Cavan County Council

CORRANURE LANDFILL

Landfill Gas Management Plan

October 2007

RPS

MGE0068CR0001

Corranure Landfill
Waste Licence No. W0077-02

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Project Title	Corranure Landfill Waste Licence Compliance					
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Consulting Engineers

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1 INTRODUCTION

Cavan County Council operate Corranure Landfill Waste Licence W0077-02. The facility is licenced to accept household waste, commercial waste, green waste, construction and demolition waste, street cleaning residues and hazardous household waste. This Landfill Gas Management Plan has been prepared in order to comply with Conditions 3.13, 3.19.3, 5.11, 6.6 and 11.5 of Waste Licence W0077-02.

The landfill has been in operation at its current location since 1988. Initially, the site was operated on a "dilute-and-disperse" basis. In 2001, a major redevelopment of the site in compliance with the conditions of the Waste Licence was completed comprising the construction of a new 19,050 m^2 composite lined cell (known as Cell 1), leachate collection system and a new site entrance area consisting of an administration building, weighbridge, wheelwash and civic amenity facility. The old remediated landfill was also capped as part of this contract.

Cell 1 ceased accepting waste in October 2005 and was permanently capped during 2006. Construction of Cell 2 commenced in 2004 and waste was accepted in this cell from October 2005 to April 2007. The installation of a permanent capping system on Cell 2 was completed in September 2007. Phase 3 which consisted of two cells 3 and 4 was constructed adjacent to Cell 2. Waste is currently being accepted in Cell 3. It is estimated that there is 4.5 years left of remaining in Cell 3 and 4.

2 GAS GENERATION

The biodegradation process in a landfill produces landfill gas. Landfill gas is primarily composed of methane, carbon dioxide and water vapour and evolves on the commencement of the anaerobic decomposition of the waste.

2.1 GAS VOLUMES

The rate of gas generation at a landfill site varies throughout the life of a landfill and is dependent on a number of factors including:

- The physical dimensions of the landfill site
- The types of waste deposited and the associated input rate
- The age of the waste
- Moisture content, pH, temperature and density of waste deposited and
- The application of cover, compaction and capping

Under optimum conditions one tonne of degradable waste can theoretically produce 400-500m^3 of landfill gas (including moisture content). In practical terms the rate at which landfill gas may be collected for utilisation purpose may be much lower.

Currently at Corranure Landfill an enclosed landfill gas flare is treating 800m^3/hr of bulk landfill gas which is generated from the old remediated landfill, Cell 1 and Cell 2. In addition, a temporary “open flare” is treating landfill gas generated within the active cell (Cell 3).

2.2 GAS COMPOSITION

The major components of landfill gas are methane and carbon dioxide, which are typically present in the ratio 3:2 with a number of minor constituents in low concentrations. These trace components provide landfill gas's characteristic vinegary smell. **Table 2.1** details typical landfill gas composition.

Table 2.1: Typical Landfill Gas Composition

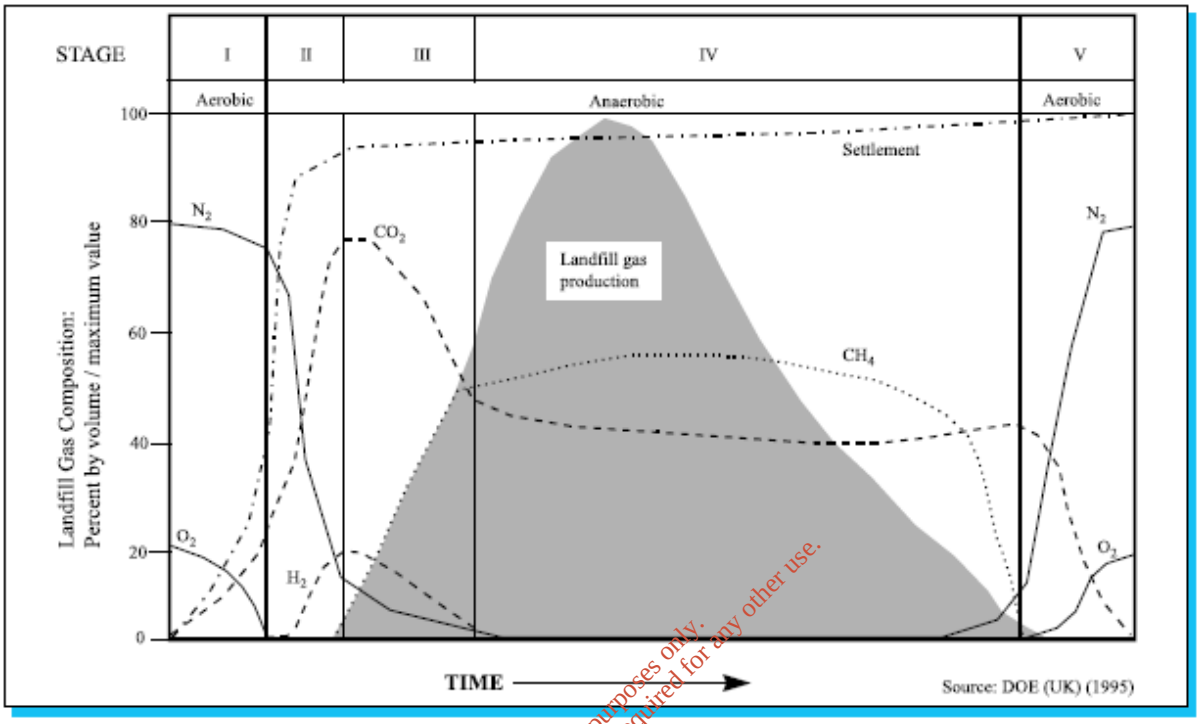
Component	Typical Value (% volume)	Observed Maximum (% volume)
Methane	63.8	88.0
Carbon Dioxide	33.6	89.3
Oxygen	0.16	20.9
Nitrogen	2.4	87
Hydrogen	0.05	21.1
Carbon Monoxide	0.001	0.09
Ethane	0.005	0.0139
Ethene	0.018	-
Acetaldehyde	0.005	-
Propane	0.002	0.0171
Butanes	0.003	0.0232
Helium	0.00005	-
Higher alkanes	0.05	0.07
Unsaturated hydrocarbons	0.009	0.048
Halogenated compounds	0.00002	0.032
Hydrogen sulphide	0.00002	35.0
Organosulphur compounds	0.00001	0.028
Alcohols	0.00001	0.127
Others	0.00005	0.023

