissions

9.55 The existing gas extraction system will apply to the extended area once the cells are completed. The combustion of landfill gas reduces the risk of uncontrolled landfill gas emission and explosion. However, the potential health and environmental impacts from any flaring systems also have to be taken into account.

9.56 The extended area will result in an increase in landfill gas emissions, therefore augmenting the formation of gaseous pollutants from the combustion process. However, the flare stack will be designed in order to meet the standards published by the Environmental Protection Agency when referred to Normal Temperature and Pressure (NTP = 0°C and 1013 mbar) and 3% oxygen and shown in Table 9.14.

Table 9.14 Emission Limit Values for Landfill Gas Flare Unit

Gas Emitted	Limit Value
Carbon Monoxide	50mg/m^3
Oxides of nitrogen (NOx)	150 mg/m^3
Particulates	130 mg/m^3
TA Luft Organics Class I	20 mg/m^3 (at mass flows > 0.1 kg/hr)
TA Luft Organics Class II	100 mg/m^3 (at mass flows > 2 kg/hr)
TA Luft Organics Class III	150 mg/m^3 (at mass flows > 3 kg/hr)
Hydrogen Chloride	50 mg/m^3 (at mass flows > 0.3 kg/hr)
Hydrogen Fluoride	5 mg/m^3 (at mass flows > 0.05 kg/hr)

Source: EPA, Ballynacarrick Landfill Site, Waste Licence (24-1)

Traffic Fumes Emissions

9.57 The Ballynacarrick landfill site is accessed from a third-class road running between Knockaglantane and Ballintra via the N15. Entrance to the proposed waste management facility will be similar as for the existing landfill site. There are several properties situated nearby the roads in the vicinity of the landfill and these dwellings have the greatest potential to be affected by emissions from traffic associated with the existing and proposed waste management facility.

9.58 **Road Traffic Assessment**: A road traffic screening study has been carried out to predict the levels of pollutants at the closest properties to the roads nearby the landfill site, including the Site Access road and two third-class local roads. The methodology for this study is, in the absence of Irish guidance, based on UK Government guidance on assessing the air quality effects of road traffic (Design Manual for Road and Bridges). This assessment considers those pollutants associated with vehicle motor exhausts which are covered by the Irish Air Quality Standards:

- Nitrogen Dioxide (NO_2);
- Carbon Monoxide (CO);
- Benzene;
- 1,3-Butadiene;
- Particulates (PM_{10}).
- The methodology considers three main factors. These are:
- Vehicle flows;
- Vehicle speeds;
- Distance of the sensitive receptors from the roads considered (approximately 10m)

9.59 Peak traffic flows were considered as a worst-case scenario. The resultant predictions were compared with the requirements of the EU Air Quality Directives. The assessment was carried out on three roads nearby the existing landfill site that are more likely to be affected by the traffic due to the extension construction. .

9.60 Table 9.15 shows the highest ambient concentration calculated with the DMRB assessment for each pollutant.

Table 9.15 DMRB Assessment Results

Substance	Location of highest concentration	Statistic	Air Quality Standards	Predicted Highest Concentration at Sensitive Receptor Point (2004)	
				Existing	Existing & Extension
Carbon Monoxide	Site Access	Max 8 hour mean	11.60 mg/m^3	1.70 mg/m^3	1.71 mg/m^3
Nitrogen Dioxide	Site Access	Annual Mean	40 $\mu g/m^3$	16.74 $\mu g/m^3$	17.79 $\mu g/m^3$
		99.8^{th} percentile of 1 hour means	200 $\mu g/m^3$	73.45 $\mu g/m^3$	77.30 $\mu g/m^3$
Particulate PM10	Site Access	Annual Mean	40 $\mu g/m^3$	6.19 $\mu g/m^3$	6.33 $\mu g/m^3$
		90.4^{th} percentile of 24 hour means	50 $\mu g/m^3$	11.07 $\mu g/m^3$	11.33 $\mu g/m^3$
Benzene	Road to Ballintra	Annual mean	16.25 $\mu g/m^3$	0.89 $\mu g/m^3$	0.90 $\mu g/m^3$
1,3 Butadiene	Road to Ballintra	Annual mean	2.25	0.1231 $\mu g/m^3$	0.1242 $\mu g/m^3$

9.61 The results indicate that the increase in traffic generated by the proposed development will lead to a minor and insignificant increase in pollutant concentrations at the receptor nearest to the landfill site access and the road section from the landfill site forwards Ballintra.

Impact of Air Emissions on the Surrounding Environment

Lateral Migration

9.62 Although the proposed site will be equipped with an active gas extraction system, a small amount of this gas will be uncollected in the capped area and will result in uncontrolled emissions from the cap and/or lining system. The quantity of emission through both the cap and liner are determined by the permeability and thickness of the most impermeable layer within each construction.

9.63 The calculation of the uncontrolled lateral emissions took into account:

- the liner thickness;
- the liner hydraulic conductivity; and
- the site dimensions.

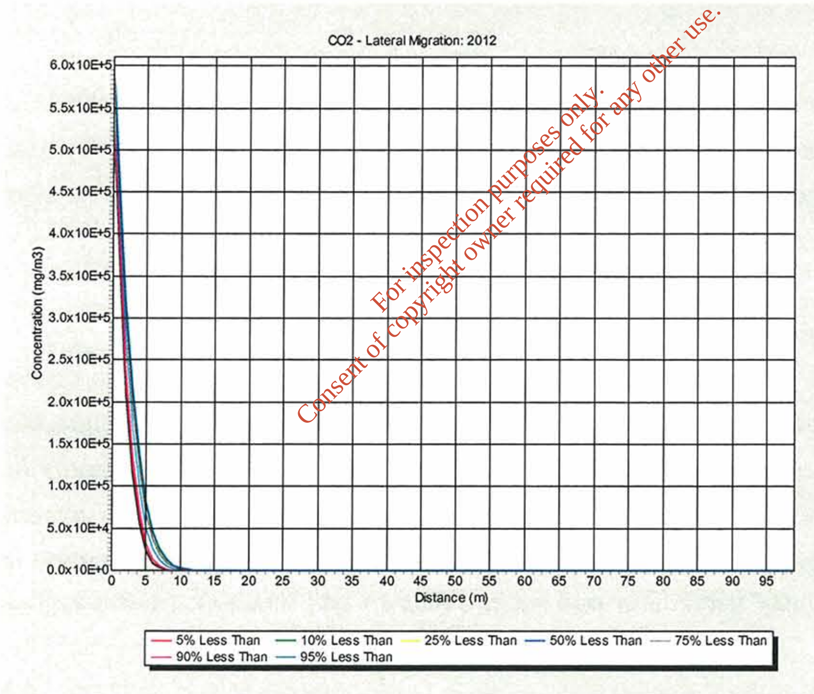
9.64 Table 9.16 illustrates the relevant parameters used by the model to assess the lateral migration of Carbon Dioxide and Methane gases.

Table 9.16 Lateral Migration Calculation Parameters

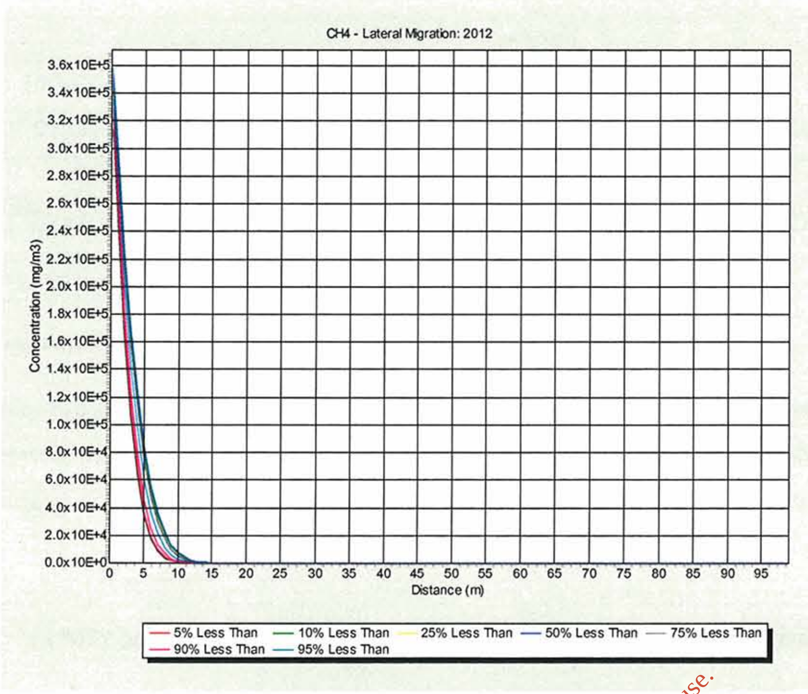
Composite Liner	
Layer 1 Thickness	2mm (HDPE Membrane)
Layer 1 Hydraulic Conductivity (m/s)	LogUniform ($1x10^{-12}$,$1x10^{-9}$)
Layer 2 Thickness	0.5m (Geotextile)
Layer 2 Hydraulic Conductivity (m/s)	LogUniform ($1x10^{-12}$,$1x10^{-9}$)
Site Dimensions	
Site Area (ha)	3.5

9.65 The simulation were undertaken for the year 2012, which is the year corresponding to the peak emission of landfill gas produced in the extended landfill area and would correspond to the worst case scenario. Results for carbon dioxide and methane are shown in graph 9.4 and 9.5.

