30 MAY 2005

ATTACHMENT A1

NON-TECHNICAL SUMMARY

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ROADSTONE DUBLIN LIMITED

REMEDIATION OF UNAUTHORISED LANDFILL SITES

AT BLESSINGTON, CO. WICKLOW

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ENVIRONMENTAL IMPACT STATEMENT

NON-TECHNICAL SUMMARY

REVISION 1 : MAY 2005

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1. BACKGROUND TO WASTE LICENCE APPLICATION

1.1 Environmental Investigations 2002 / 2003

Between December 2002 and February 2003, Wicklow County Council undertook an environmental investigation of lands owned by Roadstone Dublin Limited north-west of Blessington, Co. Wicklow. The investigations, in Dillonsdown, Deerpark and Newpaddocks townlands, were undertaken in response to allegations that unauthorised disposal of waste had occurred there in the past.

The environmental investigation comprised excavation of deep trial pits (up to and in excess of 15m deep) at eight separate areas, all of which were restored (i.e. backfilled) sand and gravel pits. The location and extent of the company's landholding, known locally as 'Doran's Pit', is indicated on the 1:50,000 scale Ordnance Series Discovery Series map in Figure 1.

Wicklow County Council's investigation uncovered domestic, commercial and industrial waste (DCI) at three separate areas on Roadstone Dublin's landholding, specifically at Area 1 in Dillonsdown, at Area 4 in Deerpark and at Area 6 in Newpaddocks. The location of these unauthorised landfill sites within Roadstone Dublin's landholding are shown on an updated Ordnance Survey map in Figure 2 (1:12,500 scale)

The unauthorised disposal of DCI waste on Roadstone Dublin's landholding at Blessington was undertaken by third parties without its knowledge or consent. Neither Roadstone Dublin nor any CRH Company made, or will make, any gain whatsoever from these unauthorised activities. Roadstone Dublin has, at all times, fully co-operated with and supported the investigations of both Wicklow County Council and the Gardaí.

Following Wicklow County Council's initial investigations, Roadstone Dublin commissioned additional hydrogeological, geotechnical and environmental investigations at each of the unauthorised landfill sites. The objective of these investigations was to obtain sufficient data to assess the potential risk to environmental receptors (principally surface water, groundwater and air) presented by the buried waste. The scope of the investigations was agreed in advance with Wicklow County Council and its technical advisors, and was supervised by them.

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The principal findings of the investigations undertaken on Roadstone Dublin's landholding were:

(i) The amount of unauthorised DCI waste buried across the site is estimated to be approximately 50,000 tonnes;
(ii) Additional inert construction and demolition (C&D) waste, mainly rubble was uncovered, and is estimated at 60,000 tonnes;
(iii) The total amount of unauthorised waste buried at the site concurs with Wicklow County Council's estimate of 110,000 tonnes;
(iv) Slow decomposition of the waste has begun, signified by some landfill gas odour at most of the areas where buried DCI waste was encountered.
(v) The predominant source of the DCI waste was businesses located in the West Wicklow / East Kildare area. No significant amount of waste was discovered from areas outside the immediate region. The waste was buried during the 1990's.

1.2 Environmental Risk Assessment

In March 2003, Roadstone Dublin appointed environmental consultant Parkman (*now* Mouchel Parkman) to assess the risk (if any) to the environment using all available hydrogeological and hydrochemical data acquired during the environmental investigations.

The environmental risk assessment was undertaken to identify:

(i) if any contamination from the buried DCI waste will travel in the underground water (aquifer or groundwater) to water wells supplying drinking water or to streams, rivers, ponds or lakes (surface water) at concentrations greater than allowed in drinking water or above levels protective of aquatic life;
(ii) if the generation and migration of landfill gas (methane and carbon dioxide) presents a risk to nearby property;
(iii) appropriate remediation strategies based on the environmental risk assessment.

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The risk assessment report (Parkman, August 2003) was forwarded to the Regulatory Authorities in accordance with notices issued under Section 55 of the Waste Management Acts 1996-2003. The findings of the environmental risk assessment for water and landfill gas were as follows:

Water

- No current risk to existing drinking water supplies has been identified
- The future risks posed to drinking water and surface water resources are generally low and should a risk arise, it may be many decades before it would occur. This allows adequate time to monitor the situation and take preventative measures / remedial actions.

Landfill Gas

- When assessed against Irish Department of the Environment Guidelines there is a potential risk to housing close to Area 6 from landfill gas;
- Areas 1 and 4 do not pose such a risk;
- There is no risk to human health from potentially volatile chemicals within the buried waste.

1.3 Environmental Risk Management Strategy

Following on from the Environmental Risk Assessment, Parkman recommended the following actions. Progress in addressing these recommendations is provided in bold italics:

(i) As a precautionary measure a temporary vent trench should be constructed in Area 6 on the southeast / southwest sides of the site to prevent potential lateral migration of landfill gas generated by the DCI waste.
This was constructed in November / December 2003.

(ii) A number of passive vents should be installed within the waste body in Area 6 to encourage the upward migration and safe escape of landfill gas from the waste body.
These were installed in December 2003 / January 2004.

(iii) An environmental monitoring programme for the site should be put in place, which covers surface water, groundwater and gas monitoring in agreement with the Environmental Protection Agency and Wicklow County Council.
Monitoring has been in place since Spring 2003, and continues in accordance with the scope defined in the Environmental Monitoring Programme (August 2003) submitted to, and agreed by Wicklow County Council.

(iv) Monitoring of groundwater and surface water should continue until such a time that the Regulatory Authorities are satisfied that there is no risk to groundwater, surface water and drinking water supplies. The scope of the monitoring programme will be defined by the EPA as part of the waste licensing process.
Monitoring programme in place as described in (iii) above.

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The environmental risk management strategy prepared by Parkman identified two potential remediation options for the unauthorised landfill sites on Roadstone Dublin's landholding:-

Option 1 required the removal of buried waste from Area 6 to Area 1, capping of Areas 1 and 4 and establishing a long-term groundwater monitoring regime to monitor groundwater quality.

Option 2 required the removal of all buried waste in Areas 1, 4 and 6 to a remediation landfill elsewhere on Roadstone Dublin's landholding.

Although the risk management strategy undertaken by Parkman indicated that the risks associated with Option 1 were acceptably low, Roadstone Dublin concluded, following further detailed environmental investigation and evaluation by its technical advisors, that its remediation strategy for the unauthorised landfill sites should provide for excavation and removal of the buried waste, processing of the excavated waste by segregation and recycling and transfer of the residual non-hazardous waste to a remediation landfill within the existing landholding.

The proposed remediation landfill facility will only be used for the remediation of the unauthorised landfills on Roadstone Dublin's landholding. No importation of waste will be permitted under any circumstances.

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1.4 Section 55 Process

Following the initial discovery of buried waste on Roadstone Dublin's lands, Wicklow County Council issued notices under Section 55 of the Waste Management Acts (1996 to 2003) in July 2003, October 2003 and January 2004 requiring the company to submit details of

(i) its environmental risk assessment and risk management strategy and
(ii) its proposed remediation scheme

After reviewing submissions made by Roadstone Dublin in response to these notices, Wicklow County Council issued a supplementary Section 55 Notice in July 2004, which indicated that

(i) it considered that the proposed remediation scheme provides an appropriate method to remedy the site;
(ii) Roadstone Dublin should make application to the Environmental Protection Agency (EPA) for a waste licence in respect of the proposed remediation scheme and
(iii) the remediation scheme should conform to a number of specified requirements.

The proposed remediation scheme has been developed, and will be undertaken, in accordance with the Section 55 notice issued by Wicklow County Council in July 2004.

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2 THE SITE

2.1 Site Location

The site to which the Waste Licence Application refers is located within Roadstone Dublin's landholding, north of Blessington, Co. Wicklow. The plan extent of the company's landholding is outlined in blue on Figures 1 and 2. For the purposes of the Waste Licence Application, the 'Application Area' comprises the three areas where unauthorised waste was uncovered, the site of the proposed remediation landfill and the interlinking road network. The plan extent of the proposed application site is outlined in red on Figures 1 and 2.

2.2 Site Description

Roadstone Dublin's total landholding at Blessington currently comprises 267 hectares (643 acres). At the present time, the company extracts sand and gravel from an area in excess of 200 acres to the west of the N81 National Secondary Road. The excavated materials are transferred by conveyor, under the N81, for processing at the washing and screening plant in Doran's Pit on the eastern side of the N81.

Reserves of sand and gravel in some areas of the company's landholding have been completely worked out and the company has progressively restored these areas to agricultural and forestry use. To date, approximately 53 hectares (130 acres) have been restored to agricultural use, with a further 60 hectares (147 acres) restored to forestry.

2.3 Site Access

At the present time, public road access to Roadstone Dublin lands is principally via the N81 National Secondary Road. Access to the lands may also be gained via a minor county road to the north of the application site, known locally as 'Darkers Lane'. Traffic movement within the landholding itself is via a network of unpaved haul roads.

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2.4 Planning History

At the present time, Roadstone Dublin is extracting sand and gravel at a 6 hectare (15 acre) site at Glen Ding ridge, on the western side of the N81 National Secondary Road. This activity is proceeding on foot of a planning permission originally granted by Wicklow County Council in July 1970 and a more recent planning permission granted by Wicklow County Council in December 1999.

Roadstone Dublin submitted a planning application to Wicklow County Council in June 2001 to re-locate the washing and screening plant from Doran's Pit on the eastern side of the N81 National Secondary Road, to a site on the opposite side of the road in Deerpark townland, in the middle of the company's landholding, closer to where existing sand and gravel extraction takes place. Following the discovery of buried waste at the application site in January 2003, Roadstone Dublin requested an extension of time so that site remediation measures could be agreed and implemented. This request was acceded to by Wicklow County Council.

Planning permission was granted to Cookehill Limited by Wicklow County Council in August 2002 to construct the northern part of the Blessington Inner Relief Road across part of the Roadstone Dublin lands fronting onto the existing N81. Part of the new road runs in cutting through the unauthorised landfill site in Newpaddocks townland (Area 6).

2.5 Surrounding Land Use

At its closest point, Roadstone Dublin's landholding lies approximately 700m north-west of the village of Blessington, Co. Wicklow. The surrounding land use is varied, with recent housing and industrial development located immediately beyond the southern and south-eastern corner of the landholding. The lands to the south-west of the landholding are forested and provide an important local amenity at Deerpark Wood.

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A number of other sand and gravel companies operate from sites adjacent to the Roadstone Dublin landholding. These include J.W Carnegie and Co. to the north-west and Hudson Brothers to the east. The sand and gravel pits at Blessington are a major source of sand and gravel used in the production of construction materials in the Greater Dublin area.

The other lands surrounding Roadstone Dublin's landholding are used for agricultural purposes, mainly pastoral grazing of sheep and cattle and forestry.

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3 REMEDIATION SCHEME

3.1 Principal Elements

The proposed remediation scheme for the unauthorised landfill sites on Roadstone Dublin's lands at Blessington, Co. Wicklow involves:

(i) Prior removal of leachate from boreholes in domestic commercial and industrial (DCI) waste at the unauthorised landfill sites (Areas 1, 4 and 6) and transport off-site to an approved wastewater treatment facility.
(ii) Construction of sumps in advance of the excavation works to facilitate collection and extraction of any residual leachate;
(iii) Excavation and removal of all DCI waste from the unauthorised landfill sites. This will include excavation and removal of 0.5m thickness of soil above, below and around the waste. Soil remaining in-situ will be subject to testing to confirm it is not contaminated.
(iv) Segregation, temporary storage and classification testing of potentially hazardous waste (identified by visual inspection, in-situ monitoring and testing of the excavated DCI waste) at a designated waste inspection and quarantine facility.
(v) Transfer of any hazardous material which is not acceptable at the engineered remediation landfill off-site to licensed hazardous waste recycling / disposal facilities.
(vi) Segregation of any significant volumes of construction and demolition (C&D) waste, encountered during excavation of the DCI waste for recycling (either on-site or off-site) or deposition in the engineered remediation landfill, as appropriate;
(vii) Transfer of residual non-hazardous DCI waste to an engineered remediation landfill within Roadstone Dublin's landholding, south of the unauthorised landfill site at Area 1;
(viii) Restoration of Areas 1, 4 and 6 using appropriate excavated soils overlying the waste bodies and excess overburden materials arising from construction of the remediation landfill;
(ix) Capping of the remediation landfill and restoration to grassland;
(x) Environmental monitoring (of surface water, groundwater and landfill gas) using the existing groundwater monitoring infrastructure around Areas 1, 4 and 6 and additional monitoring infrastructure to be installed at, around and down hydraulic gradient of the engineered cell.

The engineered remediation landfill will ONLY be used for the remediation of unauthorised landfills on this site and no importation of waste will be permitted under any circumstances.

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3.2 Waste Removal

3.2.1 Excavation of Buried Waste

The proposed remediation works at each of the three unauthorised landfill areas on Roadstone Dublin's lands at Blessington essentially comprises

(i) excavation and removal of all buried domestic, commercial and domestic waste from unauthorised landfills at Areas 1, 4 and 6;
(ii) segregation and transfer of unacceptable waste off-site
(iii) recycling and temporary stockpiling of construction and demolition waste
(iv) transfer of residual non-hazardous waste to the engineered remediation landfill.

At each of the three unauthorised landfill areas, site preparatory works will include construction of approximately 3m to 5m high earth mounds around the boundary using the inert soils overlying the main body of waste to screen on-site activities from external view and provide additional security and safety.

If significant volumes of construction and demolition waste are mixed through the overburden soil, it will be transferred to the recycling areas east of the unauthorised landfill at Area 4, where it will be passed through a mobile trommel screen fitted with a series of large screening grids and magnets to draw off any recyclable concrete or metal waste. Large boulders, concrete blocks, metal panels, large tyres and other waste which may be too large to pass through the trommel, will be removed by excavation plant and stockpiled separately to overburden soil.

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Segregated material will be transferred by public road to suitably licensed recovery facilities. Where practicable, oversize stone and concrete waste will be stockpiled on-site for future crushing and/or re-use.

A programme of soil sampling and validation testing will be established on-site to confirm that separated overburden soils are inert and free of contamination before they are re-used for site restoration and reclamation works.

A minimum of 150mm of soil will be left in place over the main body of domestic, commercial and industrial waste prior to its excavation and removal, in order to prevent windblown litter, odours etc. Where necessary, any existing leachate within the waste bodies will be removed by active pumping from existing boreholes to a mobile tanker prior to excavation and transferred to an approved / agreed treatment plant. Where required, sumps will be constructed in advance of excavation works to facilitate collection and extraction of any residual leachate within the waste bodies.

The DCI waste in each area will be excavated in a systematic and controlled manner ('strip mining') using conventional tracked excavation plant.

If the excavated DCI waste is considered on the basis of visual inspection, in-situ monitoring and testing to be non-hazardous, it shall be placed directly onto sealed (watertight) dump trucks, covered and immediately transferred to the remediation landfill.

Where visual inspection, in-situ monitoring and testing indicates the presence of potentially hazardous or unacceptable material within the excavated DCI waste, it shall be segregated, placed onto sealed trucks and transferred to the waste inspection and temporary quarantine area for more detailed testing. Any material which is not acceptable at the remediation landfill will be transferred off-site to an appropriately licensed hazardous waste disposal or recycling facility.

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During excavation operations, the area of waste exposed to the atmosphere will be minimised in order to limit odour emissions. Exposed waste will be covered at the end of each working day with available soil cover or alternatively, with hessian, impermeable PVC sheeting or recovered construction and demolition waste.

Excavation side slopes will be benched and graded as necessary to prevent instability. The width and gradient of temporary access roads into each excavation will be sufficient to ensure safe access and egress of plant and personnel. A programme of gas monitoring will be established around and within each excavation to monitor ambient concentrations of landfill gas and to safeguard the health and safety of site staff and operatives.

In order to minimise dust emissions at each excavation area, water from a tractor drawn bowser will be sprayed as and when required.

Waste excavation, removal, transfer, landfilling and processing and temporary storage activities will only be undertaken between 07.30 hours and 17.30hours Monday to Friday and 08.00hours to 13.00 hours on Saturdays. No works will be undertaken on Sundays or public holidays.

3.2.2 *Waste Transfer*

Roadstone Dublin will be responsible for overall operational control of the remediation landfill. Site management and direction of landfilling activities will be undertaken by Roadstone Dublin personnel, assisted as necessary by appropriately qualified and experienced technical advisors.

All waste unloaded from trucks at the remediation landfill will be visually inspected by qualified staff to ensure that no hazardous waste or other unacceptable waste is placed within it. Any potentially hazardous or unacceptable waste identified amongst the existing buried waste will be segregated and brought to the waste quarantine area for further testing. Any material which is not acceptable for disposal at the non-hazardous remediation landfill will be removed off site to a suitably licensed hazardous waste disposal or waste recycling facility.