Source: UK DOE, 2000 cited in the EPA Manual - Landfill Operational Practices, 1997

When the biodegradation process commences in a landfill, it is usual for aerobic decomposition to cease within a few days of wastes placement. This is followed by anaerobic processes, which result in gas generation. Enhanced carbon dioxide levels from aerobic decomposition are a precursor to the production of methane bearing landfill gas in the anaerobic phase. Once anaerobic biodegradation has started, the quantities of landfill gas will steadily increase over the following 12 months and continue for a number of decades. It will eventually decline due to the decrease in microbiological activity.

Figure 2.1 shows schematically how landfill gas composition changes with the different stages of waste decomposition.

Figure 2.1: Changes in Landfill Gas Composition



Source: Extract from the EPA Manual - Landfill Operational Practices, 1997

3 GAS CONTROL SYSTEM

3.1 OBJECTIVES OF GAS MANAGEMENT SYSTEM

The overall objective of a landfill gas management system is to collect all gas produced from the waste and treat it accordingly in order to minimise odours and emissions from the landfill. Specific objectives include the following:

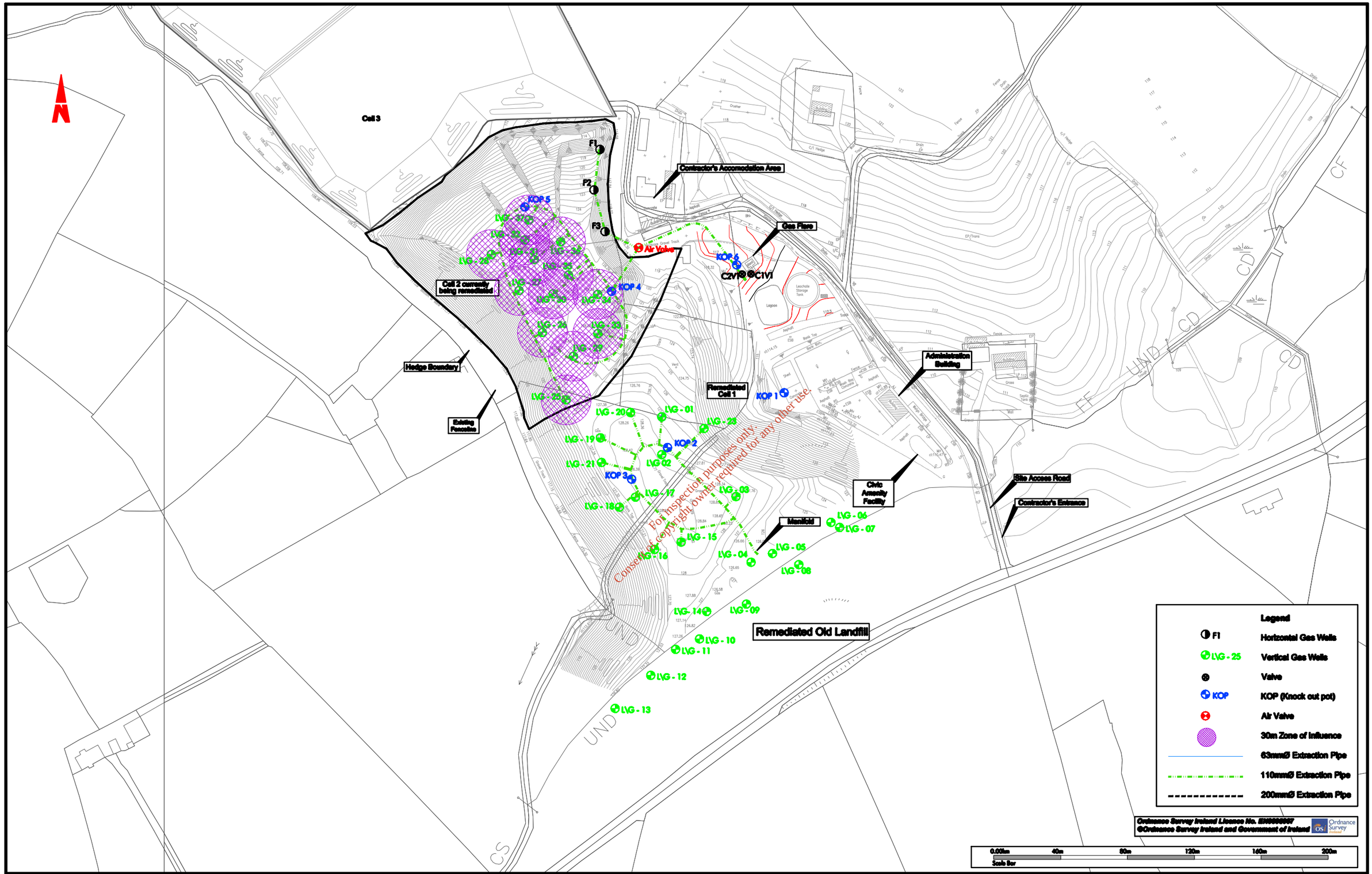
- Minimise the risk of gas migration beyond the boundary of the site
- Minimise the risk of gas migration into buildings/services on site
- Minimise impact on air quality through reduction of greenhouse gas emission
- Reduction of nuisance potential to surrounding environment (odour)
- To allow energy recovery where feasible

The major components of landfill gas are methane and carbon dioxide with a number of minor constituents in low concentrations. The gas is usually saturated with moisture and is corrosive. Methane is flammable and explosive at concentrations of 5-15% v/v in air. If not properly monitored and controlled, landfill gas can give rise to flammability, toxicity, asphyxiation and other hazards including vegetation dieback. In addition to its explosive properties landfill gas is also an asphixiant when found in a closed space. It is therefore important to manage and control the gas generated within the waste to ensure that the risks associated with its movement are minimised.