Graph 9.4 Carbon Dioxide Lateral Migration – Proposed Extension (2012)



Graph 9.5 Methane Lateral Migration – Proposed Extension (2012)



9.66 The extent of lateral migration of carbon dioxide and methane caused by the uncontrolled release through the liner is not significant as the landfill gas concentrations decrease rapidly and within 15 metres of the extension, there is no methane or carbon dioxide outside limits of detection.

Atmospheric Dispersion – Flare Gas

9.67 A computer-based dispersion modelling technique was used to determine the concentrations of pollutants at Ballynacarrick landfill site as a result of emissions from the flare stack. The dispersion model used was ADMS version 3, model for dispersion of pollutants from point sources such as the landfill gas flare. This model takes into account the dimension and location of the flare system, the emission rates of the gas flare including carbon monoxide (CO), Nitrogen Oxides (NOx) and Particulates (PM10) and meteorological conditions at the site.

9.68 Emission rates of flare gas emissions were estimated for a worst-case scenario, considering the maximum landfill gas flow rate calculated previously by GasSim for the existing and proposed landfill site and the emissions standard for flare stacks in terms of carbon monoxide (CO), Nitrogen Oxides (NOx) and Particulates (PM10). The gas flare emission rates are summarised in Table 9.17.

Table 9.17 Gas Flare Emission Rates

Parameters	Release Rate (g/s)	
	Existing Site	Proposed Site
Carbon Monoxide	0.00527	0.00597
Oxides of Nitrogen	0.01583	0.01791
Particulate Matter	0.01372	0.01553

9.69 The proposed flare is to be located on the southeast corner of the existing landfill site, near the site office, as shown in Figure 9.4. The nearest receptor point from the flare system is a mobile home, situated approximately 120 m to the northeast of the flare location. Any potential air quality impacts would be greatest at this property.

9.70 Results regarding the emissions of Carbon Monoxide, Particulates and Nitrogen Oxides are illustrated from Figures 9.5 to 9.9. The concentrations of these pollutants at the site office and the mobile home are also summarised in Table 9.18.

Table 9.18 Air Dispersion Modelling – Results

Calculated Landfill Gas Emissions						Air Quality Standards[2]
Parameter	Existing Site		Proposed Site (Existing and Extension)		Estimated Background level	
	Site Office	Caravan	Site Office	Caravan		
CO ($\mu g/m^3$)	0.323	0.145	0.340	0.150	0.23	10
NO_2[1] ($\mu g/m^3$)	0.9729	0.4362	1.020	0.461	9.6	40
Particulates ($\mu g/m^3$)	0.841	0.377	0.885	0.400	12.0	40

Note: 1. Assumes that 100% of oxides of nitrogen released from the flare are present as nitrogen dioxide.
2. AQS taken from the EPA Air Quality Monitoring Annual Report 1999

9.71 Results from the dispersion modelling study demonstrate that the extension will have no significant impact on the emission and distribution of pollutants from the flare and that in both scenarios, the predicted environmental concentration of Carbon Monoxide, Nitrogen Dioxide and Particulates will remain below the AQS standards.

Climate

9.72 The proposed landfill extension is not predicted to impact on the microclimate, including local wind flow, temperature, rainfall or solar radiations patterns. However, an important environmental consequence of landfill gas production is the increase made to greenhouse gas emissions in the atmosphere. Carbon dioxide and methane are recognised for their significant contribution to global warming.

9.73 However, the landfill gas control and combustion in Ballynacarrick landfill site will have the potential to significantly reduce the risk of global warming. Methane is an important greenhouse gas and a major environmental pollutant. Reducing methane emissions is one of the most effective ways of mitigating global warming in the short-term. Each tonne of methane released into the atmosphere has a Global Warming Potential (GWP) of more than 21 tonnes of carbon dioxide. Flaring methane converts the gas to carbon dioxide. While carbon dioxide is also a greenhouse gas, it is less destructive than methane.

Dust Deposition

9.74 Dust will be generated during all phases of the proposed extension. It will occur for example, during the deposition of dry waste containing fine particles, by the movement of vehicles and equipment on the internal roads of the landfill site or during the placing of daily cover. Dispersion of dust is influenced by a number of parameters, including particle size, wind speed, wind direction and rainfall.

9.75 The greatest potential impact from dust generated by the proposed extension is likely to occur when prevailing winds are blowing towards sensitive receptor points. The wind roses from Malin Head demonstrate that the prevailing winds at the site will blow from the south-southwest quadrant.

9.76 Research has shown that large dust particles (>30μm) are commonly the greatest proportion of dust emitted from mineral working activities and will largely deposit within 100m of sources. However, the nearest receptor point from the proposed extension is the mobile home, located approximately 250m away from the bordering point of the extended area. Dust emissions should therefore not have a significant impact on the dwellings near the landfill site.

Odour

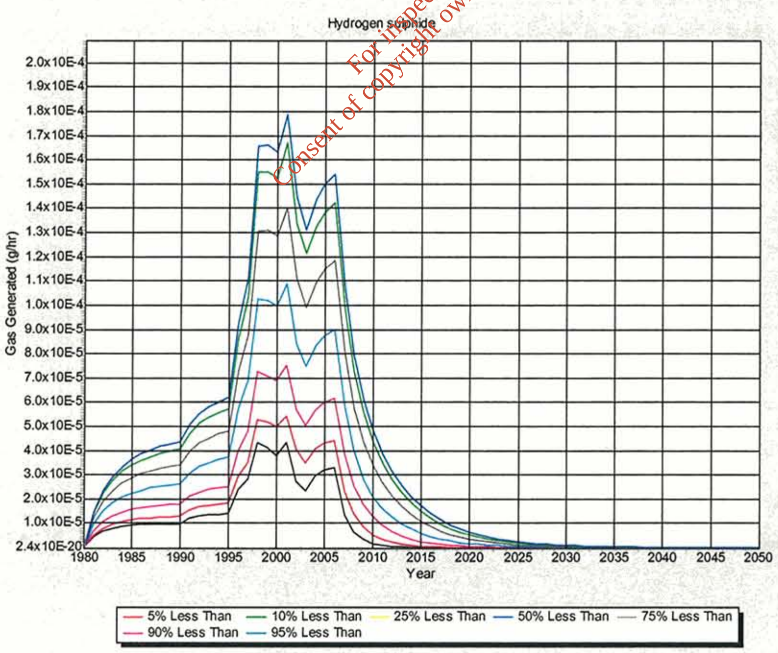
9.77 The assessment of odour nuisance is very difficult due to the subjective nature of odours and the varying responses from those affected by them. However, it is possible to predict that the impact of odour generated by landfilling operations will be more significant when the wind is blowing directly form the tipping face, where fresh waste is being deposited, to the closest receptors. It is estimated, considering the wind roses for Malin Head, that the prevailing winds (west – southwest directions) should blow directly from the proposed extension towards the nearest receptor point approximately 30% of the time

9.78 The nearest sensitive receptor is 250m away from the proposed extended area. Any potential odour impacts associated with the waste management facility will be highest at this property.