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3.3 Remediation Landfill

The engineering design of the remediation landfill has been carried out in accordance with the Environmental Protection Agency's (EPA) Guidance on Landfill Site Design on the basis that the waste to be placed within the repository is classified as non-hazardous, biodegradeable. In recognition of local concerns about potential groundwater contamination, the design of the basal lining system for the remediation landfill **exceeds** the requirements set out in EPA guidance documents.

The dimensions of the cell are dictated by the requirement to create a void sufficient to accommodate the volume of waste identified by the environmental investigations undertaken in 2003 plus an allowance for intermixed and contaminated soils and some C&D waste that may be intermixed with, or encountered during the excavation of, DCI waste.

3.3.1 Construction Duration

It is currently envisaged that the basal and formation works for the remediation landfill facility and the associated long-term infrastructure (such as the surface water management system) will be constructed in one phase by an externally appointed Works Contractor in three to four months. Thereafter, the buried waste will be excavated in sequence at Areas 4, 6 and 1 using plant and equipment owned or leased by Roadstone Dublin and operated by its employees or external Contractors. It is currently estimated that these works will take a further four to six months. The final phase of the works, final landfill capping and restoration will be undertaken by an external Works Contractor. This work is expected to take no more than one to two months.

3.3.2 Material Requirements

Roadstone Dublin will source natural drainage stone from its own sand and gravel processing facility at Doran's Pit, on the opposite side of the N81 to the remediation landfill. Topsoil and subsoil will be sourced from ongoing restoration works on sand and gravel pits on its lands at Blessington. A suitable source of clay liner material has been identified off-site (glacial till) at the Applicant's Huntstown Quarry in North Dublin and will be imported by road. Other materials, including geosynthetic liners, geotextiles, pipework etc. will be imported by road.

3.3.3 Removal of Materials Off-Site

The only materials to be removed off site are hazardous waste contained within the excavated DCI waste bodies (if any) and recoverable or segregated waste recovered within the overburden soil. Any leachate collecting in sump excavations within Areas 1, 4 or 6 or by the leachate management system at the remediation landfill will be pumped to a mobile tanker and transferred off-site to an approved treatment facility.

3.3.4 Formation Levels and Gradients

The topography of the preferred location for the remediation landfill currently provides a relatively flat area bounded on the eastern and western sides by existing slopes formed in sand and gravel. To create the required formation for the remediation landfill, excavation and filling will be required to generate the basal falls and side slopes, refer to Figure 3.

3.3.5 Bund Design

Around the western boundary of the remediation landfill, containment is provided by a bund constructed as part of the lining system. A bund has also been used to split the basal area of the remediation landfill into two cells. Containment bunds will be formed from clay liner material to a height of 2m and overlain with the geomembrane, geotextiles and the leachate drainage layer. Cross-sections through the containment / internal bunds are provided on Figure 3.

3.3.6 Capacity

The remediation landfill has been designed to provide a storage capacity of up to 175,000m^3. Ultimately however, it is expected that the total volume of waste placed at the remediation landfill will be less than that provided for in the engineering design. No waste will be imported from outside the site.

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3.3.7 *Basal and Side Slope Liner Design*

The design of the lining system **exceeds** the requirements for a residual non-hazardous biodegradable landfill set out by the Environmental Protection Agency in its publication 'Landfill Manuals – Landfill Site Design' which interprets the European Landfill Directive (Council Directive 1999/31/EC). The proposed lining system shall comprise the following elements:

(i) geotextile separator to prevent fine-sized particles (clay and silt) being washed out of the waste into the underlying leachate drainage blanket;
(ii) 500mm thick leachate drainage blanket with a minimum permeability $1x10^{-3}$ m/s to collect leachate produced by the degradation of the DCI waste;
(iii) geotextile protection layer to reduce strain applied by the drainage stone to the underlying geomembrane as waste is placed
(iv) 2mm thick HDPE geomembrane liner to contain leachate
(v) geosynthetic clay liner comprising a bentonite layer, approximately 6mm thick between two layers of geotextile. *(This liner provides enhanced protection, over and above that specified for non-hazardous engineered landfills in EPA guidance documents).*
(vi) 1m thick clay liner of maximum permeability (k) $1x10^{-9}$ m/s.

The construction of the remediation landfill will be subject to a process of construction quality assurance (CQA) by an external independent consultant appointed by Roadstone Dublin. Full details of CQA procedures to be implemented on site will be provided in a CQA Plan to be approved by the Environmental Protection Agency.

3.3.8 *Leachate Management System*

The volume generated within the proposed remediation landfill is expected to be too low to require provision of an on-site leachate storage or treatment facility. All leachate produced within the lined remediation landfill will be collected by a leachate drainage blanket and herringbone pipework system and will flow to submersible pumps at leachate extraction wells (see Figure 3). Leachate will be transferred from the wells directly to road tankers and taken off-site to an approved treatment facility, most likely an existing local wastewater treatment plant. Notwithstanding this, provision will also be made in design for re-circulation of the leachate within the waste body, should it be required.

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3.3.9 *Gas Management System*

The predicted volume of gas produced by the DCI waste transferred to the remediation landfill will be insufficient to support a generation unit and also be insufficient to support flaring.

In line with EPA guidance, the design of the remediation landfill has incorporated details for the passive venting of gas from beneath the capping system. The volume of gas released to the atmosphere is likely to be relatively low and will be significantly diluted. However, it is intended that the proposed passive venting system will have the capability to connect the vents to a small flare should monitoring ever indicate that landfill gas production rates are sufficiently high.

Passive vents will comprise 180mmm diameter perforated HDPE pipe installed through the waste body in a 300mm diameter bore, backfilled with pea gravel, connected to 180mm diameter solid HDPE pipes protruding through the capping layer and extending approximately 1.5m to 3m above ground level.

3.3.10 *Capping and Restoration*

In accordance with EPA Guidance, the permanent capping system will comprise the following elements:

(i) 150mm thick topsoil layer
(ii) 850mm thick subsoil layer
(iii) 500mm thick drainage layer of minimum permeability $1x10^{-4}$ m/s
(iv) 1mm thick linear low density polyethylene (LLDPE) geomembrane over
(v) a geosynthetic clay liner (GCL) and
(vi) a 300mm thick gas collection layer of minimum permeability $1x10^{-4}$ m/s.

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Suitable restoration soils and materials for each of the drainage layers will be sourced elsewhere within the Doran's Pit site. A detailed specification and construction quality assurance (CQA) procedure covering the supply and installation of materials used in the capping and restoration will be set out in a CQA Plan similar to that developed in respect of the basal and side slope liner.

3.4 Site Infrastructure

The following site infrastructure is in place or will be put in place as part of the remediation scheme:

3.4.1 Site Security

During the site remediation works, all materials and plant will access the site via the existing gate entrance fronting onto the western, northbound carriageway of the N81 National Secondary Road. For the duration of the construction works and the filling and capping operations, manned security will be provided at gates on a 24 hour / 7 day basis. Site security cameras (operational 24 hours/day) and lighting will also be fixed to the roof of a temporary site office adjacent to the remediation landfill.

3.4.2 Site Roads and Parking Areas

The HGV lorries transferring waste from excavation areas to the remediation landfill facility will be confined within the Roadstone Dublin landholding for the duration of the site remediation works and will travel over the existing internal road network. The extent of paved and unpaved roads is delineated on Figure 4. Temporary unpaved access roads required to access or egress each unauthorised landfill area will be constructed from the existing haul roads to the unauthorised landfill sites and the remediation landfill, as shown on the site infrastructure layout in Figure 4.

Provision will be made for additional employee car-parking near existing accommodation facilities in the middle of Roadstone Dublin's landholding (beside the rising conveyor).

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3.4.3 Hardstanding Areas

A temporary compound for storage of plant, equipment and materials, covering an area of approximately 200m by 75m, will be provided west of the unauthorised landfill at Area 1 and the remediation landfill. A hardstanding area will also be provided east of Area 4 for recovery of any C&D waste encountered above the main body of DCI waste at each unauthorised landfill site.

3.4.4 Wheelwash and Weighbridge

In order to prevent transport of mud and potential contaminants on internal and public roads, a temporary self-contained wheelwash facility will be provided at the egress from each unauthorised landfill site and the remediation landfill, as shown in Figure 4. During the installation of the lining system, construction of the site infrastructure and subsequent landfill capping activities, a temporary self-contained wheelwash facility will also be provided at the end of the existing paved internal access road as shown on Figure 4 in order to prevent the transport of fines onto the public road network by HGV's delivering construction materials to the site. A weighbridge will be provided along the access track to the remediation landfill to record the waste tonnages placed therein.

3.4.5 Fuel and Oil Storage

Fuel and oil for plant and equipment undertaking the site remediation works will be stored at an existing bunded tank facility in Doran's Pit, on the eastern side of the N81 National Secondary Route. Insofar as possible, re-fuelling of all wheeled plant and vehicles will take place at Doran's Pit. Tracked plant and equipment will be re-fuelled from a mobile bunded fuel bowser at either of the proposed hardstanding areas located on Figure 4. All wheeled plant and vehicles will be serviced as necessary using existing facilities in Doran's Pit. Tracked plant will be serviced off site.

3.4.6 Waste Inspection and Quarantine Area

Should inspection or testing identify hazardous waste, it will be segregated and temporarily stockpiled at a waste inspection and quarantine area (possibly enclosed) to be constructed north

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of Area 4 and west of the remediation landfill (see Figure 4), pending removal off-site to suitably licensed hazardous waste disposal or recovery facilities. Any liquid waste (leachate) arising during storage of this material will be collected and transferred off-site to an approved treatment facility.

3.4.7 Sewerage and Surface Water Drainage Infrastructure

Existing toilet and hand washing facilities are provided for Roadstone Dublin staff employed in quarrying activities at the site. Temporary washrooms will be provided in portacabins behind (east of) the existing offices at the centre of the site (see Figure 4) for the extra personnel employed in the construction and site remediation works. A number of temporary self-contained toilet units ('portaloos') will also be provided in the same area

At the remediation landfill facility, a surface water management scheme will be implemented to minimise the volume of water entering the waste body. The proposed surface water management system comprises a series of lined ditches which allow run off around the remediation landfill to drain to an intermediate surface water pond, from which discharge to the existing lagoon to the west can be controlled. The surface water management system will be established prior to the main construction works. Outline details of the surface water management system are shown on Figure 5.

The temporary hazardous waste inspection and quarantine area, including delivery and collection areas, will be constructed on reinforced concrete with a surface water collection system in place to ensure no liquid will infiltrate the underlying aquifer. The storage and sorting areas will be bunded to a design storm volume or else be constructed under cover.

3.4.8 Site Services

Electric power, lighting and heating will be provided to the temporary site office at the site of the remediation landfill by a temporary generator or a connection to nearby overhead power lines. Personnel directing or overseeing the site remediation works will be contactable by mobile phone. Additional telephone landline and fax facilities can be established at existing site offices.

3.4.9 Plant Sheds, Garages and Equipment Compounds

Plant and equipment will be stored at a temporary site compound adjacent to the waste inspection and quarantine of the unauthorised landfill at Area 1 and west of the engineered remediation landfill, or if necessary, at the existing sheds and garages in Doran's Pit on the opposite side of the N81. Temporary workshops may also be provided by the construction Works Contractor and/or Roadstone Dublin at the same location.

3.4.10 Site Accommodation

It is currently envisaged that temporary 'portakabin' offices will be located on high ground immediately behind, and north of, the remediation landfill facility, adjacent to the proposed access road. This will permit technical and managerial staff employed by the construction Works Contractor and/or Roadstone Dublin to monitor all construction activity, traffic movements and operational activities. Temporary staff changing (drying) facilities, a canteen and washrooms will be provided for construction personnel in portacabins at the hardstanding area alongside existing facilities in the centre of Roadstone Dublin's landholding.

3.4.11 Waste Recovery Infrastructure

If a significant volume of C&D waste is mixed through the soils overlying the main body of DCI waste at each unauthorised landfill site, it will be transferred for processing to a hardstanding area immediately east of Area 4 in Deerpark (see Figure 4). The C&D waste will be processed at that location by passing it through a mobile trommel screen fitted with a series of large screening grids and magnets to draw off any recyclable concrete or metal waste.

3.5 Environmental Nuisance Control

The proposed remediation works on Roadstone Dublin's lands include a number of environmental controls to eliminate or minimise the nuisance to the public arising from the excavation of buried waste, and its subsequent transfer and placement in the remediation landfill. The environmental

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nuisance controls accord with established best practice for operation of landfills and the EPA publication 'Landfill Manuals : Landfill Operational Practices'.

Specifically, the proposed scheme includes provision for environmental controls for the following nuisances associated with the excavation, transfer and disposal of DCI waste:

(i) scavaging birds
(ii) dust
(iii) litter
(iv) odour
(v) vermin
(vi) fire

3.6 Environmental Monitoring

Immediately after evidence of unauthorised waste disposal had been uncovered at Roadstone Dublin's lands at Blessington, the company began to extend its established environmental monitoring programme to measure what, if any, impacts the buried waste had on surrounding environmental receptors. The scope of the existing environmental monitoring programme was agreed with officials from Wicklow County Council and the Environmental Protection Agency (EPA).

Limit values for all environmental emissions arising during the site remediation works and the subsequent aftercare period will be set by any Waste Licence issued by the EPA in respect of the proposed remediation works. It is envisaged that the existing environmental monitoring regime will be extended to monitor compliance with these limits.

Environmental sampling, monitoring and testing will be undertaken by Roadstone Dublin staff, with external consultants used only as required. Records of environmental monitoring and testing will be maintained on-site and will be forwarded to Wicklow County Council and the EPA as required under the terms of the Waste Licence.

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The proposed remediation scheme includes provision for environmental monitoring of the following:

(i) Dust
(ii) Ecology
(iii) Groundwater
(iv) Landfill Gas
(v) Leachate
(vi) Weather
(vii) Noise
(viii) Odour
(ix) Surface Waters

3.7 Restoration and Aftercare

Following excavation and removal of buried waste at each unauthorised landfill area, the resultant void will be partially backfilled using the inert overburden soils used in the construction of the 3m to 5m high boundary earth mounds. As soon as practicable thereafter, Roadstone Dublin will complete backfilling of the remaining void space either using fine sandy silt (dried) generated by washing activity elsewhere on the landholding or excess soils arising from excavation of the landfill void.

In the longer term, Roadstone Dublin will continue to place dried out silt at and around each site in order to better merge them back into the surrounding undulating pastoral landscape. At all times, the ground surface will be profiled to give a domed shape in order to facilitate surface water run-off. When restoration in each area is finally complete, the soils will be grassed.

Permanent capping of the remediation landfill and subsequent site restoration will be undertaken by an external Works Contractor. This work is expected to take no more than one to two months.

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Any temporary site accommodation, infrastructure and services established for the duration of the site remediation and construction works will be decommissioned and/or removed off-site. Wherever possible, hardstanding surfaces will be broken up using a hydraulic breaker and tested to confirm the materials are acceptable for re-use in ongoing land restoration works. Any of these materials found to contain unacceptable levels of contamination will be transferred to a suitably licensed waste recovery or disposal facility.

Following completion of capping and restoration works, provision will be made for the long-term monitoring of the quality of environmental media in the immediate vicinity of the remediation landfill – soil, air, surface water and groundwater.

3.8 Contingency Arrangements

Contingency arrangements will be established on site during, and subsequent to, the proposed remediation works.

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4 ENVIRONMENTAL IMPACTS OF REMEDIATION SCHEME

4.1 Human Beings

The remediation landfill will be situated on Roadstone Dublin's landholding, west of the N81, and approximately 1.5 km from the centre of Blessington (Downshire Hotel). The three unauthorised landfill sites are (Areas 1, 4 and 6) are located 1.7km, 1.75km and 0.8 km respectively from the centre of Blessington. The unauthorised landfill sites at Areas 1 and 4 are located will within Roadstone Dublin's landholding. The unauthorised landfill at Area 6 lies close to the boundary of its landholding.

A small percentage of the current population of Blessington lives in the immediate vicinity of the remediation landfill site. The greatest potential impact of the proposed site remediation works will be experienced by the residents and working population of the housing development and business park adjacent to Area 6, and will arise from the removal and transport of the waste from that area to the remediation landfill.

The duration of landfilling activities will be short-term, estimated to be in the order of 4 to 6 months following construction of the basal liner and associated infrastructure for the remediation landfill. The duration of waste extraction at each of Areas 1, 4 and 6 will be shorter, estimated at approximately 6 to 8 weeks. Mitigation measures will be adopted during the site remediation works to minimise environmental impacts of air emissions, dust, odour and noise on surrounding residents.

4.2 Flora and Fauna

The flora and fauna at the three unauthorised landfill sites (Areas 1, 4 and 6) is very limited and of no ecological value. That surrounding the abandoned sand and gravel pit adjacent to the remediation landfill is richer since it has been abandoned for a considerable time and been colonised by a broad range of typical quarry species otherwise found at similar habitats on eskers or near limestone outcrops. Two plants are of some interest though they are known already from the Blessington area. These are the blue fleabane *Erigeron acer* and the autumn gentian *Gentianella amarella*.