3.2 ACTIVE GAS EXTRACTION SYSTEM

An active gas extraction system was installed at the site in July 2004. This consists of the following elements:

- Gas extraction wells,
- Gas extraction wellheads,
- Gas collection pipework,
- Condensate removal points,
- Extraction pump,
- Gas flare, and
- Telemetry System.



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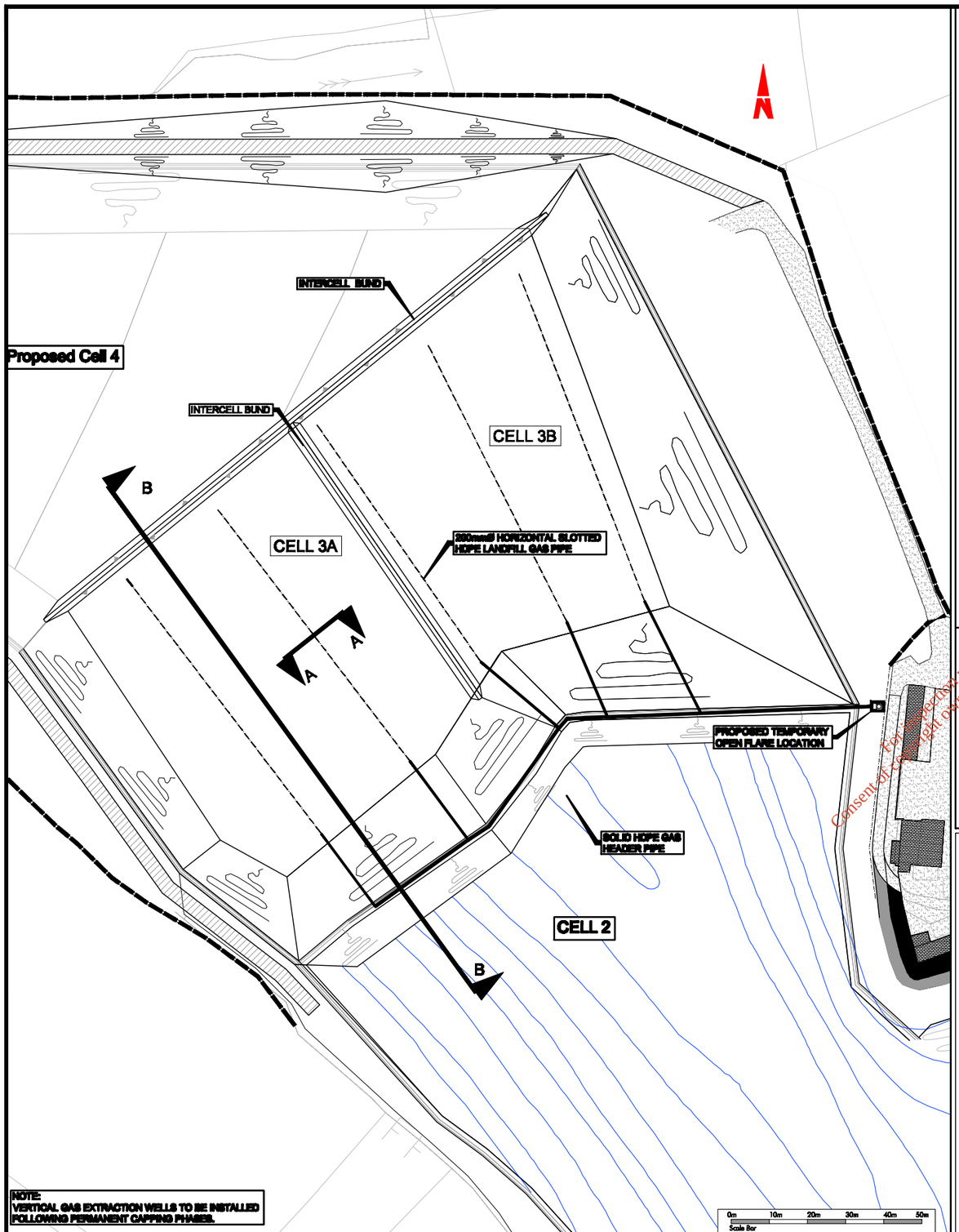
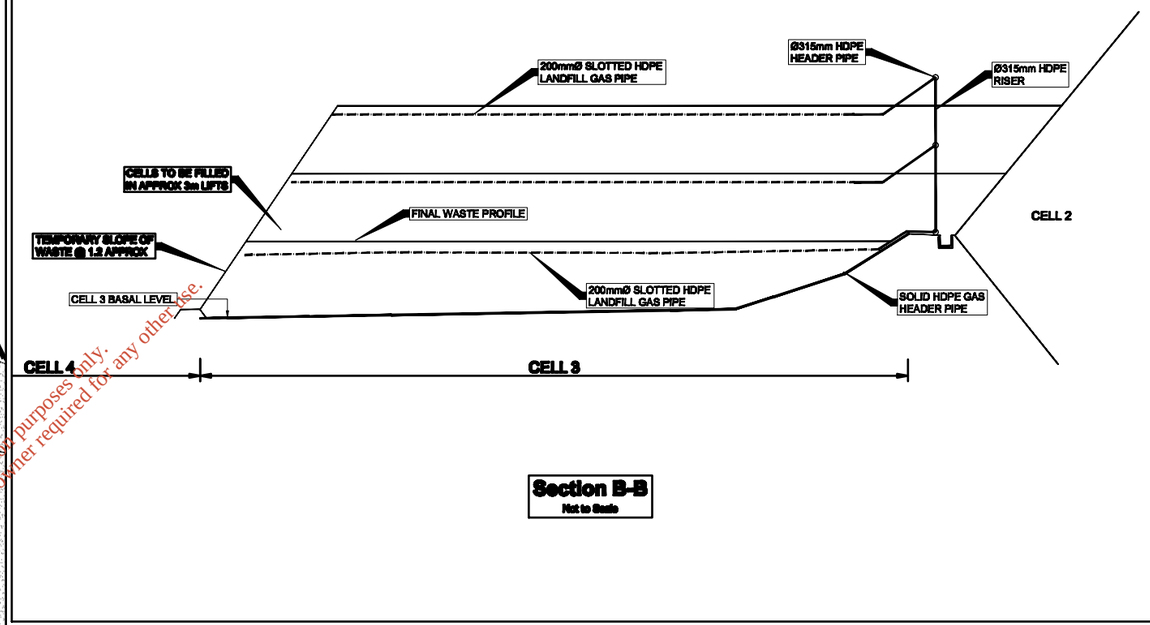
Corranure Landfill
Licence Compliance