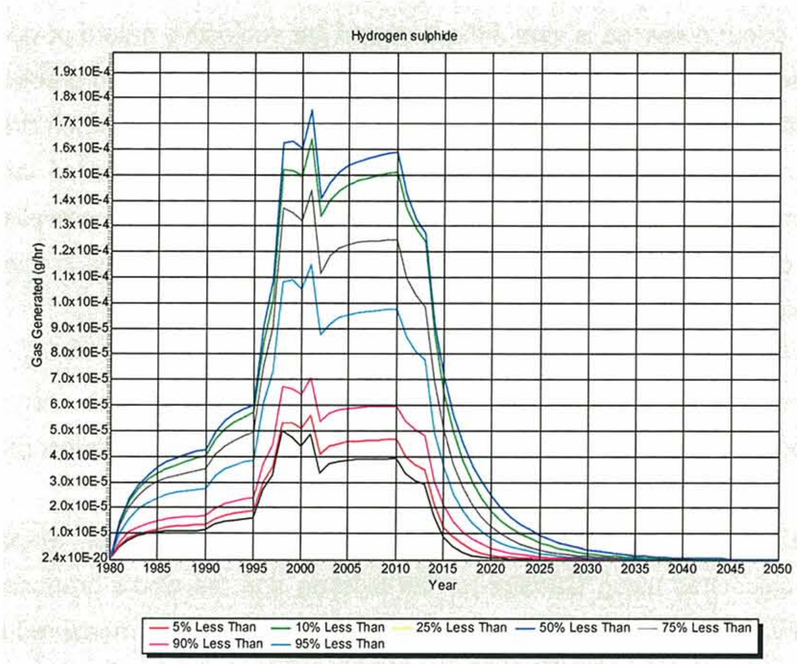
9.79 Emissions of trace gases responsible for odour impact, including Hydrogen Sulphide and Propanethiol were calculated using GasSim for the existing and the whole proposed landfill site. The calculations were based on the monitoring levels of these gases measured on site in December 2002 and shown in paragraph 9.42.

9.80 Results are shown on Graphs 9.6 and 9.7 for the existing and proposed landfill area.

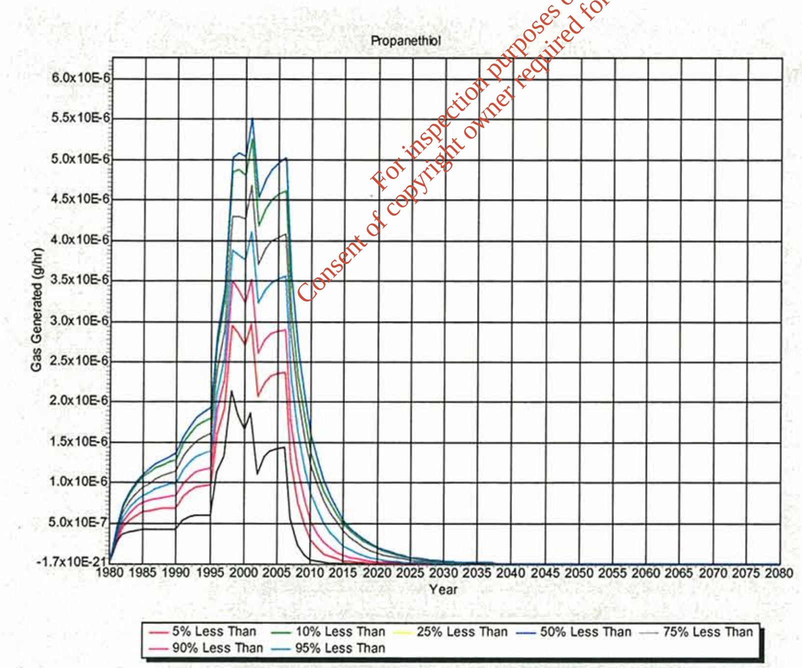
Graph 9.6 Emissions of Hydrogen Sulphide for the existing site



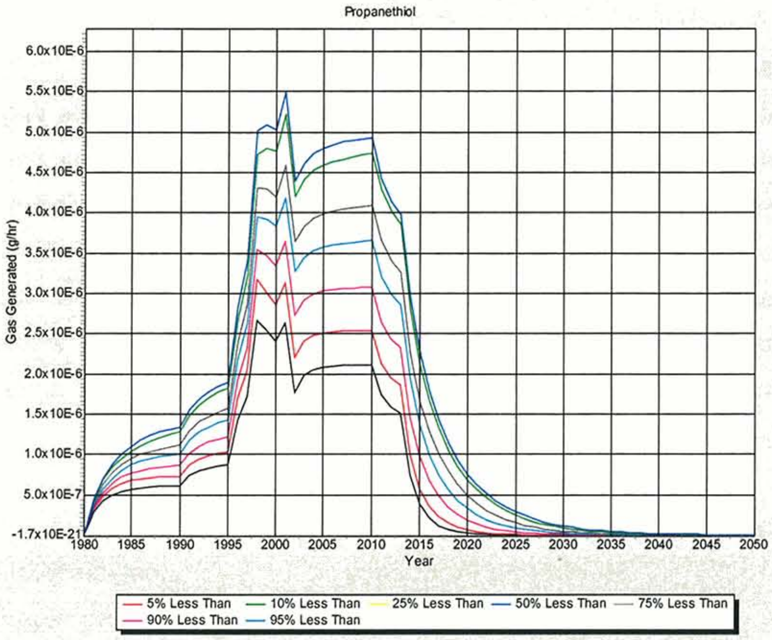
Graph 9.7 Emissions of Hydrogen Sulphide for the Proposed Site



Graph 9.8 Emissions of Propanethiol for the existing site



Graph 9.9 Emissions of Propanethiol for the proposed site



9.81 The highest level of hydrogen sulphide for the existing and proposed landfill site occurs in 2001 with a generation rate of 1.6×10^{-4} g/hr, corresponding to a maximum concentration of 0.42 µg/m^3, which is below the Limit value of 1 µg/m^3 indicated in the Danish Regulations and below the odour threshold of 0.66 µg/m^3 illustrated in paragraph 9.17 so should not present an odour nuisance for locals and site workers.

9.82 The same tendency can be applied to the emissions of propanethiol, as the maximum level for the existing and proposed site should occur in 2001, with a generation rate of 5.5×10^{-6} g/hr, corresponding to a concentration of 0.00453 ppb, which is well below the Danish Limit Value of 0.06 ppb.

9.83 The emissions of malodorous gases are likely to decrease over the years. Moreover, the proposed extension will have a robust and effective cap coupled with a flare to control and minimise migration of landfill gas from the site.

MITIGATION MEASURES

Introduction

9.84 The proposed extension of the existing landfill site is located in an area of low population, therefore reducing any nuisance impacts from the site. The local air quality is typical of rural area, with low background levels of air pollution. Dilution of pollutants occurs due to the southwest prevailing winds from the Atlantic Ocean. As for the existing waste facility, the extended area will accept only household, commercial, construction and demolition wastes, thereby minimizing any potential toxic or hazardous emissions from the site.

Landfill Gas Emissions

9.85 The proposed extension has been designed as a containment site so it will be engineered to prevent the uncontrolled migration of landfill gas. Landfill gas generated within the waste will be collected and initially vented to the atmosphere being ultimately flared. These measures will contain and control landfill gas within the site. Monitoring boreholes will be provided around the perimeter of the site to assess the efficiency of the gas management and to ensure that gas is not migrating off site. Gas monitoring after closure of the site should continue considering the landfill gas monitoring regime summarised in Table 9.19 until agreement with the EPA that it is no longer required.

Table 9.19 Landfill Gas Monitoring Requirements

Parameter	Monitoring Frequency		Analysis Method [1]/ Technique[2]
	Gas Boreholes/ Vents/Wells	Site Office	
Methane (CH_4) % v/v	Monthly	Weekly	Infrared analyser/flame ionisation detector
Carbon Dioxide (CO_2) % v/v	Monthly	Weekly	Infrared analyser/flame ionisation detector
Oxygen (O_2) % v/v	Monthly	Weekly	Electrochemical cell
Atmospheric Pressure	Monthly	Weekly	Standard
Temperature	Monthly	Weekly	Standard

Notes 1: All monitoring equipment used should be intrinsically safe
2: Or other methods agreed in advance with the Agency

9.86 **Health and Safety Risks**: Emissions from the landfill site are unlikely to have a detrimental effect on human health, assuming that the site is developed and operated to the required standards. Strict Health & Safety procedures should be implemented on site including no smoking policy to prevent any risks of fire or explosion, staff training regarding the dangers of landfill gas and gas monitoring of site buildings.