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The site of the remediation landfill was re-positioned, away from these plants, after they had been identified early in the Environmental Impact Assessment process. Existing populations of *Erigeron* and *Gentianella* outside the remediation landfill area will be fenced off to protect them from associated vehicle damage during construction.

Construction activity adjacent to the former sand and gravel pit will eliminate or greatly reduce the existing area of stabilised grassland and scattered conifers, but will largely avoid the existing populations of *Erigeron* and *Gentianella*.

4.3 Soils and Geology

The principal long-term impact of the proposed site remediation works is positive in that it reduces the risk of soil and groundwater contamination in the future from ongoing degradation and decomposition of buried waste at three unlined, unauthorised landfill sites across the Roadstone Dublin landholding at Blessington.

There are a number of short-term, potentially negative impacts arising from the proposed remediation works, principally soil erosion and dust emissions.

The excavation, stockpiling and formation of earth bunds using fine sandy silty soils above the buried waste may give rise to increased levels of fugitive dust at or beyond Roadstone Dublin's boundary, if windy conditions arise during a sustained dry weather period in the course of the proposed site remediation works.

During the site remediation works, any unsealed, unvegetated soil surfaces, including excavation side slopes, exposed to moderately heavy to intense rainfall events will be vulnerable to erosion by surface water run-off. Left unmanaged, run-off of eroded soil could eventually give rise to discharge of silt at surface watercourses.

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At the unauthorised landfill sites, the removal of the existing soil cover above the buried waste will mean that the moisture content of the waste may increase somewhat while it is exposed to the elements. The increase in moisture content could result in accelerated degradation and decomposition of the waste and cause further leaching of some contaminants out of the waste bodies, into the underlying soil.

There is a residual risk that small undetected pockets of waste or contaminated soil could remain in-situ at the unauthorised landfill sites following the excavation and removal of the buried waste. There is also a residual risk that some leakage of leachate could occur out of the basal liner of the engineered remediation landfill, increasing contaminant levels within the underlying in-situ soils.

A number of mitigation measures will be implemented on site during the remediation works to reduce or eliminate the potential short-term and long-term environmental impacts outlined above. These will include implementation of dust control measures, construction of surface water management systems in advance of excavation / landfilling operations in each area, limiting the amount of waste exposed to the atmosphere and implementing a Construction Quality Assurance (CQA) approved by the EPA.

4.4 Surface Water and Groundwater

The quarry at Blessington is situated on a sand and gravel aquifer from which groundwater is abstracted for use in Blessington village. A study of baseline groundwater conditions, both on the site and in Blessington village, indicate naturally occurring concentrations of barium, iron and manganese above drinking water standards.

In addition, groundwater in the vicinity of the unauthorised landfill sites contains low levels of other chemicals above screening levels (principally metals and hydrocarbons), which appear to originate from the buried waste. Where possible, screening levels were identified from Environmental Protection Agency (EPA) interim groundwater standards. In the absence of a screening level for groundwater, the strictest Irish water quality standard was adopted. Where neither included a screening level for a particular chemical, the strictest International standard was adopted. As such, the selected screening levels are very conservative. A quantitative risk assessment carried out at the site indicates that the concentrations of chemicals found at the unauthorised landfill sites are so low that it is unlikely the groundwater in Blessington or the water in the River Burgess will be adversely impacted by the unauthorised landfill sites.

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There are a number of surface water features in the vicinity of the quarry. These include the River Burgess, two groundwater ponds, two settling ponds and two surface water ponds. The groundwater fed River Burgess has its source immediately adjacent to the site and eventually feeds into the Poulaphouca Reservoir, which is a source of drinking water for Dublin City. The River Burgess however is effectively a very low flow rate stream. The groundwater ponds were formed by sand and gravel extraction below the groundwater table. The settling ponds were constructed to settle out fines produced from the extracted sand and gravel. The baseline study of surface water quality indicated naturally elevated manganese and barium as well as a number of other contaminants at concentrations higher than would be acceptable in groundwater.

The proposed remediation scheme will remove all commercial, domestic and industrial waste from the three unauthorised landfill sites and will remove the source of contamination. The waste will be placed in an engineered landfill and modelling suggests levels of contaminants leaking through the base and the volume of flow will be too low to effect either the River Burgess or groundwater in Blessington village.

A number of measures will be taken to mitigate the potential short and long-term risks to surface water and groundwater arising from the construction and filling of the new landfill. These measures include good site management during the remediation works, construction of bunded fuel and waste handling areas, installation of wheelwash to minimise transport of contaminants by vehicular traffic, construction of adequate surface water management systems and implementing a Construction Quality Assurance (CQA) plan approved by the EPA.

It is expected that groundwater and surface water quality will improve as a result of the remediation work. Long-term monitoring of groundwater is proposed to confirm / demonstrate the effectiveness of the proposed remediation landfill.

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Further detailed modelling of the potential risks to groundwater and surface waters in the vicinity of the sites was undertaken in response to queries raised by the Environmental Protection Agency in March 2005. Particular attention was given to risks presented by the three unauthorised landfills and the proposed engineered landfill to existing groundwater abstraction wells in the Blessington area. The modelling indicated that the risks to groundwater, surface water and abstraction wells are low. It has been calculated that the travel times for contaminants through the groundwater to the water abstraction wells will be of the order of several tens of years, allowing time for additional remedial measures to be taken.

Modelling of various scenarios for the proposed engineered landfill identified a possibility that in a worst-case scenario (lack of active monitoring and management of the facility), the leachate contained therein could overtop the perimeter bunds of the engineered landfill and contaminate surface waters and subsequently impact on groundwater quality beneath the existing lagoon and on water quality locally at the Burgess Stream.

The management scheme (institutional control) and regulatory oversight which will be put in place at the proposed engineered landfill will mean that this will never happen during the proposed 30 year management period. If overtopping occurs after this period, then the impacts on the surrounding groundwater and surface water system will be limited.

4.5 Air Quality and Climate

A key objective of the proposed remediation scheme is to reduce or eliminate the risk of landfill gas migration to adjacent sites.

Gas monitoring results for the three existing unauthorised landfill sites show levels of methane and carbon dioxide above the DoE guidance values of 1% v/v methane and 0.5% v/v carbon dioxide for proposed housing sites.

The results of gas spike tests indicate that very little of the landfill gas is migrating vertically to the surface, but there is some evidence that horizontal migration may occur at Area 6, adjacent to the recently constructed 'Woodleigh' development.

Areas 1, 4 and 6 are overlain by silty sands from the washing of sands and gravels by Roadstone, which have on the whole low permeability. This layer which is of the order of 2m thick, is likely to act as a barrier to the upward migration of landfill gas.

Left unattended, the buried waste at the three unauthorised landfill sits in Areas 1, 4 and 6 would continue to degrade and decompose and produce landfill gas. At Area 6, this could in turn give rise to a potential build up of landfill gas in confined spaces at the adjoining residences.

Monitoring carried out at the existing Roadstone Dublin site, indicates that dust emission levels at its land boundary generated by established extraction and processing activites are within normally acceptable limits (TA Luft limits).

In the course of the proposed remediation works, emissions to air, including landfill gas (methane and carbon dioxide), volatile organic compounds, hydrogen sulphide, odour and dust, are likely to arise during:

- Excavation of the three unauthorised landfill sites
- Construction of the remediation landfill
- Operation of the remediation landfill
- Venting of landfill gas generated in the landfilled non-hazardous waste
- Restoration of the disturbed sites.

An assessment was made of the health risk to construction workers removing buried waste at Area 6 as a result of the release of gas vapours from volatile chemicals. This assessment was undertaken as part of the environmental risk assessment for the site and indicated that the health risk to construction workers presented by the release of such vapours is low. By extension, the risk to occupants of newly constructed housing adjacent to Area 6 is also low. While a site specific risk assessment was not undertaken for Areas 1 and 4, a similar low risk situation also applies to these areas in respect of volatile chemicals. In the long-term, the release of landfill gases at the remediation landfill will present similarly low risks.

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Computer modelling suggests that in a worst-case scenario, there could be a significant short-term odour impact for residents in the 'Woodleigh' development while the buried waste in Area 6 is being excavated and removed. Passive vents installed in advance of waste excavation will reduce the potential odour impact arising during the excavation and removal of waste. Given that computer modelling predicted a significant short-term odour impact from on-going passive venting in this area and this has failed to materialise, the predicted worst-case odour impact may not arise during waste excavation.

Computer modelling predicts that even in a worst-case scenario, there will be no significant long-term odour impact at the residences closest to the engineered landfill.

The proposed remediation scheme includes a number of construction control and mitigation measures to be implemented on site during the remediation works in order to reduce emissions to air and the potential environmental impacts thereof. These include

- Installation of passive vents in Area 6 in advance of waste excavation and removal (installed January 2004)
- Provision of temporary cover (soil, hessian or PVC) for waste exposed in excavations and at the engineered landfill
- Active landfill site management to minimise amount of waste exposed to air at any time
- Provision and use of air misting system to reduce odour / dust where required
- Construction of temporary haul roads using coarse stone to minimise dust emissions
- Installation of temporary wheelwashes to minimise transport of dust by trucks
- Spraying water from a tractor drawn bowser on dry soil surfaces as required

4.6 Noise and Vibration

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The proposed remediation works will not result in any long-term noise or vibration impact on the existing local environment. There will however be some short-term impacts associated with the excavation and transfer of waste from the unauthorised landfill sites to the segregation / recycling facilities and remediation landfill.

At each of the unauthorised landfill sites (Areas 6, 4 and 1), an excavator and a number of trucks will be used to remove the waste from the area and a bulldozer will then be used to fill the area and for final grading. At the remediation landfill site itself, excavators and earth moving plant will be used initially for construction, along with a number of dump trucks transferring soil around the site. A sheepsfoot roller will be used to compact the waste in place and a bulldozer will be used to fill and grade the site once landfilling is complete. All truck movements in relation to the proposed remediation works will be on internal haulage roads only.

During the proposed remediation works, the operation of construction plant will be the principal source of additional noise at noise-sensitive receptors, the recently constructed housing immediately beyond Area 6 and the houses along Darkers Lane.

It is expected that the housing development immediately beyond Area 6 will experience elevated noise levels, in excess of threshold limits (typically 55 dBA by day) specified in Environmental Protection Agency guidelines. While this impact will be a short-term impact during waste excavation and transfer, a number of mitigation measures including earth bunding, erection of boundary hoarding etc. will be put in place to aid noise reduction.

It is unlikely that the existing houses along Darkers Lane will experience elevated noise levels in excess of recommended threshold limits during the site remediation works.

4.7 Landscape

The remediation landfill has been positioned in such a manner as to avoid any long-term negative impacts on the existing local landscape.

It is considered that, in general, the proposed remediation works will have limited, and generally temporary, short-term landscape and visual impacts for the following reasons :

(i) in many ways the proposed remediation landfill development has similarities in appearance and operation with existing extractive industry in the area. The scale of the

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activities associated with the existing extractive development will remain dominant and will limit the potential for negative landscape and visual impacts associated with the remediation landfill development;

(ii) the temporary / short-term nature of the waste removal and construction of the remediation landfill will limit the potential for negative landscape and associated visual impacts;

(iii) given the existing context it is considered that the proposed remediation works do not adversely impact on existing designations, on the amenity value of Glen Ding Wood, or on specific policy objectives or protected views;

(iv) visual impacts in distant views and will be only slight at worst and more than likely will be indistinguishable in the context of the sand and gravel pit environment;

(v) the most serious visual impact is to views from new residential units in the Woodleigh development immediately east of Area 6. These will be limited by the retention of the existing boundary hedgerow and provision of timber hoarding along the boundary during the waste extraction activity;

(vi) all areas will be restored to combination of grassland, species rich meadow or wildflower sward augmented by plantings of indigenous deciduous species. The long term impact on the landscape and visual character and quality of the four subject areas will not be adverse and has the potential to be positive.

Although there are some impacts on the existing landscape and visual character of the area, it is considered that the proposed development will have no significant landscape or visual impact, set as it is, within an existing active extraction area.

As restoration and reinstatement works proceed in each area, any visual impact will be effectively mitigated. In the context of the proposed restoration, medium and long-term impacts on landscape and visual quality, if only slight, will be positive.

4.8 Cultural Heritage

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There are no long-term impacts on the local cultural heritage associated with the proposed remediation scheme.

Examination of the available historical and archaeological sources indicates that while the proposed remediation works will not impact directly on any known sites, the general area at the south-east of the Glen Ding ridge can be considered to have a high archaeological potential, with a high density of recorded archaeological monuments and artefacts, predominantly of a prehistoric character.

Further analysis of aerial photographs and cartographic sources together with a detailed field inspection of the areas concerned indicates that previous quarrying works have greatly reduced and even eliminated the archaeological potential of the locations where remediation works are proposed.

In the case of the remediation landfill and the unauthorised waste landfill sites at Areas 1 and 4, the original ground level has been reduced by over 30m. Any potentially unrecognized archaeological material will have already been removed, and the proposed works will have no impact on the Cultural Heritage resource.

It is unclear to what extent the original ground surface around Area 6 has been removed by sand-and-gravel extraction. The present ground surface is an artificially created level surface formed from by-products of the extraction process. There may be undisturbed ground around the edge of the former pit and thus the potential exists for unrecognized archaeological material to be present at this location. However, as the unauthorised landfill waste is located within previously excavated ground, the excavation of buried waste is unlikely to impact upon any potential remains.

Proposed routes for transporting excavated waste to the remediation landfill site will not impact directly on any aspect of the Cultural Heritage resource. However, the haul route from Area 6 runs within 20m of a Recorded Monument (WW005-023) and measures will be implemented on site to ensure that vehicles keep to the established haul road in this area. The present study has suggested that the existing identification of Recorded Monument WW005-023 as a destroyed enclosure may be incorrect, and that the site may in fact represent a small pond still extant at that location.

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It is considered that the potential impact of these works on any aspect of the Cultural Heritage resources is very slight. To further reduce this impact, vehicles transporting excavated waste will keep to existing haul routes across Roadstone Dublin's landholding and excavations in the vicinity of Area 6 will be monitored where appropriate by a qualified archaeologist.

4.9 Material Assets

There are no long-term impacts on local matrial assets associated with the proposed remediation scheme.

The remediation landfill, at its closest point is located approximately 650 metres from the N81 National Secondary Road. The National Roads Authority's current figure for Annual Average Daily Traffic (AADT) for the section of the N81 through Blessington is 13,070 vehicles, 6.8% of which are heavy good vehicles (HGV's).

The town of Blessington is located in an area that is strongly linked to tourism, due to the close proximity of several tourist attractions including Russborough House, the Blessington Lakes and several walking and hiking routes. The attractiveness of the town as a place to live will not diminish due to the proposed remediation works, the location of the town within the Greater Dublin Area will ensure demand for property will not diminish.

During operation of the remediation landfill, trucks will only leave the western land holding for maintenance, refuelling and servicing on the eastern land holding (known as Doran's Pit). The number of additional daily truck movements generated by the proposed remediation scheme along and across the N81 (over and above existing levels), will be relatively small and of temporary duration.

Due to the short-term nature of the proposed works, there will be a negligible impact on the tourist industry of the surrounding area. There will be no significant adverse impact on the property values of adjacent land-holdings or properties. The remediation works (including the construction works) are of short-term duration. The predicted long-term impacts from the remediation landfill are limited and the character of the area will not be significantly altered.

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30 MAY 2005

APPENDIX 6A

QUANTITATIVE RISK ASSESSMENT

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30 MAY 2005

Addendum to Environmental Risk Assessment

Gas Risk Assessment Update

Blessington

11 March 2005

Produced for
Roadstone Dublin Limited

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1 Introduction

1.1 Project client

1.1.1 Terms of Reference

Roadstone Dublin Limited (RDL) requested Mouchel Parkman to update Section 5 of the Environmental Risk Assessment and Management Strategy (report reference 4000043/OR/03) for areas of unauthorised waste disposal at their landholding in Blessington on 22/01/2005.

The key objectives of the addendum are to:

- review the results of monitoring landfill gas in Areas 1, 4 and 6 and volatile organics in Area 6 since production of the Environmental Risk Assessment and Management Strategy, ERA, in August 2003 (report reference 4000043/OR/03). Particular focus is placed on Area 6 where the mitigation measures specified in the ERA have now been put in place; and

- provide an updated assessment of the gas risk to each area.

1.1.2 Scope of Works

The scope of this update is to revise where necessary the gas risk assessment report in the ERA.

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1.1.3 Limitations

The limitations of this report remain as stated in Section 1.4 of the ERA.

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2 Assessment of Landfill Gas Emissions to January 2005

2.1 Landfill Gas Monitoring Regime

2.1.1 Previous Gas Monitoring Regime (early 2003)

In 2003 JBA undertook three rounds of landfill gas monitoring at the Blessington site in and around Areas 1, 4 and 6 as reported in the ERA.