Title:
Gas Management System
Figure 3.1

Drawn by:	C.H.	Job No:	MOE0008
Checked by:	K.G.	File No:	MOE0008DG0014
Approved by:	D.C.	Dg. No:	DG0014-01
Scale: 1:1000 @ A1		Rev:	F01
Date:	July '07		





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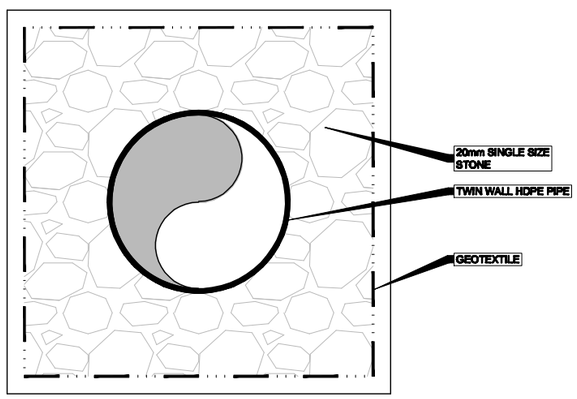

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No.	Date		Amendment / Issue	App.
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Corranure Landfill
Licence Compliance

Title:
Cell 3
Gas Management Plan
Figure 3.2

Drawn by:	C.H.	Job No:	M2E0008
Checked by:	A.F.	File No:	M2E0008DG0010
Approved by:	W.M.	Dg. No:	DG0010-01
Scale:	As Shown	Rev:	F01
Date:	April '07		

The Gas Management System for Corranure Landfill is shown in **Figure 3.1** and the Gas Management System for Cell 3 is shown in **Figure 3.2**.

There are 11 no. gas extraction wells on the old remediated landfill, five of which are presently producing quality gas for extraction. Cell 1 has 13 no. wells, 11 of which are producing quality gas for extraction. A further 13 no. gas extraction wells were also installed in Cell 2 between March and May 2007. There are also three horizontal wells which are to be connected to the gas collection system when final capping is complete. All landfill gas wells are connected to an enclosed ground flare which has a capacity of 1,500 m^3/hr. This is currently running at approximately 800m3/hr (October 2007). A landfill gas analyser was installed on the flare in 2007. In Cell 3 horizontal wells have been installed at intervals in the waste and are connected to an open flare which is being used as an odour control method prior to completion of a permanent cap. On completion of the phased permanent capping in Cells 3 and 4 vertical landfill gas extraction wells will be installed in the waste and connected to the landfill gas management system.

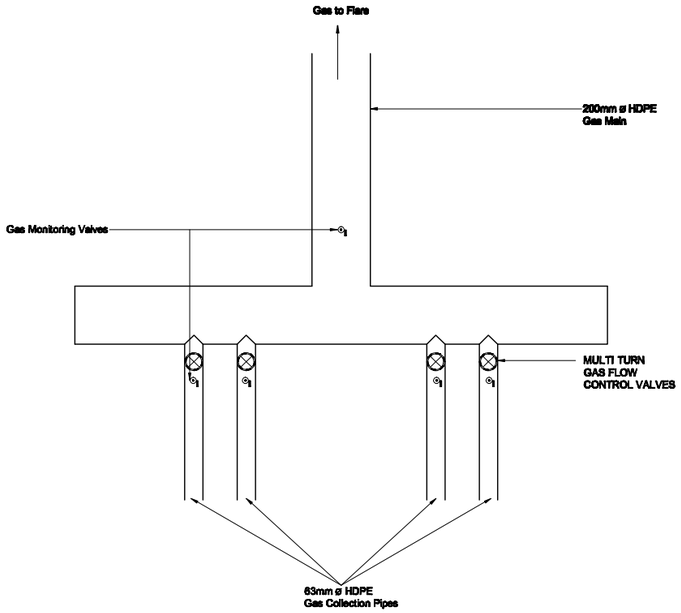
3.2.1 Gas Extraction Wells

The gas extraction system currently comprises a series of 11 no. extraction wells installed into the waste in the old remediated landfill. They are spaced approximately 40 metres apart. wells are spaced approximately 40m apart.

The gas extraction wells have been drilled through the capping layer into the waste body and have been stopped short of the base of the waste to avoid damage to the in-situ clay layers beneath which are acting as a basal liner. Each borehole was closed off with a bentonite seal plug. The gas extraction wells have been drilled at a diameter of 600mm to accommodate a 125mm diameter slotted HDPE pipe surrounded by a suitably sized no fines gravel pack of non-carbonaceous material. The pipework also has the following further specification:

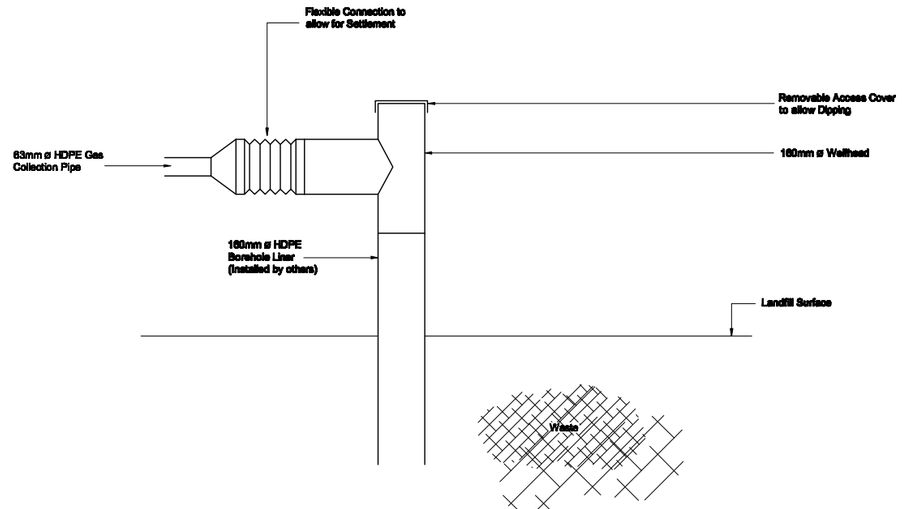
- A minimum of 17% of the surface area is cutaway to allow for the ingress of gas
- Slot widths are be 3-5mm
- A horizontal configuration of slots
- The pipe is unslotted in the capping layer

It is anticipated that a similar specification will apply for the installation of further gas wells as the field expands.



PLAN : MANIFOLD - TYPICAL ARRANGEMENT

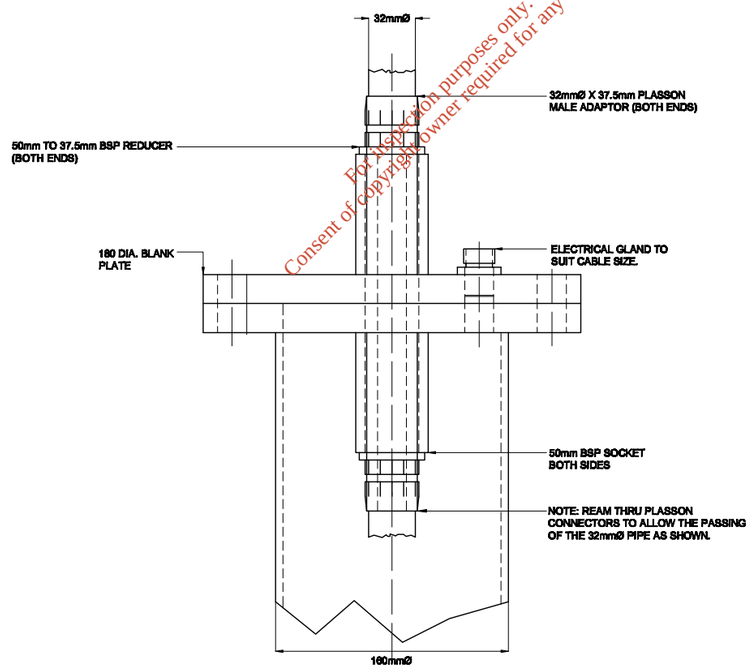
Scale 1:10



ELEVATION : TYPICAL WELLHEAD

Wellhead, pipework to be installed on
landfill surface prior to capping.

Scale 1:10



GAS WELL HEAD WORKS

NOT TO SCALE

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D01	17/05/05	Draft Issue	A.F.

Project:

Corranure Landfill
Gas Management

Title:

Wellhead Details
Figure 3.3

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Checked by:	K.G.	File No:	MCE0027DG0007
Approved by:	A.F.	Dg. No:	DG0007-01
Scale:	N.T.S.	Rev:	F01
Date:	May '05		

3.2.2 Gas Extraction Wellheads

The wellheads are installed at the top of each of the boreholes. The wellheads are joined to the collector/carrier pipework using flexible connections to allow for settlement. The wellhead allows for the monitoring of gas throughput, gas quality and suction pressure.

A typical wellhead detail including control valve is shown in **Figure 3.3**.

3.2.3 Gas Collection Pipework

The gas collection pipework layout is shown in **Figure 3.1**. A collection pipe network is needed to convey the gas from the point of generation or collection to the point of thermal destruction (flare). A single HDPE 200mm diameter SDR 17.6 pipe has been installed to act as the collector main to the flare.

The pipework in the old remediated landfill has been installed in the upper clay layers of the capping system. Pipework in the remainder of the landfill has been installed on the upper clay layers of the capping system. Future pipework will be installed on a similar basis.

Regular inspection and maintenance of the collection pipework is necessary in order to monitor the effects of settlement on the efficiency and structural soundness of the collection system.

3.2.4 Condensate Removal

When landfill gas enters cooler zones condensate may be generated which can be corrosive and could contain volatile organics. The removal of condensate from the pipeline is necessary to prevent blockages and restriction of gas flow.

There are 6 knock-out-pots on the gas collection system, 2 no. of which are pumped. These are installed in order to remove condensate at various low points in the pipework system prior to entering the gas flare. Condensate collected in these pots either goes back into the cell or is pumped to the leachate collection system.

There are 4 no. condensate knockout pots located on the collection pipework in the waste body. Condensate collected in these knockout pots drains back into the waste.

Similar arrangements will be put in place to drain condensate from future gas collection mains.

3.2.5 Extraction Pumps

The gas flare contains an extraction pump to draw the landfill gas from the wells through the collector pipework to the flare. The extraction system is fitted with flame arrestors so that when pumping a gas/air mixture within the explosive range, the risk of propagation of an explosion is minimised. Instrumentation to allow regular rebalancing of the gas flows from each well is also included in the system.

3.2.6 Gas Flare

An enclosed landfill gas flare is in operation at Corranure Landfill with a capacity to process 1,500m^3/hr of bulk landfill gas from the old remediated cell, Cell 1 and Cell 2. The flare is a "ground flare" type, supplied and installed by Biogas Technology Ltd., England. An open landfill gas flare is also in operation which is connected up to horizontal gas wells in Cell 3.