Flare Gas Emissions

9.87 The flare location has been carefully considered in relation to the hazards in the environment, including explosion and fire and human health. In accordance with EPA guidance the plume from a flare, will not be allowed to pass directly to a dwelling or human habitation under prevailing wind conditions.

9.88 Characteristics of the flare stack and the combustion process, such as the temperature of combustion or the height of the stack can moderate the impact on the emissions and dispersions of the flare gas.

9.89 The flare emissions will be operated to the emissions standards outlined in Table 9.13 and will be monitored to the standard outlined below, as set out in the waste licence by the EPA.

Table 9.20 Flare Gas Monitoring Requirements

Parameter	Monitoring Frequency	Analysis Method[1]/ Technique[2]
Inlet		
Methane (CH_4) % v/v	Weekly	Infrared analyser/flame ionisation detector
Carbon Dioxide (CO_2) % v/v	Weekly	Infrared analyser/flame ionisation detector
Oxygen (O_2) % v/v	Weekly	Infrared analyser
Outlet		
Volumetric Flow rate	Biannually	Pilot Tube Method
SO2	Biannually	Flue gas analyser
NOx	Biannually	Flue gas analyser
CO	Biannually	Flue gas analyser
Particulates	Annually	Isokinetic/Gravimetric
TA Luft Class I, II, III organics	Annually	Adsorption/Desorption/GC/GCMS[3]
Hydrochloric acid	Annually	Impinger/Ion Chromatography
Hydrogen Fluoride	Annually	Impinger/Ion Chromatography

Notes 1: All monitoring equipment used should be intrinsically safe
2: Or other methods agreed in advance with the Agency
3: Test methods should be capable of detecting acetonitrile, dichloromethane, tetrachloroethylene and vinyl chloride as a minimum.

Traffic Emissions

9.90 The extension will not have any significant impact on the surrounding air quality. In the long-term, vehicle emissions are predicted to decrease over time due to improvements in engine efficiency and stricter enforcement of vehicle emission standards.

Dust Emissions

9.91 Effective dust control measures should be applied on site to limit dust generation and prevent dust disturbance. These will include limiting dust generation by:

- Careful choice of daily cover;
- Damping down materials containing fine particulates in very dry weather;
- Landfilling operations within cells;
- Disposal and immediate burial of dusty wastes; and
- Providing a well-designed site access road.

9.92 Dust monitoring will have to be undertaken at the frequency and methodology outlined by the EPA in the waste licence and summarised in the table below.

Table 9.21 Dust monitoring Frequency

Parameter (mg/m2/day)	Monitoring Frequency	Analysis Method/Technique
Dust	Three times a year	Standard Method[1]

Notes 1: Standard method VDI2119 (Measurement of Dustfall, Determination of Dustfall using Bergerhoff Instrument (Standard Method) German Engineering Institute). A modification (not included in the standard) which 2-methoxy ethanol may be employed to eliminate interference due to algae growth in the gauge.

Odour Emissions

9.93 Odour will be controlled by means of site working practices and monitored frequently.

9.94 Odour nuisance from the proposed landfill site should be minimised in the following ways:

- Rapid deposition and covering of malodorous wastes;
- Effective compaction and covering of wastes;
- Installation of the permanent capping system; and
- Flaring of landfill gas.

CONCLUSION

9.95 The Air and Climate Impact Assessment study has demonstrated that the proposed extension will not have a significant impact on the existing air quality in the surrounding environment. There will be no significant increase of gas emissions associated with landfill operational activities in terms of landfill gas, flare gas and traffic fume emissions.

9.96 The gas emissions, dust deposition and odour nuisance will be minimised by implementation of appropriate mitigation measures during the construction works and the operational phase of the proposed extension.

BIBLIOGRAPHY

CEC, (Council of the European Communities), 1999. Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. *O.J. L163, 29 June 1999.*

Department of the Environment Transport and the Regions, 2000. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Working Together for Clean Air.

Department of Transport, 1999. Design Manual for Roads and Bridges, Volume 11. Environmental Assessment.

DoE (Department of the Environment), 1988. *The Air Pollution Act 1987 Air Quality Standards Regulations S.I. No. 244 of 1987.*

Donegal County Council, 1997. Waste Disposal Licence, Ballynacarrick Landfill Site, Ballintra, Co. Donegal.

EC, (European Commission), 1998. Proposal for a European Parliament and Council Directive relating to limit values for benzene and carbon monoxide in ambient air. COM(1998) 591.

Environmental protection Agency, 1999. Air Quality Monitoring, Annual Report 1999.

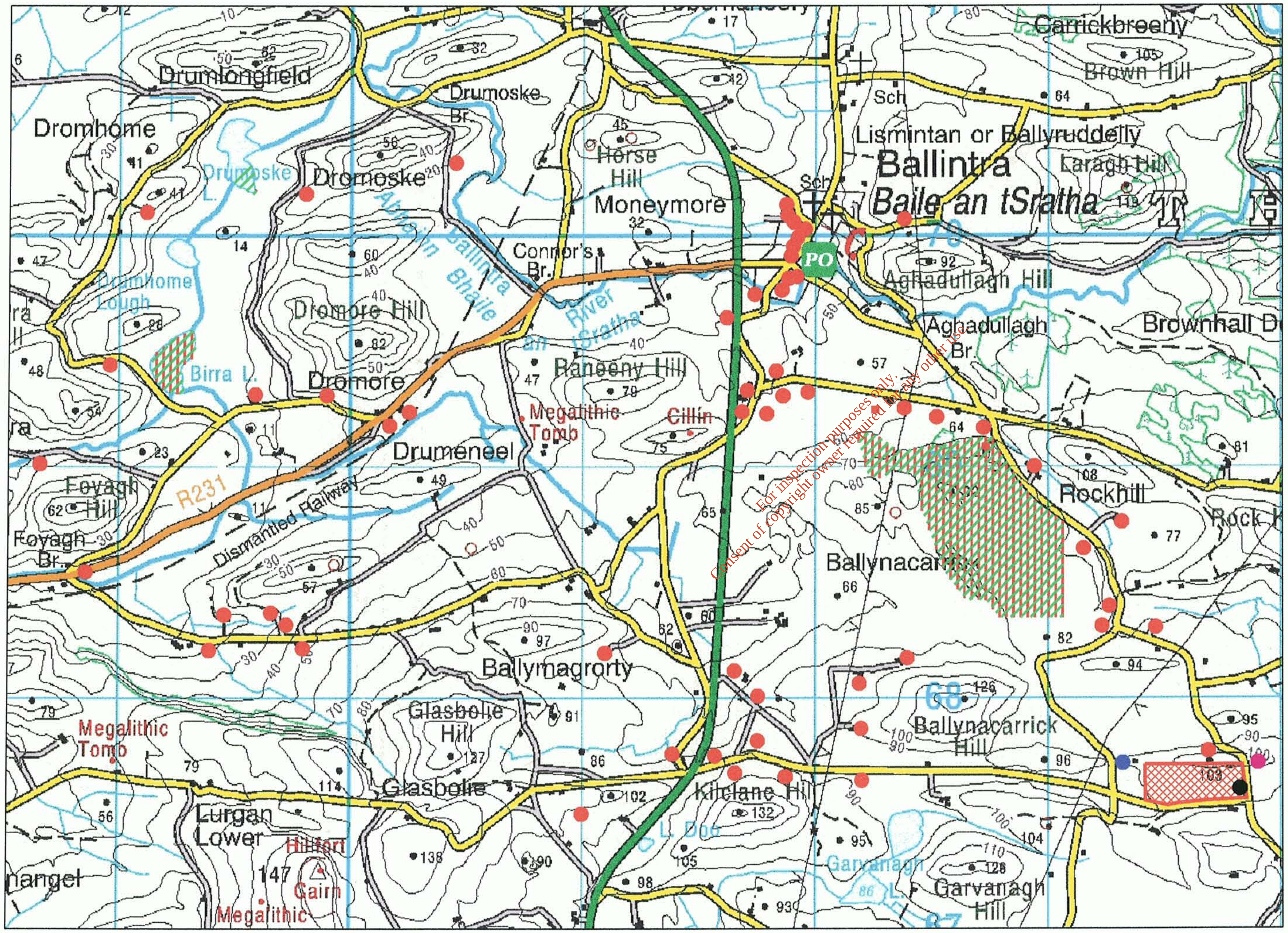
Environmental Protection Agency, 2000. Landfill Manuals, Landfill Site Design.