2.1.2 Subsequent Gas Monitoring (July 2003 to January 2005)

Subsequently a further ten rounds of monitoring have taken place from July 2003 to January 2005. The tabulated results for methane and carbon dioxide are given in Appendix 1, Tables A and B respectively. The results are also displayed graphically in Appendix 1 for each monitoring point in and around Area 6, and in summary for Areas 1 and 4. The results include the three monitoring rounds March – May 2003 reported in the ERA.

Three additional groundwater and gas monitoring boreholes GWR1 – GWR 3 were established in 2003 and monitored for gases from October 2003 onwards to January 2005, over a total of eight rounds of testing. These boreholes are located outside the RDL land boundary at significant distances from Area 6. The location of these and the other monitoring boreholes are shown on drawing DO1 in Appendix 1.

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Following the installation of a gas venting trench between Area 6 and the new housing in late 2003 and gas venting boreholes in Area 6 as recommended in the ERA in 6.2.1.3, further gas monitoring boreholes were established. These were P1 – P4 and P6, boundary monitoring points and A4 – A6, venting boreholes in Area 6, locations of which are shown in the figure in Appendix 1. These locations were tested for gases during six rounds of monitoring between April 2004 and January 2005.

Additionally nine rounds of monitoring has taken place in boreholes located S/SE of Area 6 at GW 6/5 and BH 6/5A, also as recommended in the ERA in 6.2.1.3. Included in this was one borehole, GW 6/4, located just north of Area 6. At the same time two gas monitoring boreholes, GW6/6 and GW6/6A, were established west of Area 6 in the new housing area and monitored on eight occasions between July 2003 and January 2005. The location of these boreholes are shown on Plan DO1 in Appendix 1.

2.1.3 Monitoring at No.28 Woodleigh, Blessington (5th November 2004)

In November 2004 one gas monitoring round was undertaken at the above residence located just east of the Area 6 venting trench, as shown in the figure in Appendix 1.

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3 Gas Monitoring Results

3.1 Area 6

3.1.1 Methane

The trend in methane results identified in the charts given in Appendix 1 show:

- That methane levels within Area 6 (BH 6/10 – BH 6/12) have decreased from well above the DOE guideline value of 1% (up to 30%) to well below or zero since the installation of passive venting boreholes in the first part of 2004. However the results for monitoring points A4 – A6 within the waste still show methane levels up to 6%, which are above the guidance level.

- The methane levels monitored at the edge of Area 6 in P1 – P3 and GW6/3 adjacent to the housing and P4, P6, EW 6/1 and GW 6/2, the southern boundary, show zero methane. This indicates that no methane is escaping laterally from the site.

- The methane levels measured outside Area 6, either in the housing estate (GW 6/6, BH 6/6a) or south west of Area 6, GW 6/5, BH 6/5A also show zero methane.

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From this it can be concluded that the risk of methane escaping from Area 6 remains very low. The installation of the passive venting boreholes and the vent trench appears beneficial.

3.1.2 Carbon Dioxide

The trends for carbon dioxide identified in the charts given in Appendix 1 are:

- Carbon dioxide levels have fallen from above to below the 0.5% threshold in BH 6/10 and BH 6/11 but remained above by a factor of four in BH 6/12. The results for A4 – A6 show continued carbon dioxide generation within Area 6 well above threshold levels.

- The levels of carbon dioxide in P1 – P3 of the vent trench adjacent to the housing are well below the 0.5% threshold in the last five monitoring rounds. For the monitoring on the boundary south of Area 6 at P4, P6 – P7 and GW 6/2 – GW 6/2 carbon dioxide levels are occasionally up to four times above the threshold.

- The levels of carbon dioxide detected in the housing estate in BH 6/6 and 6/6A has on two occasions out of sixteen exceeded 0.5% but are generally well below.

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- For the area south and south west of Area 6 at GW 6/5 and BH 6/5A carbon dioxide levels are showing a trend to increase from below threshold to above.
- In three of the last four monitoring rounds carbon dioxide has been up to a factor of six times above the threshold.

From this analysis we conclude the risk to the housing area from carbon dioxide has not increased from the previous assessment. It is possible some carbon dioxide is migrating in the ground to the south of Area 6. However given that gas flows are very low, as discussed in 3.1.4 below, the risk of this possible migration is also very low.

A further question is if carbon dioxide is migrating, why does methane not also (Comment: Is this related to the relative density of each gas – carbon dioxide being heavier. There are two possibilities. The first is that methane can oxidise to carbon dioxide when oxygen is present, a possible circumstance in this case. Secondly it is possible, for example at GW6/5 and BH 6/5A, the source of carbon dioxide is local to the boreholes, e.g. rotting vegetation, rather than Area 6. This is the likely explanation of carbon dioxide found in GWR/1 – GWR3 at above threshold levels.

3.1.3 Landfill Gas Flow

The gas flows out of each monitoring borehole has been measured and is reported in Appendix 1 in the bulk results. The gas flows on all occasions have been minimal, below a maximum of 3 litres per hour. A normal gassy landfill will produce 10,000 litres per hour (i.e. 10 m^3/hr (1 m^3 = 1000 litres)). Hence the biological activity in Area 6 was very low during the monitoring period in comparison.

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3.1.4 Carbon Monoxide

Carbon monoxide was found in traces in April 2003 at 2 ppm in Area 6. However all subsequent monitoring rounds have not detected carbon monoxide. The April 2003 results have therefore been discounted as an anomaly.

3.1.5 Hydrogen Sulphide

Routine measurements have failed to detect hydrogen sulphide at the ppm level. It was measured to a ppb detection level in 2004 and the results from Odour Monitoring Ireland of 31st August 2004 are given in Appendix 2. The maximum level detected in Area 6 was 11 ppb (parts per billion) whilst at the boundary at 2 ppb. The results are tiny concentrations, some 2500 times below the long term occupational exposure limit published by the UK Health and Safety Executive in EH40/2002.

3.1.6 Volatiles

Possible volatile and odorous chemicals arising in emissions from Area 6 and adjacent were monitored in 2004 by absorption on to tubes and subsequent testing. The detection limits used were extremely low. The results are reported in Appendix 2. Odour monitoring found that elevated Total Volatile Organic Compounds (TVOC) and benzene were detected compared to ambient monitoring. However all the emissions for individual chemicals were less than 1 mg/m^3. Benzene is likely to be

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the most harmful of the gasses released, but the monitoring indicates the 'worst case' emissions from the Area 6 landfill of benzene is less than one quarter of the long term exposure limit in the UK Health and Safety Executive EH40/2002 Supplement 2003. The results on the boundary for benzene are below detection for the active monitoring (i.e. less than 0.026mg/m^3) and for the long term passive monitoring, at least 10,000 times below the long term exposure limit for benzene. On this basis benzene is not an exposure risk.

3.2 Area 1 and 4

The Gas Risk Assessment relating to these areas in the ERA found that these two areas were remote from buildings and fell outside the DoE guidelines.

3.2.1 Area 1

On going monitoring since May 2003 (see charts Appendix 1) indicates that the position is relatively unchanged from that prior to May 2003. The dominant source of landfill gas is from BH 1/13 which produces high levels of methane gas, generally 50% or more. However the flow rate from this borehole is less than 2.1 litres per hour, a tiny output of no real significance.

On the basis of intensive monitoring since the original ERA we have no reason to reconsider the landfill gas risk from Area 1, which remains very low.

3.2.2 Area 4

Carbon monoxide was found in traces in April 2003 at up to 20 ppm in Area 4. However all subsequent monitoring rounds have not detected carbon monoxide. The April 2003 results have therefore been discounted as an anomaly.

The gas regime for Area 4 is largely unchanged except that BH 4/12, in the heart of this area of waste deposition has started to show methane at the 15% level and carbon dioxide at 10% level, where as prior to October 2003 the levels of methane and carbon dioxide were within guideline values. However, given the remoteness of Area 4 from housing and buildings, this is not a cause for concern.

3.3 GasSim Modelling

During the GasSim Air Dispersion Modelling (report ref. 4000043/OR/5 version C) as enclosed in Appendix 3, the emission of landfill gas from the proposed engineered repository was considered in terms of volatile gas thresholds being exceeded at three receptors. GasSim default values were used for odorous trace gases and benzene. However, whenever gas monitoring levels recorded within Area 6 were shown to exceed the default level for specific trace gases, this greater value was input into the model to provide a more conservative prediction.

When the model was re-run using actual recorded levels from Area 6, all of the odorous trace gases and benzene were found to be well below threshold levels at the nearest site boundary to the proposed new landfill.

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5 Conclusions

5.1 Monitoring

Roadstone has initiated very intensive gas monitoring since the original ERA and landfill gas assessment in August 2003. The independently conducted gas monitoring by John Barnett and Associates has comprised an extended monitoring network following the implementation of the recommended gas venting trench and gas venting boreholes in Area 6 as a precautionary measure. The scope of monitoring has also been extended geographically. Some work has also been done on measuring volatile organic compounds in Area 6 and adjacent land.

5.2 Area 6

We continue to hold the view that provided ongoing monitoring is continued there is very little risk from the landfill gas being produced in Area 6 migrating to the nearest receptor, i.e. adjacent occupied housing. This is because the precautionary venting trench and venting boreholes have been installed and monitoring does not indicate any significant gas flow to the houses. Additional gas volume measurements show only extremely small volumes of landfill gas are being produced, which should vent safely to atmosphere, and hence there is no pressure to drive gas laterally. Notwithstanding this, there is some evidence of elevated carbon dioxide levels to the south and south west of Area 6, which may be due to the landfill gas production or to a very local source.

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We remain of the view that relocation of active waste from Area 6 to Area 1 into a designed repository is the preferred solution to this problem and this should occur as soon as possible to minimise the environmental and other impact on local residents.

5.3 Area 1 and 4

These areas are remote from people and buildings. Monitoring shows the production of landfill gas is at a very low stable rate and has a very low risk. We recommend only ongoing monitoring of these areas, prior to any relocation into a designed repository as Roadstone have proposed.

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Location of No. 28. Woodleigh, Blessington. Location of residence at which gas monitoring was undertaken on the 5th November 2004 (refer to Section 3, Gas monitoring Results 5th Nov. 2004.

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Appendix 1A

Gas Monitoring - Methane

Methane	Mar-03	Apr-03	May-03	Jul-03	Oct-03	Jan-04	Apr-04	May-04	Jun-04	Sep-04	Dec-04	Jan-05
GW 1/1	0	0		0	0	0	0	0	0	0	0	0
GW 1/2	0	0	0	0	0	0	0	0	0	0	0	0
GW 1/3		0	0	0	0	0	0	0	0	0	0	0
GW 1/4		0	0	0	0	0	0	0	0	0	0	0
BH 1/10	12.2	0	3	5.5	6.5	15.5	19.7	11.4	0	13.8	18.4	0
BH 1/11	6	6	8.8	7.9	11.2	0	0	0	0	2.3	0	0
BH 1/12	2	1.7	20	0.8	2.1	20.2	35.2	8.3	1.1	17.2	30.7	7.1
BH 1/13	63.8	6.3	64	61	64.9	23.4	59	57.5	55	55.8	50.6	50.1
BH 1/14	0.2	0	1.1	0	0	0	0	0	0	0	0	0
GW 4/1							0	0	0			-
GW 4/2				0	0	0	0	0	0		0	0
GW 4/3	0	0	0.1	0	0	0	0	0	0	0	0	0
GW 4/4		0	0	0.2	1.1	1.6	0.3	0	0	3.4	0	0
BH 4/10	0	0	0.1	0.1	25.2	40.2	12.1	0	0	1.6	0	2.6
BH 4/11		0.9	54.3	44	20.8	35.3	40.1	34.5	29.5	31.7	3.8	30.1
BH 4/12		1.2	0.3	0.7	0	5.7	19.5	2.4	19.5	12.9	0	15.1
GW 6/1	0	0		0	0	0	0	0	0	0	0	0
GW 6/2	0	0		0	0	0	0	0	0	0	0	0
GW 6/3	0	0	0	0	0	0	0	0	0	0	0	0
GW 6/4				0	0	0	0	0	0	0	0	0
GW 6/5				0	0	0	0	0	0	0	0	0
GW 6/5A				0	0	0	0	0	0	0	0	0
GW 6/6				0	0	0	0	0	0		0	0
GW 6/6A				0	0	0	0	0	0		0	0
BH 6/10	30.3	17.1	14.9	24.1	6.4	7.9	0	0.1	0	0	0	-
BH 6/11	0	0.1	0.1	0	0	0	0	0	0	0	0	0
BH 6/12	1.4	1.2	6.5	2.7	3.1	1.2	1.6	0.2	0	0	0	0
GWR1					0	0	0	0	0	0	0	0
GWR2					0	0	0	0	0	0	0	0
GWR3					0	0	0	0	0	0	0	0
P1							0	0	0	0	0	0
P2							0	0	0	0	0	0
P3							0	0	0	0	0	0
P4							0	0	0	0	0	0
P6							0	0	0	0	0	0
P7							0	0	0	0	0	0
A4							0.2	9.1	14.4	6	0	5.2
A5							7.2	2.4	11	4.9	0	5.8
A6							19.1	6.6	20	1.5	0	5.7
A Guideline	1	1	1	1	1	1	1	1	1	1	1	1

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Gas Monitoring - CO_2

CO2	Mar-03	Apr-03	May-03	Jul-03	Oct-03	Jan-04	Apr-04	May-04	Jun-04	Sep-04	Dec-04	Jan-05
GW 1/1	1.4	0		0	0.5	0.1	1	0	0	0	0	0
GW 1/2	0	0.1	0.1	0.1	0	0.1	2	0.5	0	0.4	0	0.1
GW 1/3		0.5	0	0.6	0	0	0.2	0	0.1	0	0	0.2
GW 1/4		0.1	1.1	0.6	0.5	0.3	0.1	0.1	0	0.1	0.1	0.1
BH 1/10	8.7	0	5.2	4.5	7.6	8.3	9.7	8.6	0	7.1	10.4	0
BH 1/11	11.9	3.7	5.8	5.7	7.2	0.2	0.7	0.8	0.7	2.6	4	2.4
BH 1/12	0	0	0.5	0.3	1.3	1.1	2.02	2.6	1.8	3.6	1.9	2.5
BH 1/13	11.2	11	9.5	12.3	12.8	3.9	10.8	11	11.3	10.4	9.3	9.1
BH 1/14	3.1	0	2.4	0	2.4	0	0.1	0	3.2	3.1	0	0.1
GW 4/1							0.1	0	0			-
GW 4/2				0.3	0.5	0.1	1	0.6	0.8		0.9	0.9
GW 4/3	5.1	0.2	3	1.7	0	0	0.1	0	307	4	0	4
GW 4/4		0.2	0.2	0.1	2.9	0.9	0.2	0	0.8	2.1	1	0.9
BH 4/10	0.1	0	0.8	0	14.7	15.9	3.5	0	0	3.6	0	3.8
BH 4/11		0.8	16.6	15.6	11.3	14.9	12.7	12	11.5	12.1	2.9	9.9
BH 4/12		0.6	0.2	0.1	0.2	2.8	9.2	0.9	7	9.3	0	10.2
GW 6/1	1.1	1.7		0	0	0.2	1.2	1.1	1.3	0	1.2	0.9
GW 6/2	2.2	0.1		0	0	0	0.1	0	0.5	1.3	0.1	0
GW 6/3	1.7	0	0	0	2.4	3.9	1.7	0	0	0	0	0.8
GW 6/4				0	1.1	0	0.2	0	0	0	0	0
GW 6/5				0	0	0	0.1	0.2	0.5	2.3	0.1	1.8
GW 6/5A				2.1	0	0	0.1	1.6	2.4	3	0.1	2.3
GW 6/6				0	0	0	0	0	1.5		0	0.3
GW 6/6A				0.1	0	0	0.8	0	0.4		0	0
BH 6/10	15.1	9	7.8	20.4	9.6	10.4	0.4	0.3	0.1	0	0	-
BH 6/11	7.6	0	0.1	0	7	0	0.1	0	0	0	0	0.2
BH 6/12	0.1	0	1	0.6	2.3	0.6	1.2	0.2	0	1.3	0	1.7
GWR1					0.2	0.4	1	1.3	1.6	1.5	0	1.5
GWR2					1.7	0.1	2.6	2.2	2.9	3	0	3.3
GWR3					0.5	0	1.5	1.4	0.8	0.6	0.2	0.6
P1							0.2	0	0	0	0.1	0
P2							0.2	0.2	0	0	0	0.1
P3							0.5	0	0	0.3	0	0.2
P4							0.1	0.6	0.6	0	0.3	0.9
P6							0.1	0.2	0.9	1.8	0	0
P7							0.1	0	0	0	0	0.6
A4							1.4	16.3	18.8	10.1	0.8	14.2
A5							11.1	4.3	15.4	10.4	0	14.7
A6							18.7	6	22.9	4.1	0.1	7.7
EPA Guideline	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Atmospheric Pressure	997	981	989	995	987	965	978	996	984	964	990	998