The following gas emissions concentrations have been stipulated by the EPA in Schedule C.4 of the Waste Licence W0077-02 for the landfill gas flare at Corranure Landfill:

Table 3.1: Gas Emission Limits

Parameter	Flare (enclosed) Emission Limit Value note 1	Utilisation Plant Emission Limit Value note 1
Nitrogen Oxides ($NO_{X)}$	150 mg/m^3	500 mg/m^3
CO	50 mg/m^3	650 mg/m^3
Particulates	Not Applicable	130 mg/m^3
Total Organic Carbon (TOC)	10 mg/m^3	Not Applicable

Note 1: Dry gas referenced to 5% oxygen by volume for utilisation and 3% oxygen by volume for flares

Landfill gas is flared at a temperature range between 1000^{0}C and 1200^{0}C to remove minor constituents in the landfill gas. For adequate destruction, combustion retention time is typically between 0.3 and 0.6 seconds.

Typically a methane content of at least 20% by volume is specified for operation of a landfill gas flare unit and it is likely that this minimum concentration will be achieved in the collected gas, certainly in the short to medium term.

The flare is fitted with gas monitoring equipment capable of measuring the composition of the input and outputs of the flare as required under the terms of Table E.6 of the Waste Licence.

The flare is connected up to a new telemetry system which was installed at the landfill in 2006. The purpose of this system is to control the landfill gas and leachate management system. The control system at the administration building was upgraded by connecting the existing control panel to a new, dedicated desktop computer.

3.2.7 Maintenance of System

Flare - Routine and non-routine maintenance carried out by Biogas Ltd. (routine operation by landfill management)

Wells - Routine inspection by landfill management.

Pipework - Routine inspections by landfill management for leakages and maintained as per suppliers recommendations.

Condensate - The gas lines on all cells including the knockout pots are monitored daily. The pumped knockout pots on the mainline are inspected weekly. The knockout pots are dewatered as appropriate. After the capping has been completed on Cell 2 each gas well and gas line will be individually graded in order to maintain gas quality and condensate removal.

Telemetry System – The Operations Manual should be consulted for further information on Maintenance (EMR).

4 ENERGY RECOVERY

4.1 UTILISATION OF LANDFILL GAS

In September 2006 a Preliminary Gas Utilisation Feasibility Study was completed in order to explore feasible gas utilisation options for the site. An assessment of the current and future landfill gas production was undertaken.

It is concluded that based on this preliminary study, the utilisation of landfill gas may be viable, but would need verification though a more detailed assessment including an on-site gas pumping trial to determine quality of the gas resource and confirm that the gas flows could be sustained over the given time period. The viability of utilising the landfill gas is also dependent on economic viability, including ESB connection costs which would need to be determined.

5 MONITORING

5.1 COMPLIANCE MONITORING REQUIREMENTS

A gas-monitoring programme is in place to establish whether gas production at the site is giving rise to a hazard or nuisance and to determine the effectiveness of the landfill gas management system. The monitoring can also help establish the viability of gas combustion and energy recovery.

In compliance with Schedule D.2 of the Waste Licence, the following gas monitoring programme is currently in operation at the site.

Table 5.1: Monitoring Programme

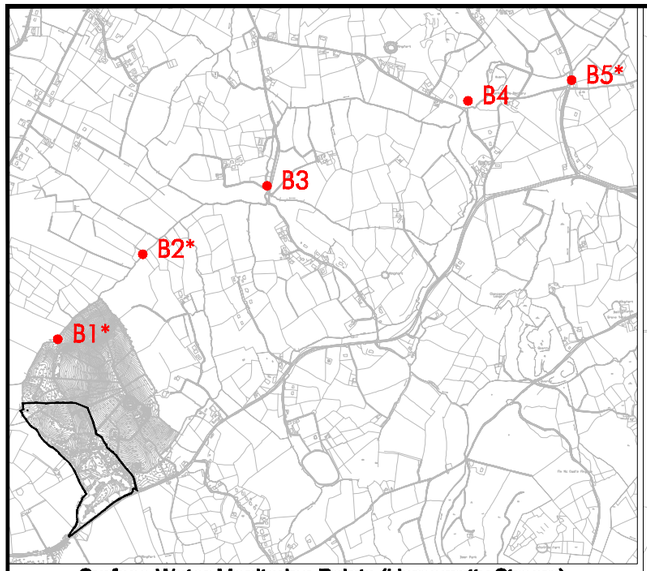
Parameter	Monitoring Frequency		Analysis Method [Note 1]/Technique [Note 2]
	Gas Boreholes/Vents/Wells	Site Office	
Methane (CH_4) % v/v	Monthly	Weekly	Infrared analyser/Flame ionisation detector
Carbon Dioxide (CO_2) % v/v	Monthly	Weekly	Infrared analyser/Flame ionisation detector
Oxygen % v/v	Monthly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

Note 1: All monitoring equipment used should be intrinsically safe.
Note 2: Or other methods agreed in advance by the Agency

The local geological and hydrogeological conditions of the area will influence the rate of gas migration from the site. Corranure Landfill is underlain by thick layers of boulder clays of low permeability and the risk of lateral gas migration from the site is low.

Landfill gas is monitored from the gas extraction boreholes within the waste body and in gas wells around the perimeter of the landfill.

Monitoring locations are shown in **Figure 5.1.**



Surface Water Monitoring Points (Lismagratty Stream)

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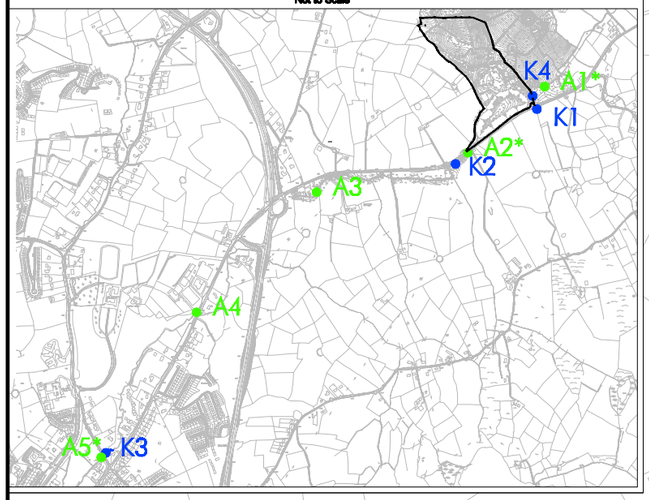