Environmental Protection Agency, 2000. Landfill Manuals, Landfill Monitoring.

Golder Associates (UK) Limited, 2002. GasSim User Manual.

(Ruth, Jon H. (1986) Odour Thresholds and Irritation Levels of Several Chemical Substances: A Review. Am. Ind. Hyg. Assoc. J., 47, 142-151)

FIGURES



KEY

- BUILDINGS
- HOUSE UNDER CONSTRUCTION
- CARAVAN
- DISUSED BUILDINGS
- SITE OFFICE
- SAC
- NHA
- SITE LOCATION

SCALE: 1:20,000

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PROJECT

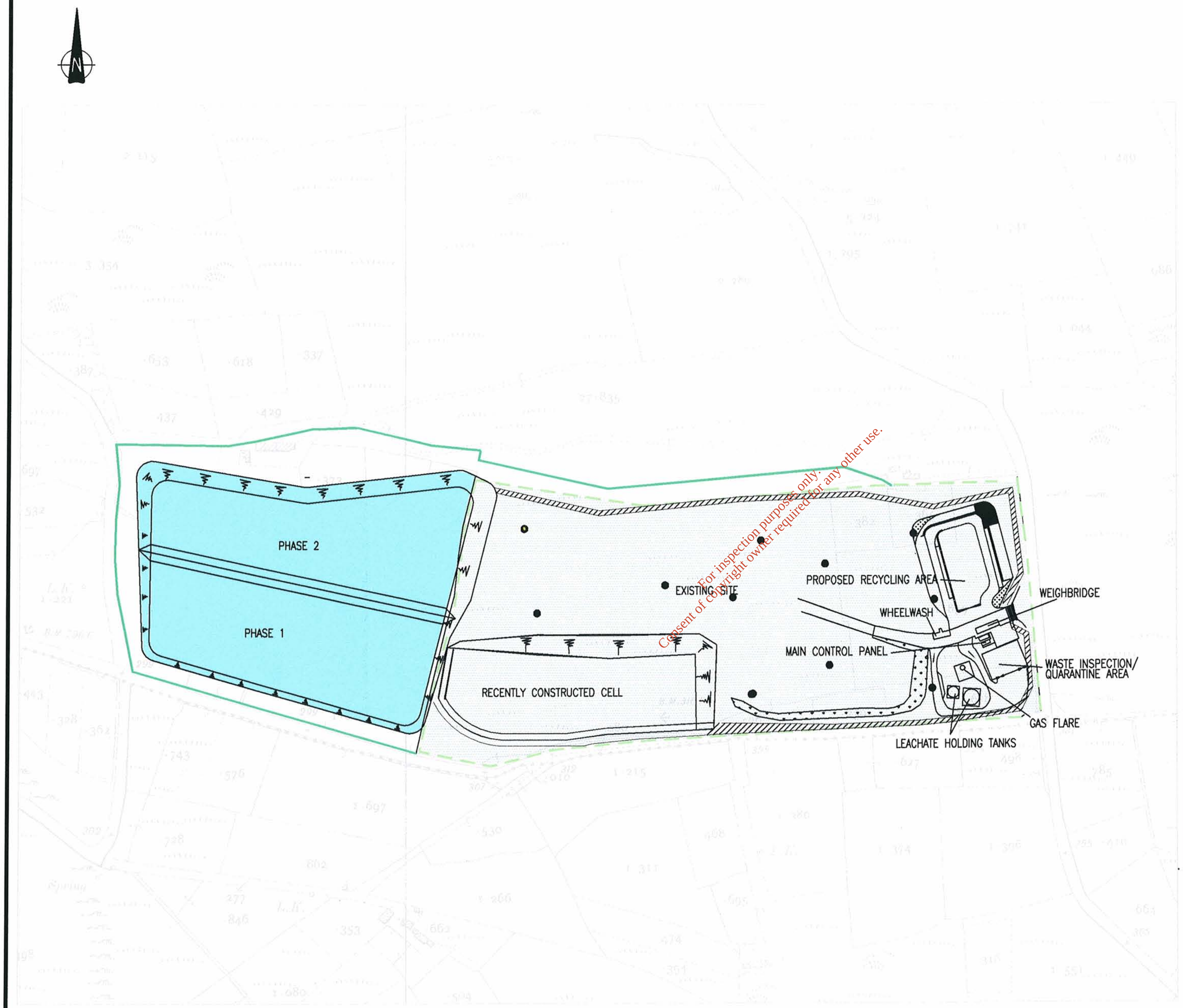
BALLYNACARRICK LANDFILL PROJECT

TITLE

SENSITIVE RECEPTOR POINT LOCATIONS

FIGURE

9.1



KEY

BOUNDARY OF EXISTING LANDFILL

BOUNDARY OF PROPOSED EXTENSION

LIMIT OF PROPOSED LANDFILL EXTENSION

EXISTING PASSIVE GAS VENTS

LIMIT OF EXISTING SITE

SCALE: 1:2500

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PROJECT

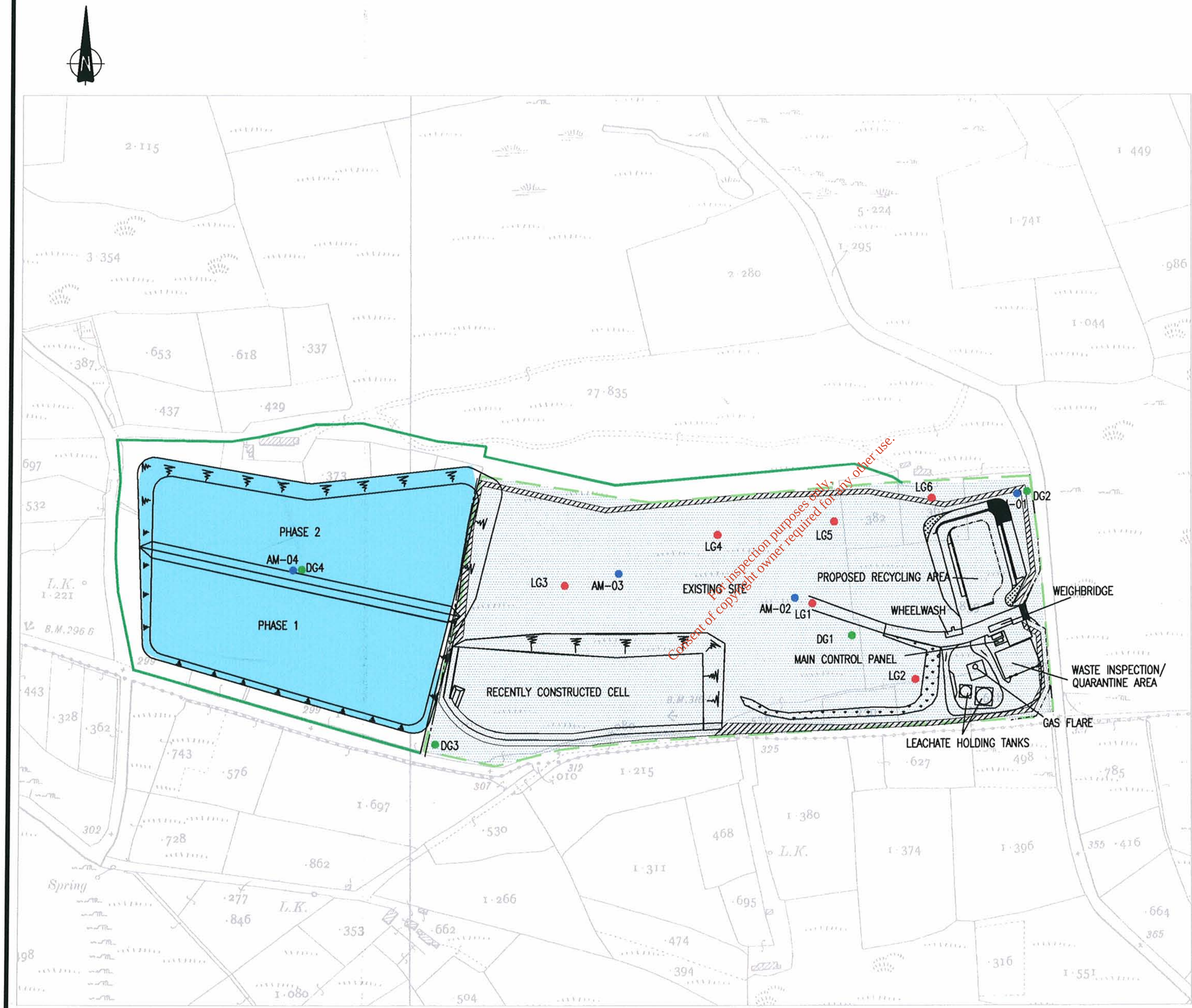