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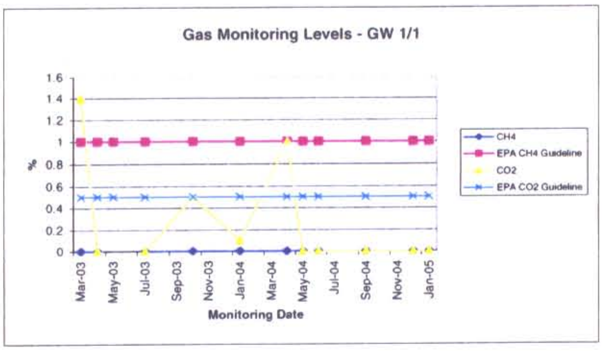

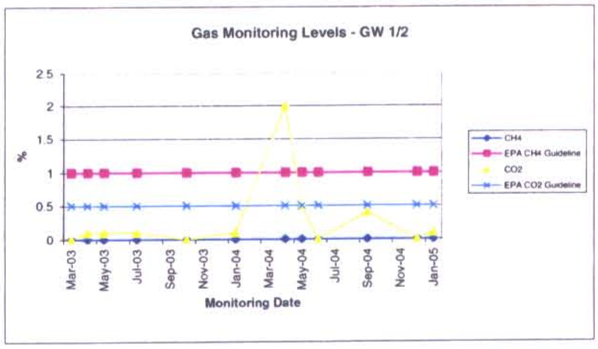

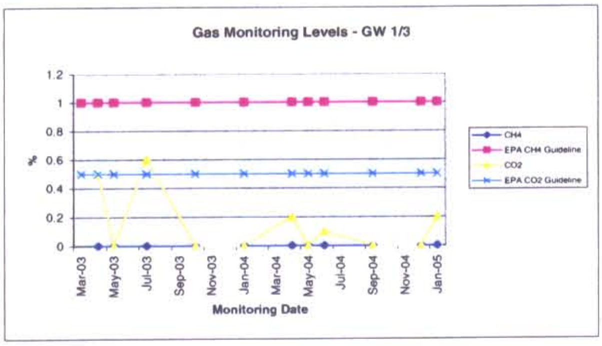

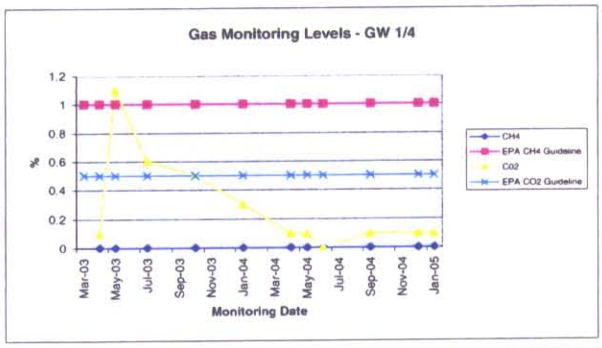

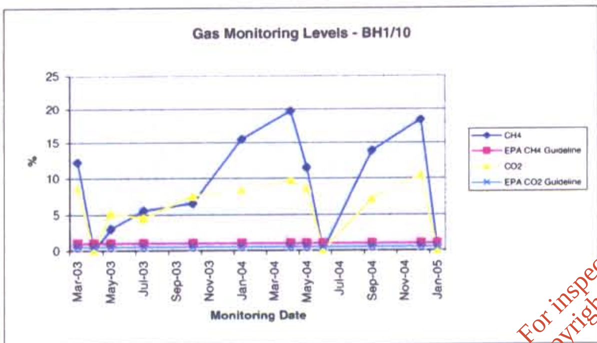

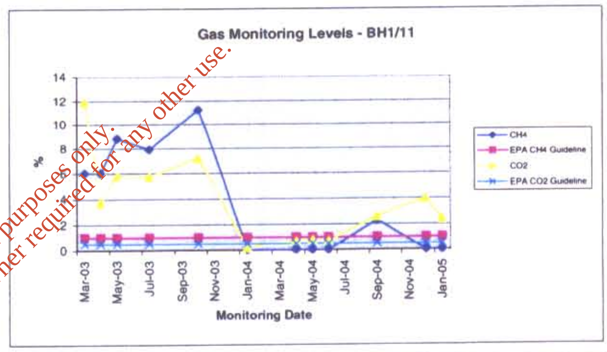

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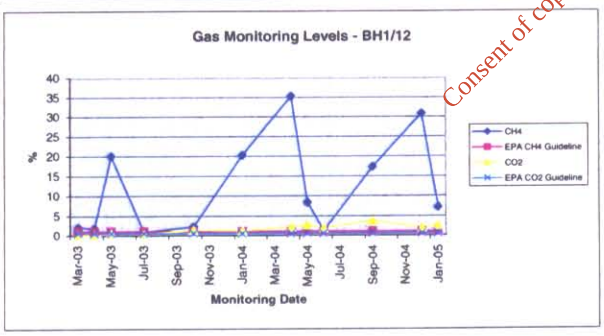

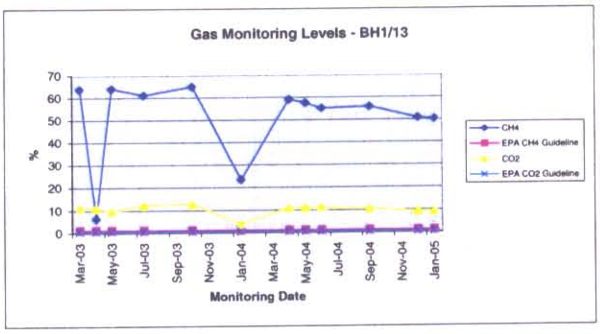

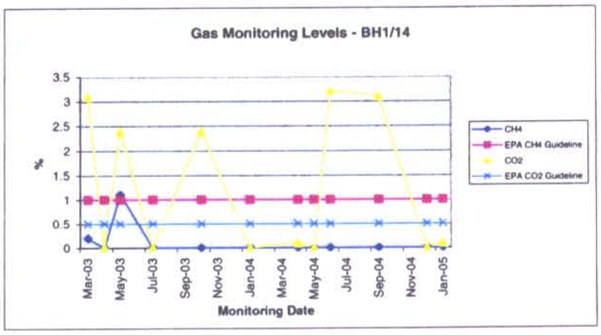

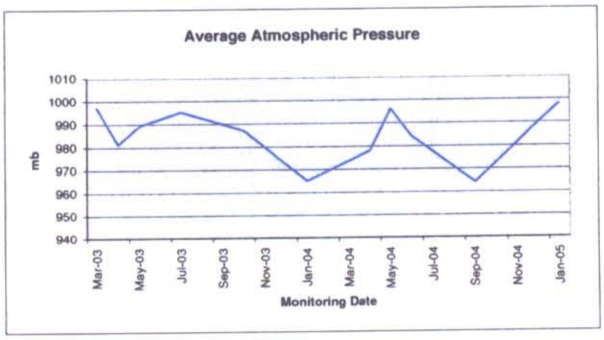

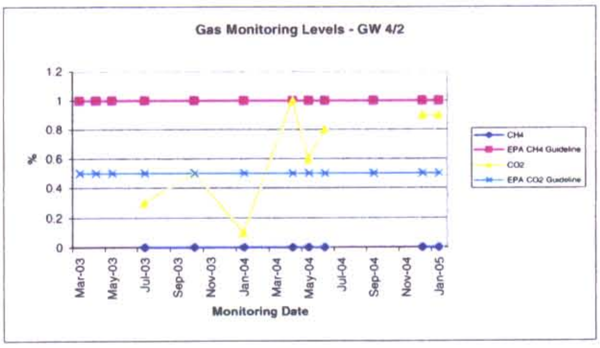

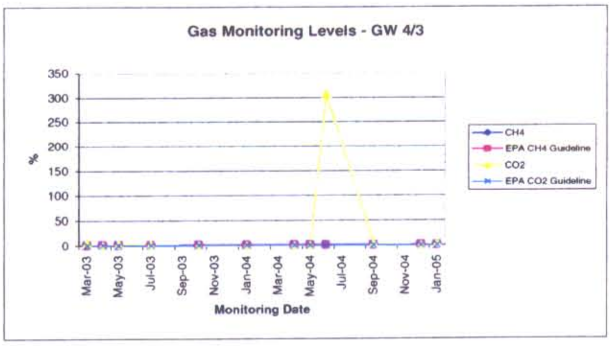

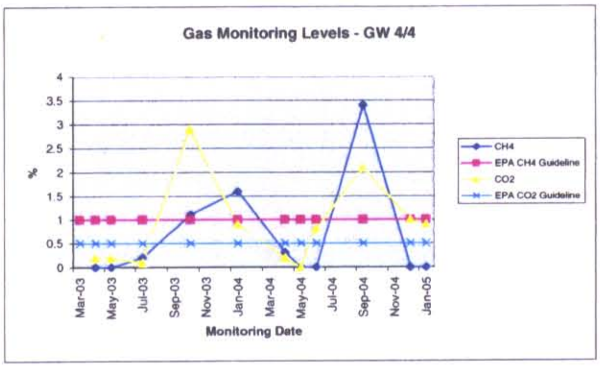

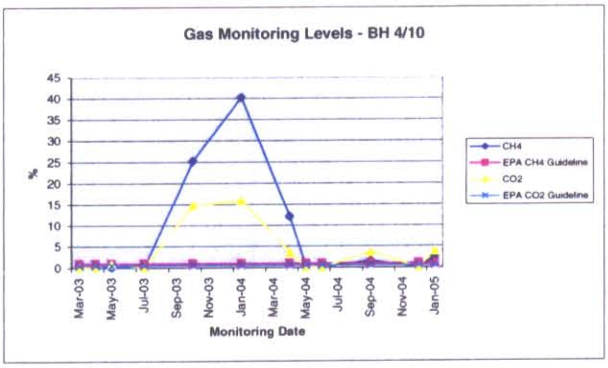

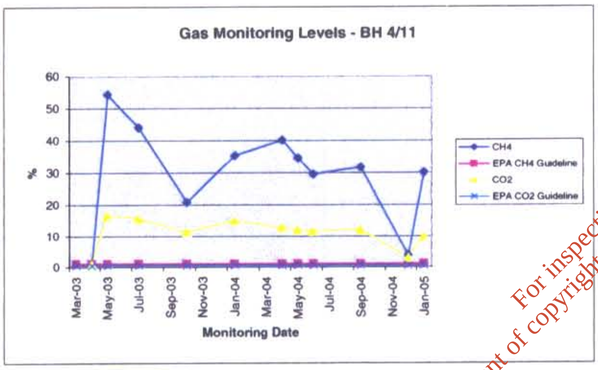

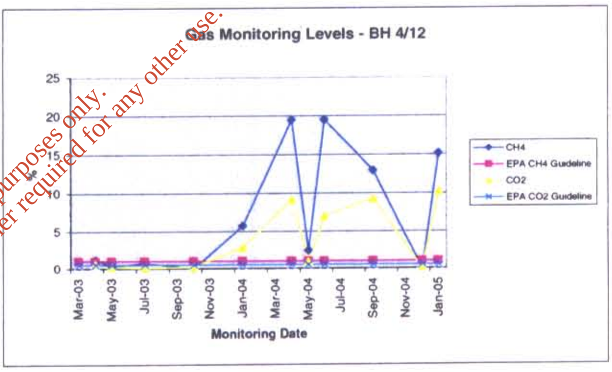

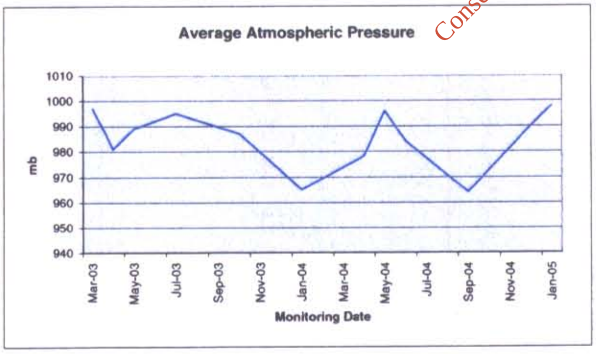

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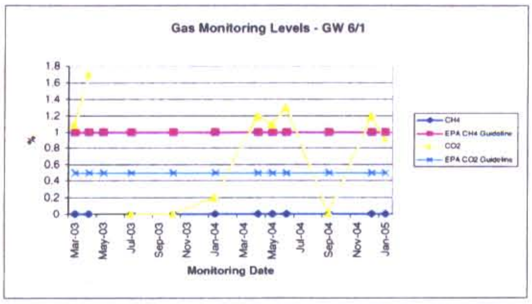

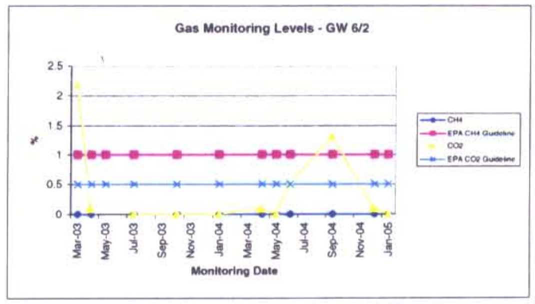

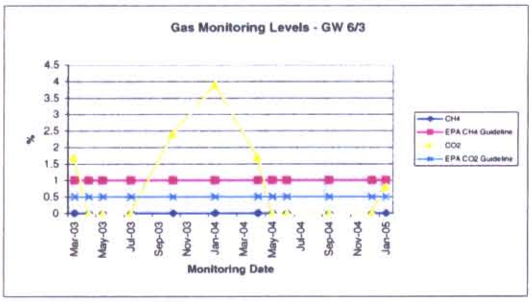

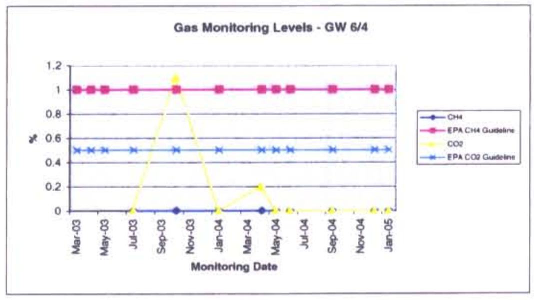

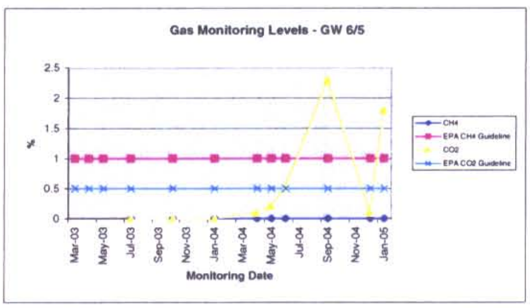

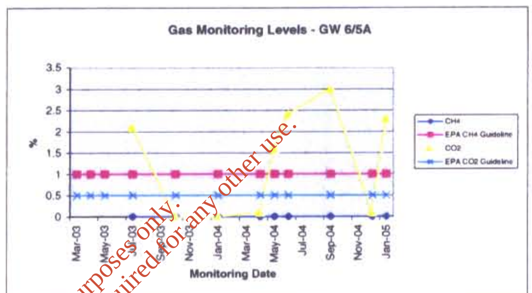

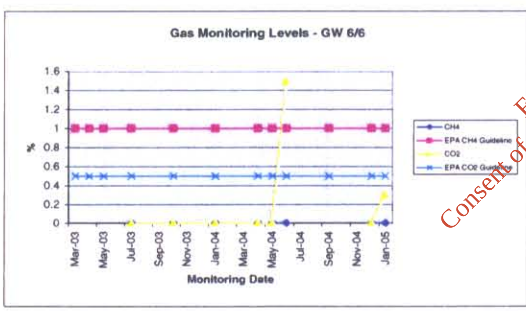

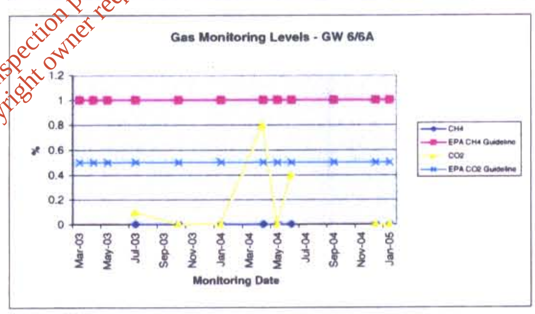

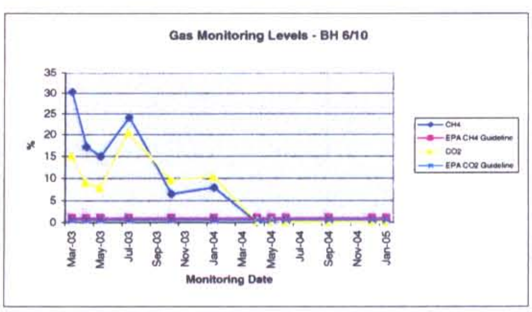

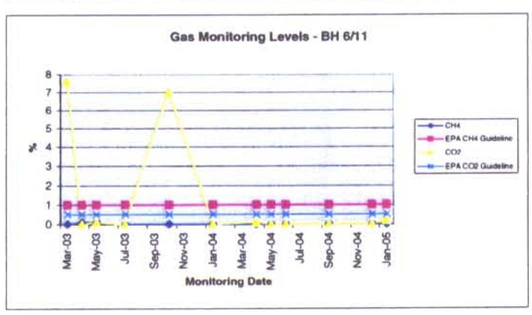

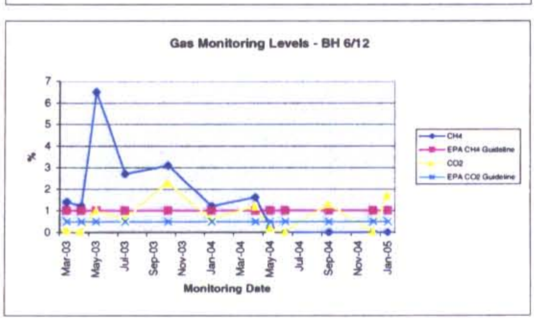

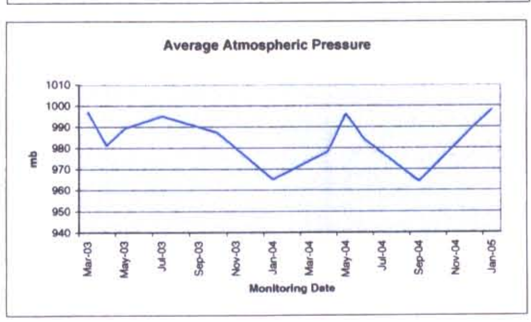

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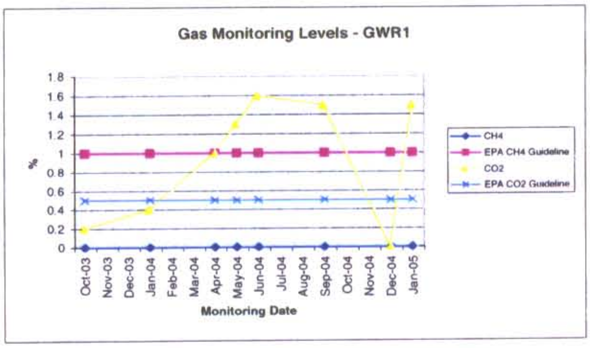