Surface Water Monitoring Points (Corranure Stream)

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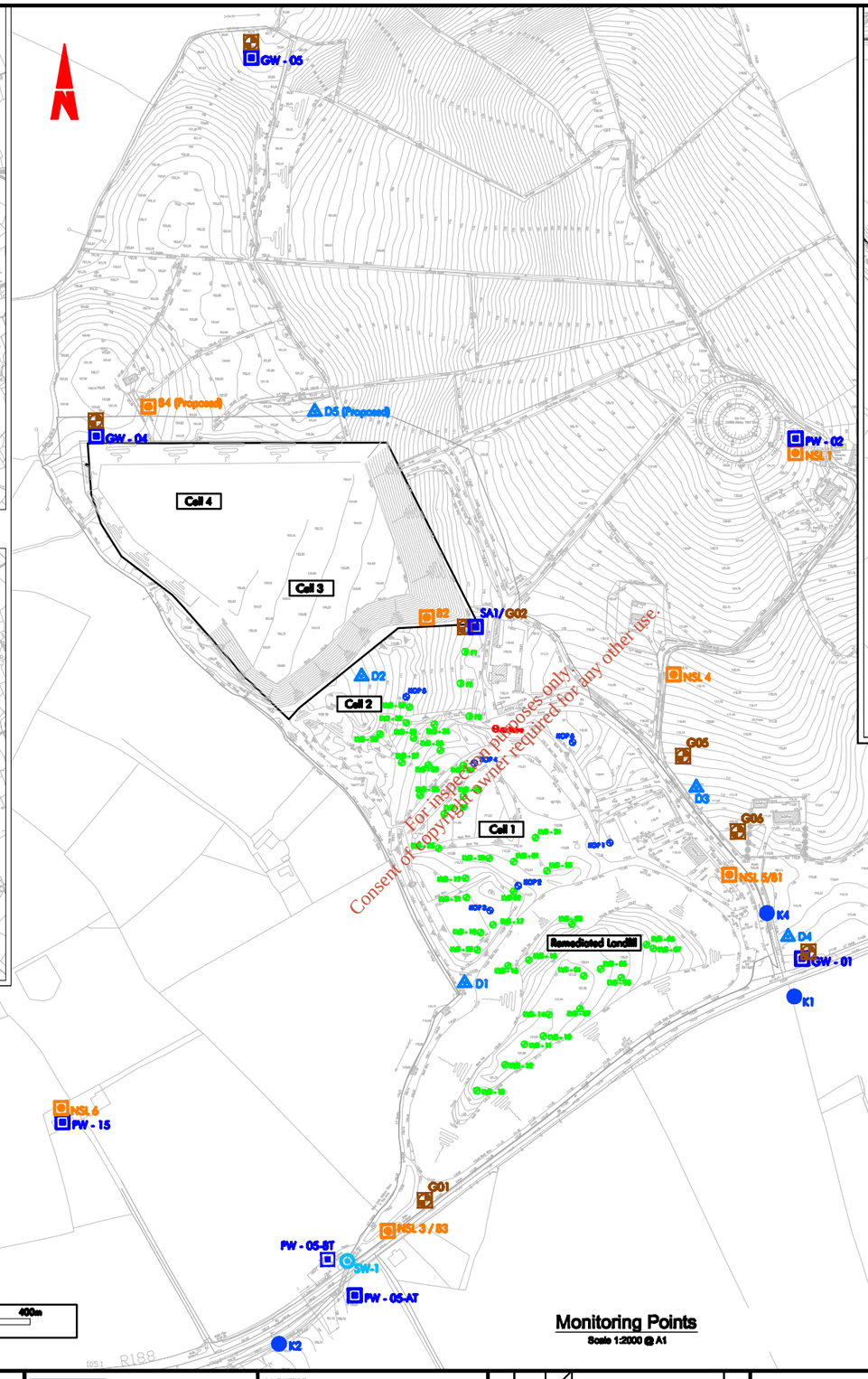
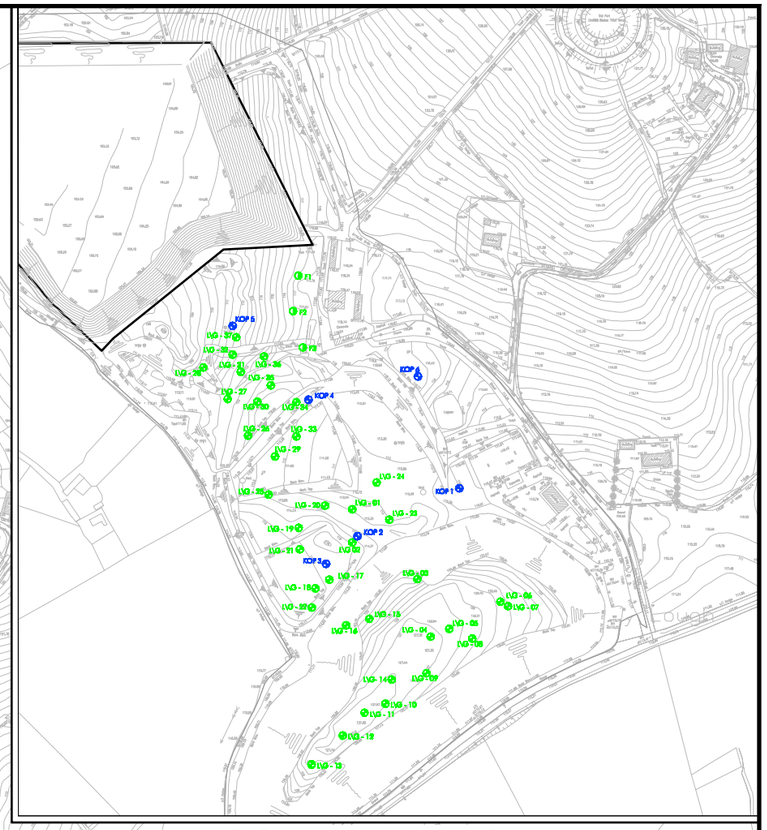
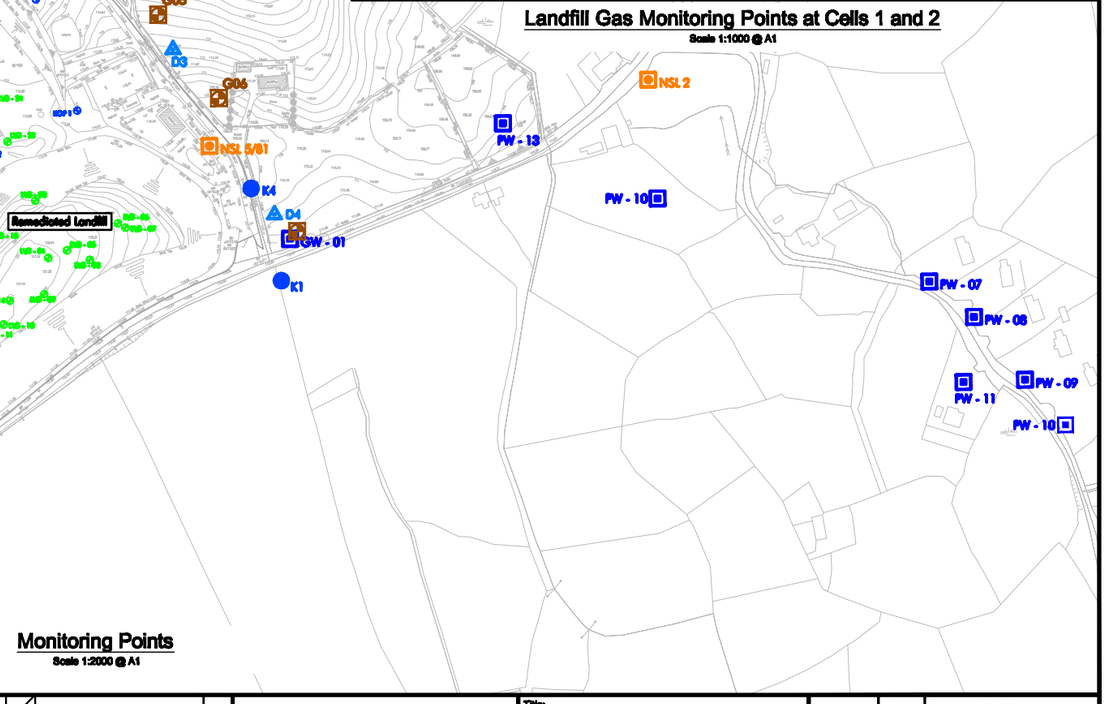