BALLYNACARRICK LANDFILL PROJECT

TITLE

EXISTING GAS VENT LAYOUT

FIGURE

9.2



KEY

- BOUNDARY OF EXISTING LANDFILL
- BOUNDARY OF PROPOSED EXTENSION
- LIMIT OF PROPOSED EXTENSION
- LG — LANDFILL GAS MONITORING POINTS
- AM — TRACE GAS MONITORING POINTS
- DG — DUST MONITORING POINTS
- LIMIT OF EXISTING SITE

SCALE: 1:2500

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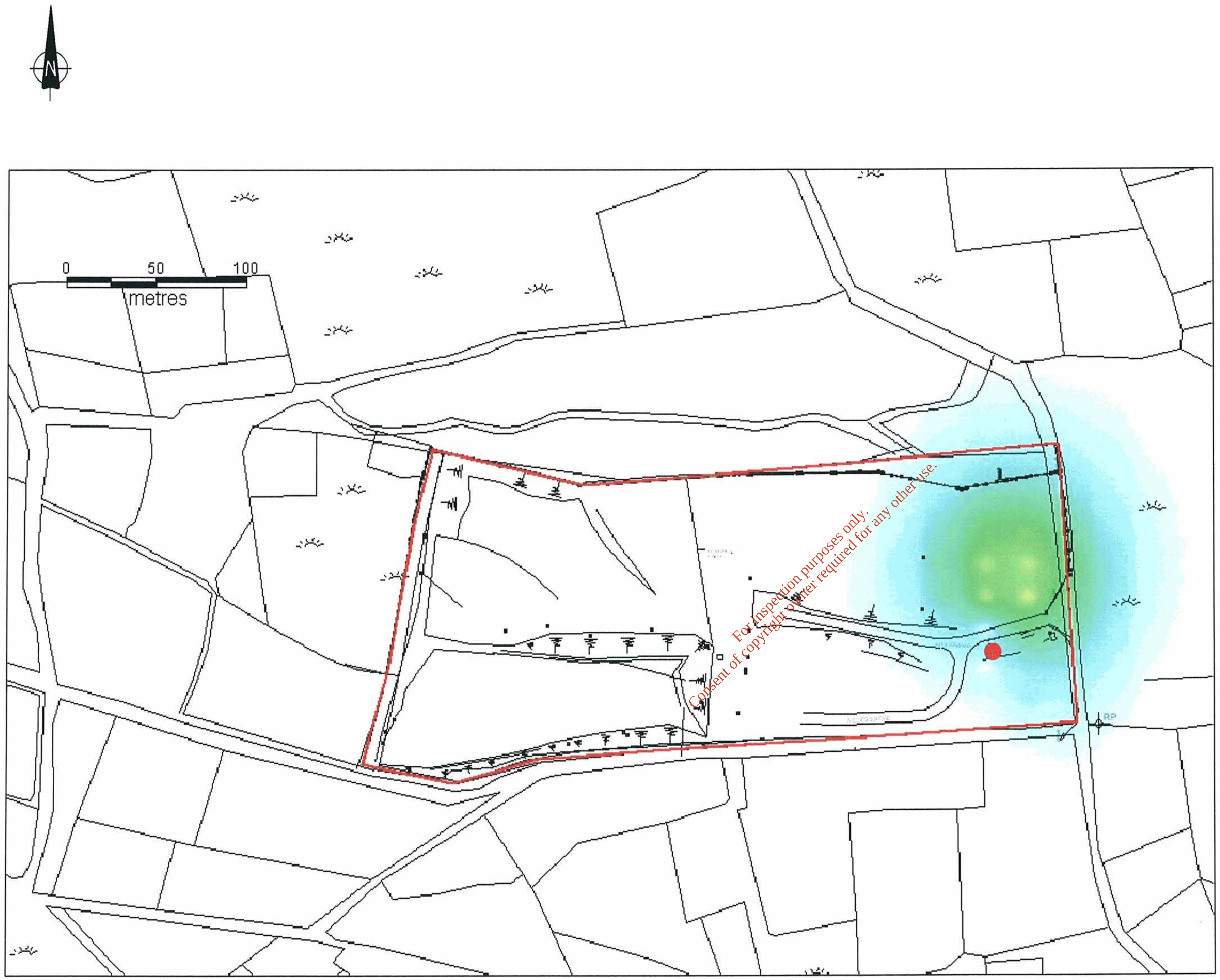
PROJECT
BALLYNACARRICK LANDFILL PROJECT

TITLE
LANDFILL GAS & DUST MONITORING POINTS

FIGURE
9.3



KEY

BOUNDARY OF EXISTING LANDFILL

PROPOSED FLARE LOCATION

CO EMISSIONS

CO BASELINE LEVEL = 230 ug/m3

CO FLARE EMISSIONS

0.4 ug/m3

0.3 ug/m3

0.2 ug/m3

0.1 ug/m3

CO AIR QUALITY STANDARDS = 10,000 ug/m3

SCALE: 1:2500

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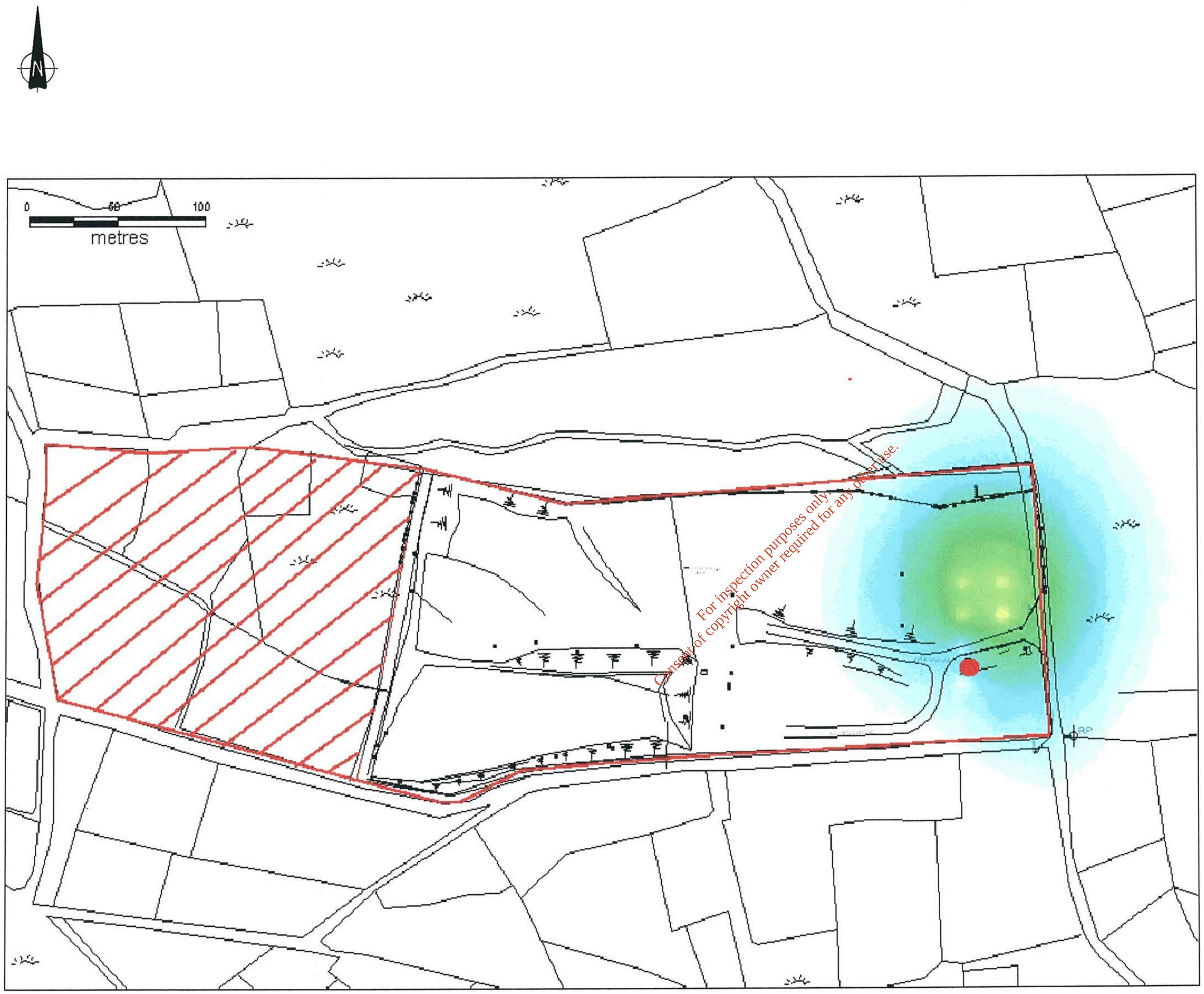
BALLYNACARRICK LANDFILL PROJECT