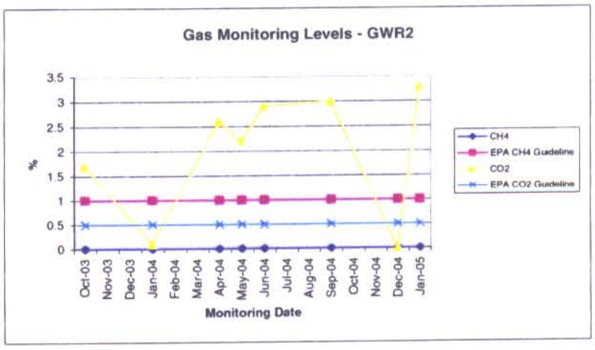

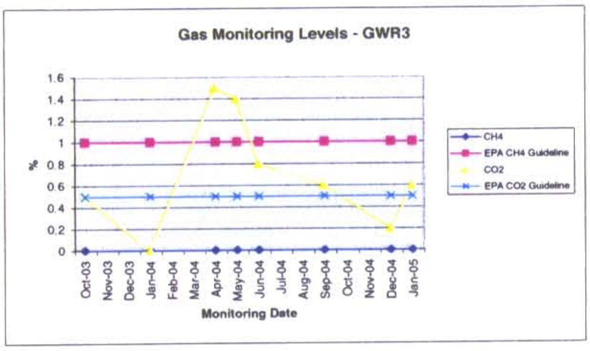

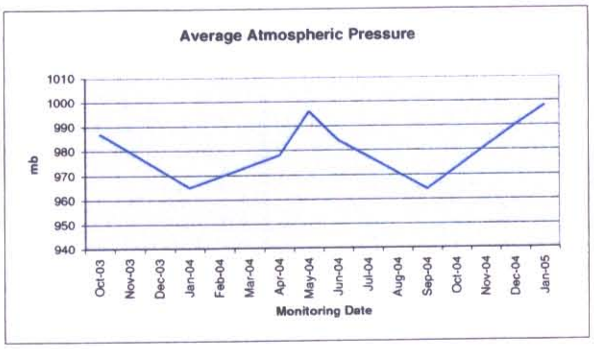

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Appendix 2 **Gas Monitoring Results- Volatiles**

Gas Monitoring Results at Boreholes GW+BH, RDL Blessington

Monitoring date: 20th August 2004 Monitoring undertaken by JBA PG/DG

Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
GW 1/1	0	0	22.2	0	0	977	na	0	0
GW 1/2	0	0	22	0	0	977	1.9-2	0	0
GW 1/3	0	0	22	0	0	977	1.6-2.4	0	0
GW 1/4	0	0	21.5	0	0	977	1.6-2.3	0	0
BH 1/10	0.3	0.8	20.9	0.4	7	977	1.4-2.9	0	0
BH 1/11	0	2.2	17.8	0	0	977	1.3-2	0	0
BH 1/12	33.9	3.9	6.3	34	>>>	977	1.4-2.3	0	0
BH 1/13	45.8	9.5	3.7	45.8	>>>	977	1.4-2.2	0	0
BH 1/14	0	0	22	0	0	977	1.3	0	0
GW 4/1	na.								
GW 4/2	0	0.2	21.8	0	0	978	1.6	0	0
GW 4/3	0	0	21.9	0	0	978	1.8-3	0	0
GW 4/4	0	0	22.1	0	0	978	3.3	0	0
BH 4/10	0	0	22.1	0	0	978	1.5	0	0
BH 4/11	18.3	8.1	11	19.4	>>>	978	1.4-2.2	0	0
BH 4/12	0	0	22.2	0	0	978	1.4-2.2	0	0
GW 6/1	0	0.2	23.8	0	0	980	1.4	0	0
GW 6/2	0	0.1	24.1	0	0	980	1.5	0	0
GW 6/3	0	0	24.5	0	0	980	1	0	0
GW 6/4	0	0	24.6	0	0	980	na.	0	0
GW 6/5	0	0	24.5	0	0	980	1.5	0	0
GW 6/5A	0	0	24.5	0	0	980	1.5	0	0
GW 6/6	0	0	24.6	0	0	980	0	0	0
GW 6/6A	0	0.1	24.4	0	0	980	na.	0	0
BH 6/10	0	0	24.5	0	0	980	1.3	0	0
BH 6/11	0	0	24.5	0	0	980	1.4	0	0
BH 6/12	0	0	24.4	0.3	0	980	1.6-2.2	0	0
GWR1	0	0	22.2	0	0	980	na.	0	0
GWR2	0	2.6	22.2	0	0	980	na	0	0
GWR3	0	1	23.5	0	0	980	0.9	0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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Gas Monitoring Results at Boreholes GW+BH, RDL Blessington

Monitoring date: 20th August 2004. Monitoring undertaken by JBA
Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
P1	0	0	24.5	0	0	980	na.	0	0
P2	0	2	24.4	0	0	980	na.	0	0
P3	0	0	24.6	0	0	980	na.	0	0
P4	0	1	24.1	0	0	980	na.	0	0
P6	0	1.4	23	0	0	980	na.	0	0
P7	0	0.2	24.4	0	0	980	na.	0	0
A4	15	18.7	4.1	16.6	>>>	980	na.	0	0
A5	0	0	24.7	0	0	980	na.	0	0
A6	0.1	0.6	23.9	0.3	5	980	na.	0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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Gas Monitoring Results at Boreholes GW+BH, RDL Blessington

Monitoring date: 19th April 2004. Monitoring undertaken by JBA
Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
GW 1/1	0	1	21	0	0	995	0	0	0
GW 1/2	0	2	20.5	0	0	995	0	0	0
GW 1/3	0	0.2	20.3	0	0	995	0	0	0
GW 1/4	0	0.1	20.9	0	0	995	0	0	0
BH 1/10	19.7	9.7	3.9	19.7	>>>	995	0.5-0.5	0	0
BH 1/11	0	0.7	20.4	0	0	979	0.2-1.1	0	0
BH 1/12	35.2	2.02	6.8	35.3	>>>	995	0.2-0.7	0	0
BH 1/13	59	10.8	1.9	59.1	>>>	995	1.2	0	0
BH 1/14	0	0.1	20.9	0	0	995	0	0	0
GW 4/1	0	0.1	21	0	0	980	0	0	0
GW 4/2	0	1	20.5	0	0	980	0	0	0
GW 4/3	0	0.1	20.9	0	0	980	0	0	0
GW 4/4	0.3	0.2	19.9	0.3	0.6	980	0	0	0
BH 4/10	12.1	3.5	0.8	12.1	>>>	980	0	0	0
BH 4/11	40.1	12.7	2.7	40.2	>>>	980	0.2-0.9	0	0
BH 4/12	19.5	9.2	1.9	19.8	>>>	980	0.3-1.4	0	0
GW 6/1	0	1.2	18.2	0	0	958	0	0	0
GW 6/2	0	0.1	20.8	0	0	958	0	0	0
GW 6/3	0	1.7	16.7	0	0	980	0	0	0
GW 6/4	0	0.2	21.2	0	0	980	0	0	0
GW 6/5	0	0.1	20.6	0	0	958	0	0	0
GW 6/5A	0	0.1	20.6	0	0	958	0	0	0
GW 6/6	0	0	21	0	0	958	0	0	0
GW 6/6A	0	0.8	20.5	0	0	958	0	0	0
BH 6/10	0	0.4	20.5	0	0	980	0	0	0
BH 6/11	0	0.1	20.8	0	0	980	0	0	0
BH 6/12	1.6	1.2	9.3	1.7	32	980	0.2-0.4	0	0
GWR1	0	1	20.9	0	0	958	0	0	0
GWR2	0	2.6	17.8	0	0	958	0	0	0
GWR3	0	1.5	18.6	0	0	958	0	0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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Gas Monitoring Results at Boreholes GW+BH, RDL Blessington

Monitoring date: 19th April 2004. Monitoring undertaken by JBA

Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
P1	0	0.2	20.7	0	0	980	-	0	0
P2	0	0.2	20.9	0	0	980	-	0	0
P3	0	0.5	20.7	0	0	980	-	0	0
P4	0	0.1	21.2	0	0	980	-	0	0
P6	0	0.1	21.3	0	0	980	-	0	0
P7	0	0.1	21.4	0	0	980	-	0	0
A4	0.2	1.4	19.6	0.3	4	980	-	0	0
A5	7.2	11.1	6.8	58.1	>>>	980	-	0	0
A6	19.1	18.7	5.3	19.1	>>>	980	-	0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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Gas Monitoring Results - Volatiles

Gas Monitoring Results at Boreholes GW+BH, RDL Blessington
Monitoring date: 21st May 2004. Monitoring undertaken by JBA
Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
P1	0	0	22.1	0	0	985	-	0	0
P2	0	0	22.1	0	0	985	-	0	0
P3	0	0	22.2	0	0	985	-	0	0
P4	0	0.6	21.6	0	0	985	-	0	0
P6	0	0.9	21.3	0	0	985	-	0	0
P7	0	0	22.3	0	0	985	-	0	0
A4	14.4	18.8	2	14.4	>>>	985		0	0
A5	11	15.4	3.6	11.1	>>>	985		0	0
A6	20	22.9	3.1	21.8	>>>	985		0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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Gas Monitoring Results - Volatiles

Gas Monitoring Results at Boreholes GW+BH, RDL Blessington

Monitoring date: 21st May 2004 Monitoring undertaken by JBA

Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
GW 1/1	0	0	22.5	0	0	994	na.	0	0
GW 1/2	0	0.5	21.6	0	0	994	0.3-1.1	0	0
GW 1/3	0	0	22.4	0	0	994	0.1-1.7	0	0
GW 1/4	0	0.1	22.5	0	0	994	0.1-1.2	0	0
BH 1/10	11.4	8.6	4.9	11.5	<<<	994	0.3	0	0
BH 1/11	0	0.8	23.2	0	0	994	0.1-0.5	0	0
BH 1/12	8.3	2.6	15.7	8.11	<<<	994	0.2-1.1	0	0
BH 1/13	57.5	11	1.5	57.6	<<<	994	1-1.5	0	0
BH 1/14	0	0	22.3	0	0	994	0.2-0.5	0	0
GW 4/1	0	0	22.4	0	0	996	0.2-0.4	0	0
GW 4/2	0	0.6	21.9	0	0	996	0.1-0.8	0	0
GW 4/3	0	0	22.2	0	0	996	0.1-0.5	0	0
GW 4/4	0	0	22.5	0	0	996	0.1	0	0
BH 4/10	0	0	22.5	0	0	994	0.1-1	0	0
BH 4/11	34.5	12	5.6	34.7	<<<	994	0.1-0.7	0	0
BH 4/12	2.4	0.9	20.6	17.5	<<<	994	0.1	0	0
GW 6/1	0	1.1	20.4	0	0	996	0.2-0.8	0	0
GW 6/2	0	0	22.6	0	0	998	0.2-1.1	0	0
GW 6/3	0	0	21.1	0	0	998	0.4-2	0	0
GW 6/4	0	0	21.2	0	0	998	na.	0	0
GW 6/5	0	0.2	22.3	0	0	996	0.1	0	0
GW 6/5A	0	1.6	21.6	0	0	996	0.1-0.8	0	0
GW 6/6	0	0	22.4	0	0	996	0.2-0.8	0	0
GW 6/6A	0	0	22.5	0	0	996	na.	0	0
BH 6/10	0.1	0.3	20.3	0.1	2	998	0.2-0.8	0	0
BH 6/11	0	0	20.4	0	0	998	0.2-1.1	0	0
BH 6/12	0.2	0.2	19.3	0.2	3	998	0.1	0	0
GWR1	0	1.3	21.7	0	0	996	0.1	0	0
GWR2	0	2.2	19	0	0	996	na.	0	0
GWR3	0	1.4	20.4	0	0	996	0.1-0.8	0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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Gas Monitoring Results at Boreholes GW+BH, RDL Blessington

Monitoring date: 21st May 2004. Monitoring undertaken by JBA

Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
P1	0	0	20.4	0	0	998	na.	0	0
P2	0	0.2	20.4	0	0	998	na.	0	0
P3	0	0	20.5	0	0	998	na.	0	0
P4	0	0.6	20.3	0	0	998	na.	0	0
P6	0	0.2	20.6	0	0	998	na.	0	0
P7	0	0	20.8	0	0	998	na.	0	0
A4	9.1	16.3	1.6	9.1	<<<	998	na.	0	0
A5	2.4	4.3	15.2	2.4	49	998	na.	0	0
A6	6.6	6	115.3	18.2	<<<	998	na.	0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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Appendix 2

Gas Monitoring Results - Volatiles

Gas Monitoring Results at Boreholes GW+BH, RDL Blessington

Monitoring date: 17/18 June 2004 — Monitoring undertaken by JBA

Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
GW 1/1	0	0	21.7	0	0	981	-	0	0
GW 1/2	0	0	21.7	0	0	981	0.8	0	0
GW 1/3	0	0.1	21.7	0	0	981	1.3-2.2	0	0
GW 1/4	0	0	21.8	0	0	981	1.3	0	0
BH 1/10	0	0	21.9	0	0	981	0.2	0	0
BH 1/11	0	0.7	21.2	0	0	981	1.3-2.2	0	0
BH 1/12	1.1	1.8	4.6	1.2	24	981	0.2-0.3	0	0
BH 1/13	55	11.3	0.9	55	>>>	981	0.8-1.2	0	0
BH 1/14	0	3.2	8.4	0	0	981	0.1-0.8	0	0
GW 4/1	0	0	22.1	0	0	982	0.1-0.4	0	0
GW 4/2	0	0.8	21.3	0	0	982	0.2	0	0
GW 4/3	0	307	14.4	0	0	981	1.4	0	0
GW 4/4	0	0.8	19.3	0	0	981	1.5	0	0
BH 4/10	0	0	22	0	0	981	0.1-0.5	0	0
BH 4/11	29.5	11.5	7.1	29.7	>>>	981	0.2-1	0	0
BH 4/12	19.5	7	6.5	19.6	>>>	981	0.4-1.2	0	0
GW 6/1	0	1.3	19.6	0	0	983	0	0	0
GW 6/2	0	0.5	21.5	0	0	983	0.1	0	0
GW 6/3	0	0	22.2	0	0	985	1	0	0
GW 6/4	0	0	22.1	0	0	985	0	0	0
GW 6/5	0	0.5	21.9	0	0	983	0.1-0.4	0	0
GW 6/5A	0	2.4	20.7	0	0	983	0.1-0.4	0	0
GW 6/6	0	1.5	18.8	0	0	983	0.2	0	0
GW 6/6A	0	0.4	21.8	0	0	983	0	0	0
BH 6/10	0	0.1	21.7	0	0	985	1.7-0.8	0	0
BH 6/11	0	0	21.7	0	0	985	0.8-1.5	0	0
BH 6/12	0	0	21.8	0	0	985	0.8-1.4	0	0
GWR1	0	1.6	21.2	0	0	983	-	0	0
GWR2	0	2.9	19	0	0	983	-	0	0
GWR3	0	0.8	21.1	0	0	983	0.1	0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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Gas Monitoring Results at Boreholes GW+BH, RDL Blessington