Landfill Gas Monitoring Points at Cells 1 and 2

Scale 1:1000 @ A1



Monitoring Points

Scale 1:2000 @ A1

Legend:

- Surface Water Monitoring Point
- Perimeter Gas Well
- Sewer Sample Monitoring Point
- Surface Water Emission Point
- Cell Outline
- Ground Water Well / Private Well
- Dust Monitoring Point
- Noise Monitoring Point
- Landfill Gas/ Leachate Extraction Well
- Horizontal Gas Extraction Well
- Condensate Knock Out Pot

Scale Bar: 0.0m 100m 200m 300m 400m

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F01	04.04.07	Issue	Final Issue	W.M.

Corranure Landfill
Licence Compliance

Title:
Corranure Landfill
Locations of
Monitoring Points
Figure 5.1

Drawn by:	C.N.	Job No:	MGE0068
Checked by:	S.G.	File No:	MGE0068DG0007
Approved by:	W.M.	Drg. No:	DG0007-01
Scale:	As Shown	Rev:	F03
Date:	April '07		

Portable gas monitoring equipment are susceptible to interference by water vapour or water entering the equipment and therefore it is essential that all such equipment is periodically calibrated and serviced by staff according to the manufacturers instructions. All monitoring equipment should be carefully stored when not being used.

A permanent gas monitoring system is in place in the landfill administration building. The monitoring equipment is programmed with parameter emission limits and a contingency system to alert staff in the event of any of these limits being exceeded.

A gas reading exceeding these limits will trigger the Contingency Arrangements outlined in the Facility's Emergency Response Procedure.

The monitoring proposal should be kept under constant review to ensure the effectiveness of the monitoring regime and the landfill gas control systems in general.

5.2 MONITORING OF FLARE

Table D.7.1 of Waste Licence W0073-02 outlines the following monitoring programme for the flare **(See Table 5.2).**

Table 5.2: Proposed Monitoring for Gas Flare

Parameter	**Flare (enclosed)** **Monitoring Frequency**	**Utilisation Plant** **Monitoring Frequency**	**Analysis Method** [Note 1] **/ Technique** [Note2]
Inlet			
Methane (CH_4) % v/v	Continuous	Weekly	Infrared Analyser/Flame Ionisation Detector/ Thermal Conductivity
Carbon Dioxide (CO_2) % v/v	Continuous	Weekly	Infrared Analyser/ Thermal Conductivity
Oxygen % v/v	Continuous	Weekly	Electrochemical/Thermal Conductivity
Total Sulphur	Annually	Annually	Ion Chromatography
Process Parameters			
Combustion Temperature	Continuous	Quarterly	Temperature Probe/ Datalogger

Carbon Monoxide (CO)	Continuous	Continuous	Flue Gas Analyser/ datalogger
Nitrogen Oxides (NO_X)	Annually	Annually	Flue Gas Analyser
Sulphur Dioxide (SO_2)	Annually	Annually	Flue Gas Analyser
Particulates	Not Applicable	Annually	Isokinetic/ Gravimetric
Total Organic Carbon (TOC)	Annually	Not Applicable	Flame Ionisation

Note 1: All monitoring equipment used should be intrinsically safe.

Note 2: Or other methods agreed in advance by the Agency