TITLE

CO FLARE EMISSIONS
EXISTING CONDITIONS

FIGURE

9.4



KEY

BOUNDARY OF EXISTING LANDFILL

PROPOSED EXTENSION

PROPOSED FLARE LOCATION

CO EMISSIONS

CO BASELINE LEVEL = 230 ug/m3

CO FLARE EMISSIONS

0.4 ug/m3

0.3 ug/m3

0.2 ug/m3

0.1 ug/m3

CO AIR QUALITY STANDARDS = 10,000 ug/m3

SCALE: 1:2500

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BALLYNACARRICK LANDFILL PROJECT

TITLE

CO FLARE EMISSIONS
PROPOSED EXTENSION

FIGURE

9.5

KEY

BOUNDARY OF EXISTING LANDFILL

PROPOSED EXTENSION

PROPOSED FLARE LOCATION

NOx/NO2 EMISSIONS

NO2 BASELINE LEVEL = 230 ug/m3

NO2 FLARE EMISSIONS

1.6 ug/m3

1.2 ug/m3

0.8 ug/m3

0.4 ug/m3

NO2 AIR QUALITY STANDARDS = 40 ug/m3

SCALE: 1:2500

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PROJECT

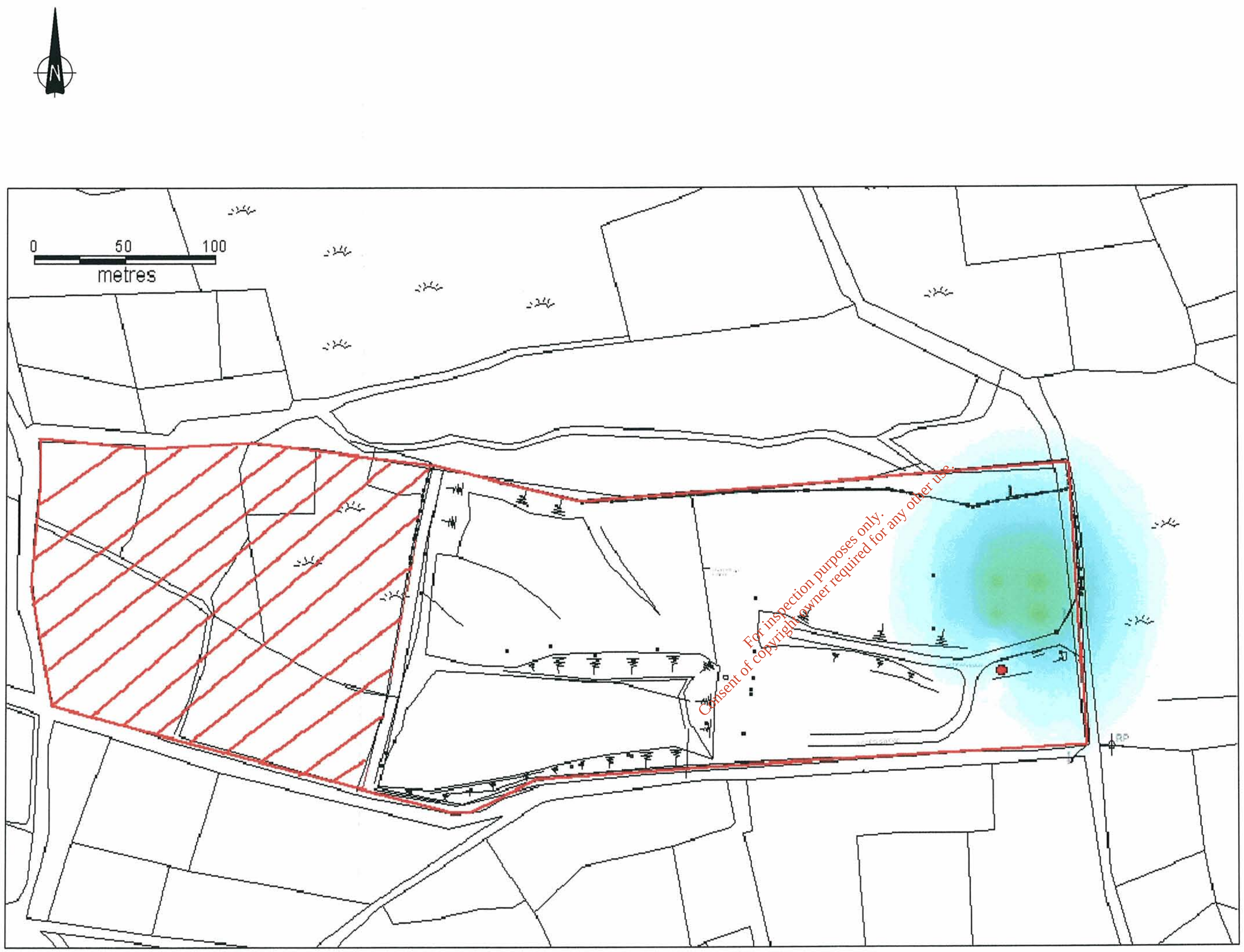
BALLYNACARRICK LANDFILL PROJECT

TITLE

NOx FLARE EMISSIONS
EXISTING CONDITIONS

FIGURE

9.6



KEY

BOUNDARY OF EXISTING LANDFILL

PROPOSED EXTENSION

PROPOSED FLARE LOCATION

NOx/NO2 EMISSIONS

NO2 BASELINE LEVEL = 230 ug/m3

NO2 FLARE EMISSIONS

1.6 ug/m3

1.2 ug/m3

0.8 ug/m3

0.4 ug/m3