Monitoring date: 13th January 2004 Monitoring undertaken by IGSL

Instrument: Geotechnical Instruments GA2000 Gas analyser

BOREHOLE	METHANE CH_4 %	CARBON DIOXIDE CO_2 %	OXYGEN O_2 %	Peak CH_4 %	LEL CH_4 %	BAROMETRIC PRESSURE (mb)	Flow L/H	CARBON MONOXIDE CO (ppm)	HYDROGEN SULPHIDE H_2S (ppm)
GW1/1	0	0.1	19.4	0.0	0.0	962	0.1	0	0
GW1/2	0	0.1	20.4	0.0	0.0	963	0.1	0	0
GW1/3	0	0	19.9	0.0	0.0	963	-0.2	0	0
GW1/4	0	0.3	20.1	0.0	0.0	962	0	0	0
BH1/10	15.5	8.3	7.5	15.8	>>>	962	1	0	1
BH1/11	0	0.2	20.2	0.0	0.0	962	0	0	0
BH1/12	20.2	1.1	12.1	20.8	>>>	962	0.1	0	0
BH1/13	23.4	3.9	12.8	24.7	>>>	962	-0.8	0	0
BH1/14	0	0	19.7	0.0	0.0	962	0	0	0
GW4/1	na.	na.	na.	na.	na.	na.	na.	na.	na.
GW4/2	0	0.1	20.2	0.0	0.0	965	0	0	0
GW4/3	0	0	19.9	0.0	0.0	963	-0.2	0	0
GW4/4	1.6	0.9	14.5	1.6	32.0	964	-0.1	0	0
BH4/10	40.2	15.9	0.1	40.3	40.3	965	0	0	0
BH4/11	35.3	14.9	0.0	35.8	>>>	965	0	0	0
BH4/12	5.7	2.8	6.9	5.8	>>>	965	-0.5	0	0
GW6/1	0	0.2	20.4	0.0	0.0	966	0	0	0
GW6/2	0	0	20.8	0.0	0.0	966	0	0	0
GW6/3	0	3.9	17.4	0.0	0.0	966	-0.2	0	0
GW6/4	0	0	20.0	0.0	0.0	966	0	0	0
GW6/5 North	0	0	21.0	0.0	0.0	966	0	0	0
GW6/5 South	0	0	21.0	0.0	0.0	966	0	0	0
GW6/6 West	0	0	20.9	0.0	0.0	966	0	0	0
GW6/6 East	0	0	21.0	0.0	0.0	966	0	0	0
BH6/9	7.9	10.4	12.6	9.2	>>>	966	0	0	0
BH6/11	0	0	20.1	0.0	0.0	966	0.1	0	0
BH6/12	1.2	0.6	14.3	1.2	2.3	964	0	0	0
GWR1	0	0.4	0.0	0.0	0.0	966	0	0	0
GWR2	0	0.1	20.4	0.0	0.0	966	0	0	0
GWR3	0	0	21.1	0.0	0.0	966	0	0	0

Gas detection employed by a GA2000 Landfill Gas Analyser which measures CH_4 and CO_2 in % by Infra-red measurement, CO and H2S in ppmand O_2 in % by internal electrochemical cell measurement.

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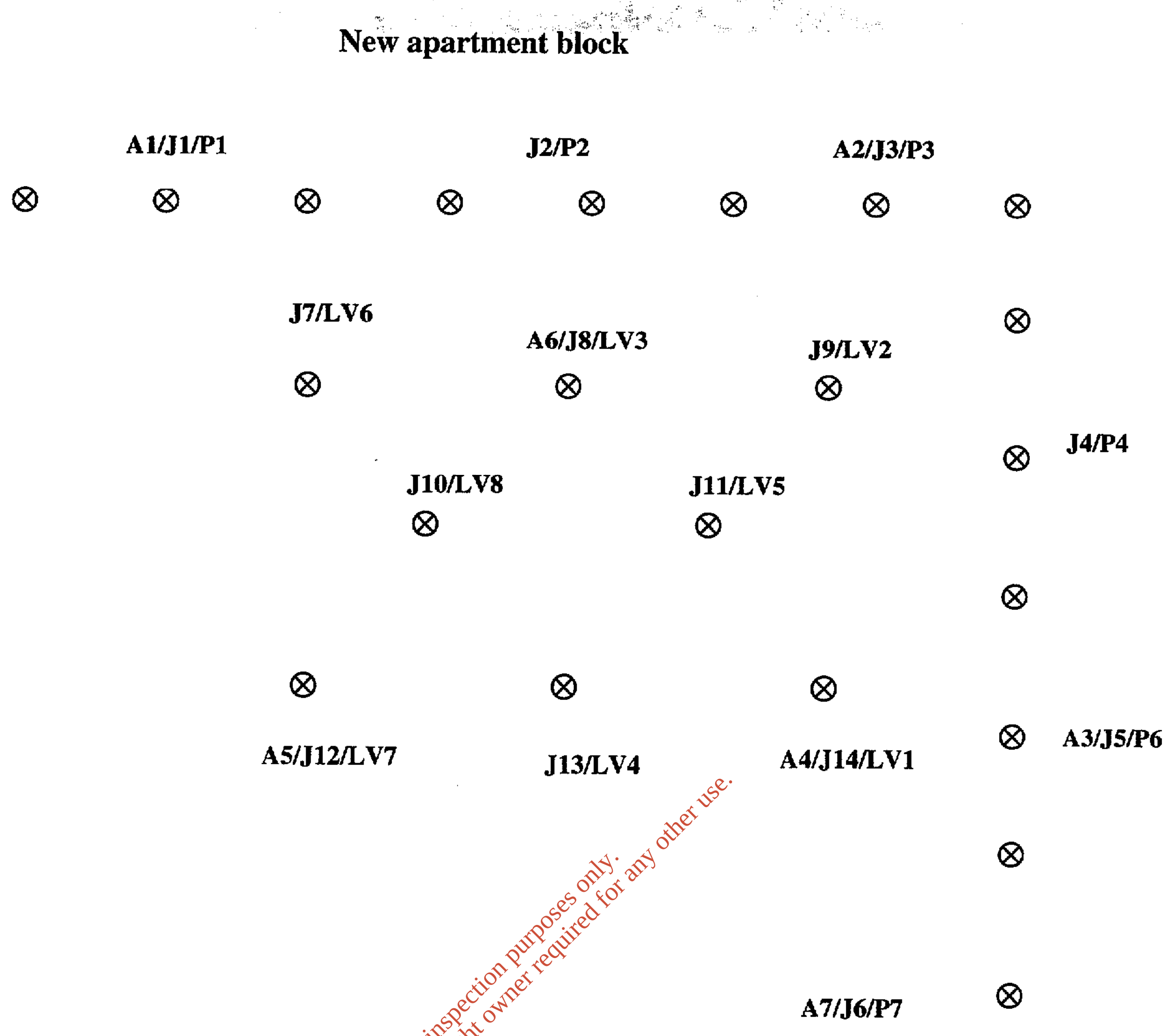

Figure 1. Sampling location identity at Area 6 within the Blessington site.

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Table 1. Characteristics of active sampling of identified monitoring locations A1 to A7.

Sample Number	Sample Location	Pumping Rate of tube (mls/min)	Start Time	Airflow rate well head (litre/hr)[1]	Sampling duration (hr)
BL A1	Boundary/Ambient	99	09:30	-	4
BL A2	Boundary/Ambient	100	09:30	-	4
BL A3	Boundary/Ambient	98	09:30	-	4
BL A4	Well Head	94.9	13:45	5.694	1
BL A5	Well Head	113.9	13:50	6.834	1
BL A6	Well Head	151.9	13:55	9.114	1
BL A7	Background/Ambient	100	15:00	-	3

[1]denotes 0.150 m wellhead diameter; volume calculation based on airflow rate and radius of well head.

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Table 2. Compound concentration at Monitoring location A1.

Compound identity	Amount adsorbed (ng on tube)	Location BLA1 concentration ($\mu g\ m^{-3}$)
Chloroethane	<LOD	<LOD
Chloroethene (Vinyl chloride)	<LOD	<LOD
Benzene	<LOD	<LOD
2-butoxy ethanol	<LOD	<LOD
1,1-dichloroethane	<LOD	<LOD
Trichloroethene	<LOD	<LOD
Tetrachloromethane	<LOD	<LOD
Hydrogen sulphide	<LOD	<LOD
1,1 dichloroethene	<LOD	<LOD
1,2-dichloroethene	<LOD	<LOD
Carbon disulphide	<LOD	<LOD
Methanethiol	<LOD	<LOD
Butyric acid	<LOD	<LOD
Ethanal (acetaldehyde)	<LOD	<LOD
Ethyl butyrate	<LOD	<LOD
1-propanethiol	<LOD	<LOD
Dimethyl disulphide	<LOD	<LOD
Ethanethiol	<LOD	<LOD
1-pentene	<LOD	<LOD
1-butanethiol	<LOD	<LOD
Dimethyl sulphide	<LOD	<LOD
Limonene	<LOD	<LOD
1H-Indole-3-carboxylic acid, 5-hydroxy-	1.69	17.05
Benzoic Acid	1.51	15.25
3-Buten-2-ol, 1-bromo-2-methyl-	1.11	11.21
Nonanal	1.07	10.80
Benzaldehyde	1.01	10.21
Eicosane	1.01	10.18
2-Methyl-5-nitro-2H-indazole	0.93	9.40
Trimethylsilyl methyl sulfide	0.85	8.56
Acetonitrile, 1-(6-chloro-2-pyridyl)-1-(4-cyanomethylphenyl)-	0.68	6.83
Decanal	0.65	6.62
Total Voc's	**34.25**	**345.93**

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Table 3. Compound concentration at Monitoring location A2.

Compound identity	Amount adsorbed (ng on tube)	Location BLA1 concentration ($\mu g\ m^{-3}$)
Chloroethane	<LOD	<LOD
Chloroethene (Vinyl chloride)	<LOD	<LOD
Benzene	<LOD	<LOD
2-butoxy ethanol	<LOD	<LOD
1,1-dichloroethane	<LOD	<LOD
Trichloroethene	<LOD	<LOD
Tetrachloromethane	<LOD	<LOD
Hydrogen sulphide	<LOD	<LOD
1,1 dichloroethene	<LOD	<LOD
1,2-dichloroethene	<LOD	<LOD
Carbon disulphide	<LOD	<LOD
Methanethiol	<LOD	<LOD
Butyric acid	<LOD	<LOD
Ethanal (acetaldehyde)	<LOD	<LOD
Ethyl butyrate	<LOD	<LOD
1-propanethiol	<LOD	<LOD
Dimethyl disulphide	<LOD	<LOD
Ethanethiol	<LOD	<LOD
1-pentene	<LOD	<LOD
1-butanethiol	<LOD	<LOD
Dimethyl sulphide	<LOD	<LOD
Limonene	<LOD	<LOD
Toluene	3.54	35.43
Benzaldehyde	1.93	19.29
Decane	1.46	14.60
Nonanal	1.39	13.86
Nonane	1.23	12.33
1-Hexanol, 2-ethyl-	1.20	12.03
p-Xylene	0.94	9.37
Pyrrolidine, 2,5-dimethyl-1-nitroso-	0.93	9.35
Acetophenone	0.87	8.71
Cyclohexane, propyl-	0.85	8.53
Total Voc's	**64.89**	**648.90**

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Table 4. Compound concentration at Monitoring location A3.

Compound identity	Amount adsorbed (ng on tube)	Location BLA1 concentration ($\mu g\ m^{-3}$)
Chloroethane	<LOD	<LOD
Chloroethene (Vinyl chloride)	<LOD	<LOD
Benzene	<LOD	<LOD
2-butoxy ethanol	<LOD	<LOD
1,1-dichloroethane	<LOD	<LOD
Trichloroethene	<LOD	<LOD
Tetrachloromethane	<LOD	<LOD
Hydrogen sulphide	<LOD	<LOD
1,1 dichloroethene	<LOD	<LOD
1,2-dichloroethene	<LOD	<LOD
Carbon disulphide	<LOD	<LOD
Methanethiol	<LOD	<LOD
Butyric acid	<LOD	<LOD
Ethanal (acetaldehyde)	<LOD	<LOD
Ethyl butyrate	<LOD	<LOD
1-propanethiol	<LOD	<LOD
Dimethyl disulphide	<LOD	<LOD
Ethanethiol	<LOD	<LOD
1-pentene	<LOD	<LOD
1-butanethiol	<LOD	<LOD
Dimethyl sulphide	<LOD	<LOD
Limonene	<LOD	<LOD
2-mercapto-3-benzol (b) thienylidene)-4-methylaniline	0.52	5.31
1,3-Bis(trimethylsilyl)benzene	15.50	158.18
Toluene	3.88	39.62
Benzaldehyde	1.20	12.26
Hydrazine, 1,1-dimethyl-	1.20	12.25
Nonanal	0.66	6.78
p-Xylene	0.62	6.36
Oxime-, methoxy-phenyl-	0.61	6.21
Decanal	0.55	5.65
Acetophenone	0.48	4.88
Eicosane	0.32	3.32
Total Voc's	**42.37**	**432.39**

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Table 5. Compound concentration at Monitoring location A4.

Compound identity	Amount adsorbed (ng on tube)	Location BLA1 concentration ($\mu g\ m^{-3}$)
Chloroethane	<LOD	<LOD
Chloroethene (Vinyl chloride)	<LOD	<LOD
Benzene	**88.48**	**932.40**
2-butoxy ethanol	<LOD	<LOD
1,1-dichloroethane	<LOD	<LOD
Trichloroethene	<LOD	<LOD
Tetrachloromethane	<LOD	<LOD
Hydrogen sulphide	<LOD	<LOD
1,1 dichloroethene	<LOD	<LOD
1,2-dichloroethene	<LOD	<LOD
Carbon disulphide	<LOD	<LOD
Methanethiol	<LOD	<LOD
Butyric acid	<LOD	<LOD
Ethanal (acetaldehyde)	<LOD	<LOD
Ethyl butyrate	<LOD	<LOD
1-propanethiol	<LOD	<LOD
Dimethyl disulphide	<LOD	<LOD
Ethanethiol	<LOD	<LOD
1-pentene	<LOD	<LOD
1-butanethiol	<LOD	<LOD
Dimethyl sulphide	<LOD	<LOD
Limonene	<LOD	<LOD
Nonane, 4-methyl-	136.87	1442.23
Cyclohexane, propyl-	116.93	1232.19
Decane, 4-methyl-	115.25	1214.45
Benzene, 1,2,3-trimethyl-	114.54	1207.00
Nonane, 3-methyl-	102.49	1079.93
Benzene, 1-ethyl-2-methyl-	93.69	987.20
Octane, 2,6-dimethyl-	89.89	947.17
2-Hexene, 3-methyl-, (Z)-	78.25	824.54
Nonane	74.11	780.90
Octane, 3-methyl-	73.90	778.73
Total Voc's	**3712.27**	**39117.75**

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Table 6. Compound concentration at Monitoring location A5.

Compound identity	Amount adsorbed (ng on tube)	Location BLA1 concentration ($\mu g\ m^{-3}$)
Chloroethane	<LOD	<LOD
Chloroethene (Vinyl chloride)	<LOD	<LOD
Benzene	31.99	280.83
2-butoxy ethanol	<LOD	<LOD
1,1-dichloroethane	<LOD	<LOD
Trichloroethene	<LOD	<LOD
Tetrachloromethane	<LOD	<LOD
Hydrogen sulphide	<LOD	<LOD
1,1 dichloroethene	9.56	83.94
1,2-dichloroethene	<LOD	<LOD
Carbon disulphide	<LOD	<LOD
Methanethiol	<LOD	<LOD
Butyric acid	<LOD	<LOD
Ethanal (acetaldehyde)	<LOD	<LOD
Ethyl butyrate	<LOD	<LOD
1-propanethiol	<LOD	<LOD
Dimethyl disulphide	7.85	68.91
Ethanethiol	<LOD	<LOD
1-pentene	<LOD	<LOD
1-butanethiol	<LOD	<LOD
Dimethyl sulphide	<LOD	<LOD
Limonene	282.52	2480.45
Benzene, 1-methyl-2-(1-methylethyl)-	189.23	1661.34
.alpha.-Pinene	143.17	1257.02
3-Carene	130.64	1146.94
Toluene	124.80	1095.71
Nonane	114.17	1002.41
Ethylbenzene	113.43	995.88
Octane, 2,6-dimethyl-	95.78	840.92
Cyclohexane, propyl-	91.85	806.38
Nonane, 4-methyl-	91.28	801.42
Ethane, 1,1,1-trichloro-	90.37	793.38
Total Voc's	**3649.38**	**32040.25**

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Table 7. Compound concentration at Monitoring location A6.