NO2 AIR QUALITY STANDARDS = 40 ug/m3

SCALE: 1:2500

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Donegal County Council

PROJECT

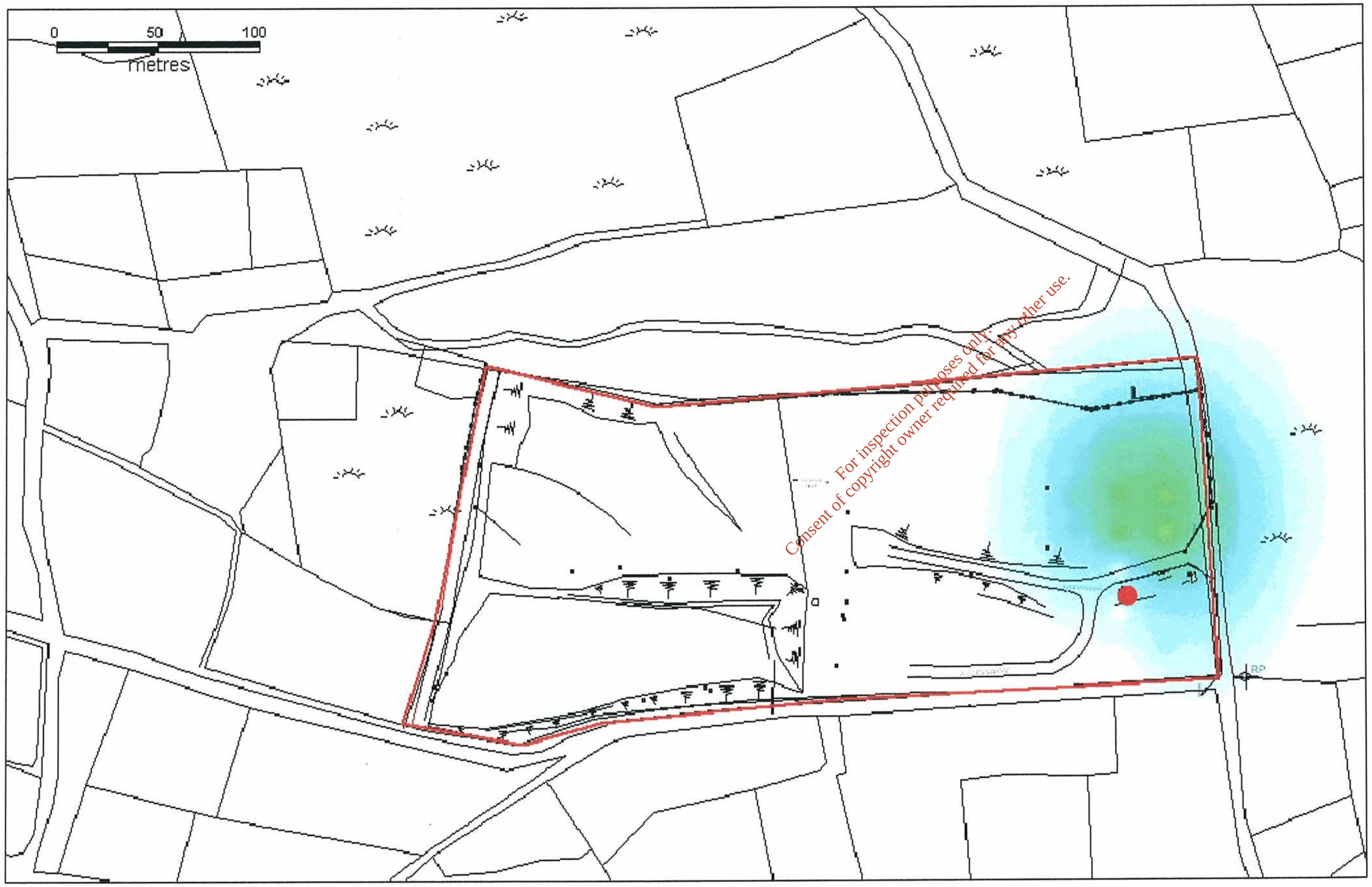
BALLYNACARRICK LANDFILL PROJECT

TITLE

NOx FLARE EMISSIONS PROPOSED EXTENSION

FIGURE

9.7



KEY

BOUNDARY OF EXISTING LANDFILL

PROPOSED FLARE LOCATION

PM10 EMISSIONS

PM10 BASELINE LEVEL = ug/m3

PM10 FLARE EMISSIONS

1.5 ug/m3

1.2 ug/m3

0.9 ug/m3

0.6 ug/m3

PM10 AIR QUALITY STANDARDS = 50 ug/m3

SCALE: 1:2500

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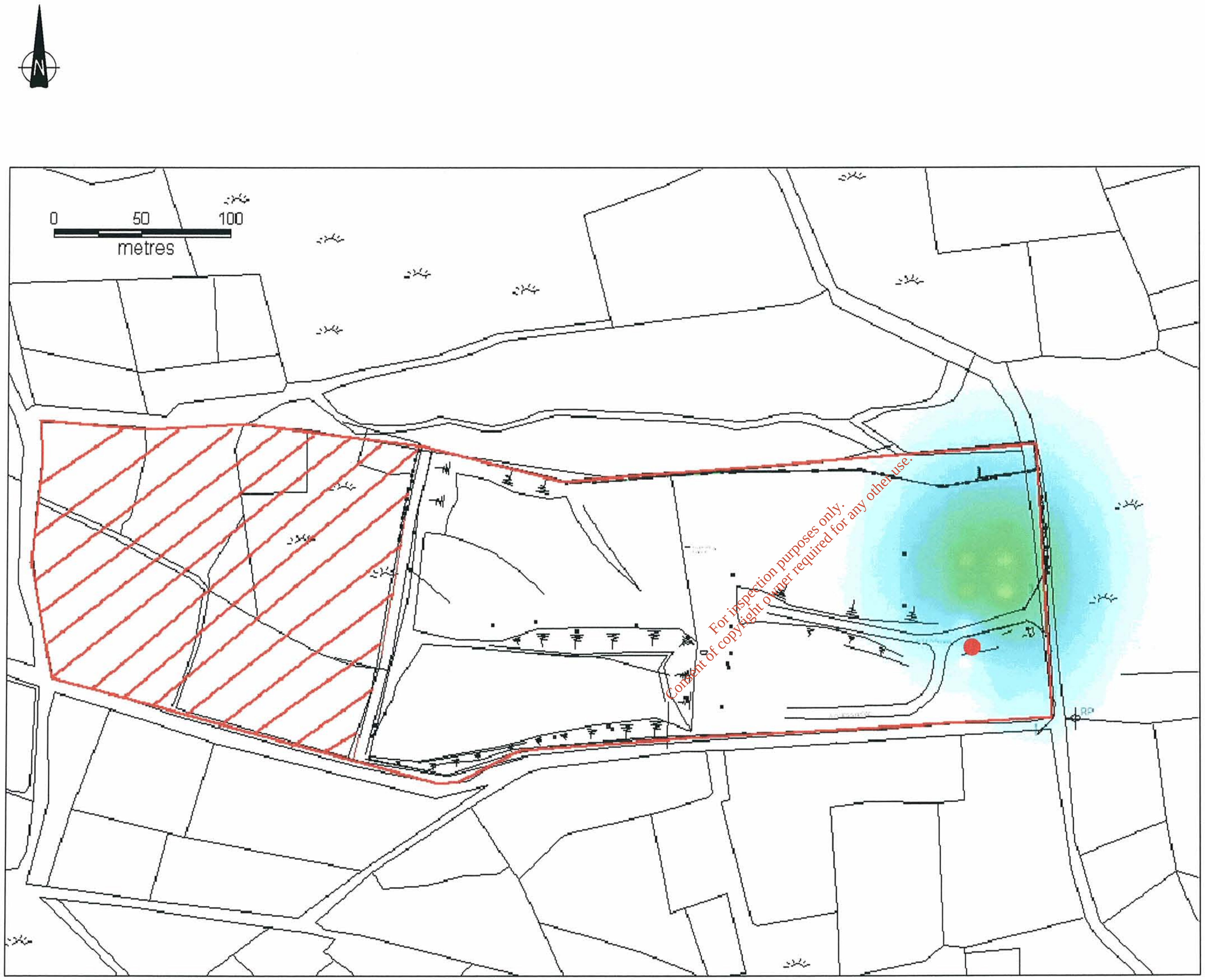
Donegal County Council

PROJECT
BALLYNACARRICK LANDFILL PROJECT

TITLE
PARTICULATES FLARE EMISSIONS
EXISTING CONDITIONS

FIGURE
9.8



KEY

BOUNDARY OF EXISTING LANDFILL

PROPOSED EXTENSION

PROPOSED FLARE LOCATION

PM10 EMISSIONS

PM10 BASELINE LEVEL = 50 ug/m3

PM10 FLARE EMISSIONS

1.5 ug/m3

1.2 ug/m3

0.9 ug/m3

0.6 ug/m3

SCALE: 1:2500

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PROJECT
BALLYNACARRICK LANDFILL PROJECT

TITLE
PARTICULATES FLARE EMISSIONS
PROPOSED EXTENSION

FIGURE
9.9