Compound identity	Amount adsorbed (ng on tube)	Location BLA1 concentration ($\mu g\ m^{-3}$)
Chloroethane	<LOD	<LOD
Chloroethene (Vinyl chloride)	<LOD	<LOD
Benzene	<LOD	<LOD
2-butoxy ethanol	<LOD	<LOD
1,1-dichloroethane	<LOD	<LOD
Trichloroethene	<LOD	<LOD
Tetrachloromethane	<LOD	<LOD
Hydrogen sulphide	<LOD	<LOD
1,1 dichloroethene	<LOD	<LOD
1,2-dichloroethene	<LOD	<LOD
Carbon disulphide	<LOD	<LOD
Methanethiol	<LOD	<LOD
Butyric acid	<LOD	<LOD
Ethanal (acetaldehyde)	<LOD	<LOD
Ethyl butyrate	<LOD	<LOD
1-propanethiol	<LOD	<LOD
Dimethyl disulphide	<LOD	<LOD
Ethanethiol	<LOD	<LOD
1-pentene	<LOD	<LOD
1-butanethiol	<LOD	<LOD
Dimethyl sulphide	<LOD	<LOD
Limonene	<LOD	<LOD
Benzene, 1-methyl-2-(1-methylethyl)-	685.43	4512.40
Bicyclo[4.1.0]heptane, 3,7,7-trimethyl-	337.85	2224.15
Decane, 4-methyl-	286.89	1888.66
Nonane	254.05	1672.51
4-Octene, 2,6-dimethyl-, [S-(Z)]-	230.82	1519.57
Octane, 2,5-dimethyl-	210.69	1387.03
Decane	168.06	1106.41
3-Carene	167.74	1104.27
Cyclohexane, propyl-	166.79	1098.04
1-Methyl-4-(1-methylethyl)-cyclohexane	160.27	1055.10
Total Voc's	**5956.63**	**39214.16**

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Table 8. Compound concentration at Monitoring location A7.

Compound identity	Amount adsorbed (ng on tube)	Location BLA1 concentration ($\mu g\ m^{-3}$)
Chloroethane	<LOD	<LOD
Chloroethene (Vinyl chloride)	<LOD	<LOD
Benzene	<LOD	<LOD
2-butoxy ethanol	<LOD	<LOD
1,1-dichloroethane	<LOD	<LOD
Trichloroethene	<LOD	<LOD
Tetrachloromethane	<LOD	<LOD
Hydrogen sulphide	<LOD	<LOD
1,1 dichloroethene	<LOD	<LOD
1,2-dichloroethene	<LOD	<LOD
Carbon disulphide	<LOD	<LOD
Methanethiol	<LOD	<LOD
Butyric acid	<LOD	<LOD
Ethanal (acetaldehyde)	<LOD	<LOD
Ethyl butyrate	<LOD	<LOD
1-propanethiol	<LOD	<LOD
Dimethyl disulphide	<LOD	<LOD
Ethanethiol	<LOD	<LOD
1-pentene	<LOD	<LOD
1-butanethiol	<LOD	<LOD
Dimethyl sulphide	<LOD	<LOD
Limonene	<LOD	<LOD
1,3-Bis(trimethylsilyl)benzene	0.19	1.92
Silicic acid, diethyl bis(trimethylsilyl) ester	0.20	2.04
2,4-Cyclohexadien-1-one, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-	0.12	1.16
N-Methyl-1-adamantaneacetamide	0.09	0.94
Indole-2-one, 2,3-dihydro-N-hydroxy-4-methoxy-3,3-dimethyl-	0.05	0.50
2-Ethylacridine	0.05	0.49
Arsenous acid, tris(trimethylsilyl) ester	0.05	0.46
5-Methyl-2-phenylindolizine	0.04	0.45
Silanamine, N-[2,6-dimethyl-4-[(trimethylsilyl)oxy]phenyl]-1,1,1-trimethyl-	0.04	0.43
Acetaldehyde, chloro-	0.04	0.39
Total Voc's	**5.57**	**55.71**

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Sample Number	Sample Location	Sample Time	H_2S (ppb)
J1	Boundary/Ambient	15:35	2
J2	Boundary/Ambient	15:37	2
J3	Boundary/Ambient	15:39	2
J4	Boundary/Ambient	15:42	2
J5	Boundary/Ambient	15:45	2
J6	Boundary/Ambient	15:50	<LOD
J7	Well Head	16:10	13
J8	Well Head	16:13	6
J9	Well Head	16:16	4
J10	Well Head	16:20	1
J11	Well Head	16:22	10
J12	Well Head	16:25	3
J13	Well Head	16:27	17
J14	Well Head	16:30	6

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Air Dispersion Modelling Report

Engineered Landfill

Blessington, Co Wicklow

June 2004

Produced for
Roadstone Dublin

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APPENDICES

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Appendix D	Composition of 1980's to 2010 Waste Streams
Appendix E	Single Vent and Generated Landfill Gas Output Graphs
Appendix F	GasSim Trace Gas Default Inputs for Odorous Gas
Appendix G	Lateral Migration Graphs
Appendix H	Ongoing Gas Monitoring Results (Areas 1, 4 and 6)

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1 Executive Summary

Current Status	The site is located in the county of Wicklow in Ireland and is owned by Roadstone Dublin Limited. The site area is approximately 276 hectares.
Landfill Source	Three unauthorised landfill sites known as Areas 1, 4 and 6, comprising an estimated 50,000 tonnes of domestic, commercial and industrial (DCI) Waste.
Landfill Characteristics	190 x 85m (16,150m^2 area) to be capped with a 5mm geosynthetic clay liner overlying a 1mm LLDPE Geomembrane, overlying a 5mm geosynthetic clay liner, overlying a 1m thick clay liner.
Model Parameters	Singe point emission of vent stack of 3m length and 0.1m diameter. Three potential receptors modelled: 1. Darkers Lane 450m north east from source 2. Residential housing 600m south east from source 3. Site boundary 20m east from source A wind rose with dominant flow direction from the south west was input into the model.
Model Results and Summary	Insignificant risk to human health at all receptors is likely from methane and carbon dioxide. Insignificant risk to human health or potential nuisance at all receptors is likely from odorous trace gas and benzene. Monthly gas monitoring is recommended during the operational phase of the landfill for safety of operators, further information for any remodelling and assessment of the impact of the works on air quality.

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2 Introduction

Over the last few years there has been an increased detection of large scale unauthorised tipping of waste in the county of Wicklow in Ireland. Investigations at the Blessington landholding of Roadstone Dublin Limited (RDL) in early 2003 revealed that approximately 50,000 tonnes of domestic, commercial, and industrial (DCI) waste had been infilled at three unauthorised landfill sites over the last 10 years, together with a similar amount of construction and demolition (C&D) waste. The three unauthorised landfill sites are illustrated as Areas 1, 4 and 6 on the figure reproduced within Appendix A.

Mouchel Parkman has undertaken an environmental risk assessment of the threats to drinking water and groundwater posed by these unauthorised landfills and also reviewed the risks from landfill gas to a recently constructed housing development (Mouchel Parkman, August 2003).

Air dispersion modelling was conducted to predict down-gradient methane and carbon dioxide concentrations as well as potential odour issues that may result from the passive venting of landfill gases from the proposed non-hazardous engineered landfill on Roadstone Dublin's landholding at Blessington.

In addition, benzene was added to the model due to significant levels recorded in Area 6 during the monitoring of volatiles in March 2003. The same levels were also recorded in March 2004 (see Appendix H).

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2.1 Previous Studies

The Mouchel Parkman Risk Assessment, Report 4000043/OR/03, prepared in consultation with the Environmental Protection Agency, concluded that remediation works of the unauthorised landfills was required due to the risk of landfill gas (recorded within Area 6) to nearby housing under construction. After considering the remediation options in terms of cost, environmental benefits, implementation and public impact, it was decided that all of the DCI waste would be transferred from each of the three affected areas to a proposed engineered landfill to be constructed within the Blessington site (see Appendix A).

It has been calculated that this waste will total approximately 55,000 tonnes of DCI waste. It has been assumed that up to a further 10,000 tonnes of inert C&D waste will also be placed in the landfill during deposition, with the balance of material deposited in the landfill comprising soils beneath and around the buried waste.

The proposed engineered landfill is located approximately 450m from the nearest housing development. These properties located at Darkers Lane are outlined on the figure provided (Appendix A).

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2.2 Model Description

The GasSim model version 1.03 (supplied by Golder Associates) was selected for this assessment as it enables the combined contribution of vented gases and those released through the landfill surface cap to be considered. This model assumes that the landfill is a simple point source of emission, with atmospheric dispersion off-site simulated by a Gaussian plume deterministic model.

GasSim is a probabilistic model that uses the Monte Carlo simulation technique to select randomly from a pre-defined range of possible input values (probability density functions – PDF) to create parameters for use in the model calculations. Repeating the process many times gives a range of output values, the distribution of which reflects the uncertainty inherent in the input values. This enables the likelihood of the estimated output levels being achieved to be ascertained.

2.3 Model Assumptions

In modelling the landfill, it was necessary to make various assumptions about the discharge conditions that would then be incorporated into the future engineering designs. The model also required information to be input on the landfill design itself, including the source material composition, deposition rates and hydrogeological parameters. These parameters and their justifications are included in the following sections and are summarised in Appendix B. In general, parameters were chosen to provide a conservative estimation of risk, which is tending to a 'worst case' situation that could apply.

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3 Pollutants and Air Quality Guidance

The following table gives a list of pollutants that were modelled with the relevant environmental assessment levels (EAL's) and odour thresholds. The trace gases were chosen as they form the odorous components of landfill gas; benzene was also chosen as significant levels had been recorded during previous monitoring.

Gas Modelled	Long Term EAL taken from EA's H1 Guidance (mg/m3)	Odour Threshold (mg/m3) - GasSim Default
Carbon disulphide	0.064	0.7
Diethyl disulphide	Not Applicable	0.0003
Dimethyl sulphide	Not Applicable	0.0037
Ethanethiol (ethyl mercaptan)	0.013	0.00046
Hydrogen sulphide	0.14	0.0001
Limonene	Not Applicable	0.02
Methanethiol (methyl mercaptan)	0.01	0.0002
Propanethiol	Not Applicable	0.00014
Toluene	1.91	0.7
Xylene	4.41	0.54
Benzene	0.016	N/A

According to H1 Guidance issued by the EA•, air emissions are considered to be insignificant if the maximum process contribution (long term) is less than or equal to 1% of the long term EAL as provided above.

When considering methane (CH_4) and carbon dioxide (CO_2), the Irish EPA guidelines of 1% and 0.5% respectively were considered (Irish Department of Environmental Standards for Building Construction).

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• UK Environment Agency – Horizontal Guidance Note IPPC H1 "Environmental Assessment and Appraisal of BAT"

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4 Landfill Source

For the purposes of modelling we have assumed that source material from Areas 1,4 and 6 will be deposited in the engineered landfill between 2004 and 2005, reaching a total of 65,000 tonnes. This was input to the model as a uniform range of between 19,500 to 23,800 tonnes for 2004, increasing to between 39,000 to 47,700 tonnes in 2005. A zero waste amount was then input to the model for the years between 2006 and 2022.

During the period of waste deposition, it was assumed that 75% of the waste was covered by some form of cap. From the time of completion, in 2005, it was then assumed that all the waste was covered with a capping layer.

For the purposes of the model it was assumed that the 55,000 tonnes of DCI waste was split between approximately equal amounts of commercial, industrial and domestic waste. GasSim contains default waste streams for commonly deposited waste materials filled between 1980 and 2010, from HELGA (Gregory et al., 1999), this is enclosed as Appendix D. The composition of each type of waste was determined for the model using the model default values for 1980's to 2010 waste streams. This was input as a uniform range 21% to 37.4% of total waste input to the proposed landfill for each of the three waste types.

Up to a further 10,000 tonnes of residual C&D waste was also assumed within the model and given as a uniform range between 7.7% and 15.4% of total waste input to the proposed landfill.

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5 Landfill Characteristics

The landfill area was input as 190m x 85m giving a total area of 16,150 m^2, which has been assessed as being the potential area of active waste deposited. Biological methane oxidation was limited to 10%, this being the proportion suggested by DEFRA* policy.

It is intended that the waste material is to be capped with a 5mm thick Geosynthetic Clay Liner overlying a 1mm thick Linear Low Density Polyethylene (LLDPE) Geomembrane. This was included in the model as a 0.005m thick layer with a hydraulic conductivity of 5E-11m/sec, with a second layer of 0.001m thickness with a hydraulic conductivity of 4.3E-19m/sec. Whilst this may reduce the degree of methane release from the surface it should enhance the content of gases released passively through the proposed landfill gas management system.

It is also proposed that the base of the landfill is to be lined with a 2mm thick high density polythene (HDPE) Geomembrane, overlying a 5mm thick Geosynthetic Clay Liner, overlying a 1m thick clay liner. This was included in the model as a 0.002m thick layer with a hydraulic conductivity of 4.3E-19m/sec, with a second layer of 0.005m with a hydraulic conductivity of 5E-11m/sec, and a third layer of 1m with a hydraulic conductivity of 1E-9m/sec.

As the presence of recirculated leachate is likely within the engineered landfill, a 'wet' scenario was selected for the model using the GasSim default.

Previous hydrogeological analysis provided a representative value for the hydraulic conductivity of 0.865m/day (or 0.00001m/sec).

Default values for moderate cellulose decay rates were included in the model set up. It was also assumed that any vented gases would comprise 66% methane in the first instance. 66% methane is the likely maximum concentration of methane in any landfill gas generation *(Department of Environment – Waste Management Paper 27)*

The value for infiltration, uniform PDF of 10 to 15 mm/year *(provided by JBA)*, corresponds to 1-1.5% of annual rainfall recorded locally and was decided using professional judgement based on the cap design of the landfill.

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6 Emission Parameters - Gas Plant

The GasSim programme has been adapted to model a single point emission. To achieve this, the air / fuel ratio was lowered to 0.01 and ambient air temperature (20^0C) was assumed, thereby removing aspects of bleeding and heating that would be associated with an engine. Furthermore there was assumed to be no down time to represent constant passive venting. Similarly zero methane destruction efficiency was assumed and no operational flares were modelled. The assumed vent stack dimensions were a diameter of 0.1 m and height of 3 m.

The first model runs were based on emissions occurring from 2004 onwards. The proportion of methane and carbon dioxide in the exhaust streams were input as 66% and 16.8%, respectively, these concentrations having been previously recorded in the landfill *(area 6)*. Predicted levels of generated CH_4 and CO_2 are provided within Appendix E. Production of landfill gas peaks in 2006, with an estimated $87m^3$/hr of CH_4 and $44m^3$/hr of CO_2 being generated. With the simulation of a single vent point, generated levels of landfill gas decline to approximately half peak levels over three years. However, generated levels are then shown to gradually decline over the next fifteen years with approximately one eighth of peak levels still being generated in 2024.

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Landfill gas generation is expected to occur for approximately thirty years after deposition *(Department of Environment – Waste Management Paper 27)*. Therefore predicted levels of landfill gas are expected to continue to decrease after 2024, for approximately 10 more years before the generation of landfill gas ceases. Management measures, such as gas flaring, could potentially be incorporated to reduce the generated levels of methane gas over time.

The model shows that the predicted CH_4 and CO_2 discharge rate between 2004 and 2024 were $6.6m^3$/hour and $3.3m^3$/hour, respectively, for a single vent point with the above dimensions. Therefore, at least fourteen separate vents with the above dimensions would be required for dispersion of generated landfill gas at peak levels. The vent output graphs are also attached in Appendix E.

Default concentrations in the landfill gas were assumed for the model and these were compared with trace gas concentrations recorded during monitoring. Particular attention was given to the standard odour suite, which includes a range of sulphur containing hydrocarbons (known as thiols or mercaptans), gaseous sulphides, xylene, toluene and limonene, in addition benzene was added to the trace gas suite. Trace gas default inputs for odorous components of landfill gas are shown in the table (Appendix F), these default trace gas concentrations were derived from performing statistical analysis on the data gathered by a number of authors (AERC draft database, 2001; Derwent et al., 1996; and Stoddart et al., 1999). Concentrations recorded during in-situ monitoring that exceeded the relevant

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default values were also input for re-runs of the model, with the outcome discussed in Section 7.

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7 Atmospheric Dispersion Parameters

Dispersion of methane and carbon dioxide to the following receptors was modelled with each receptor assumed to be located down gradient from the venting source to provide the most conservative modelled scenario. The location of the three receptors are shown on the drawing within Appendix A. Each receptor was considered to be at the same elevation as the vent stack, although further analysis (not reported) showed that variation on the height did not influence the results.

Receptor	Distance from Source (m)	Direction from Source
1. Darkers Lane (isolated rural housing)	450	NE
2. Residential Housing (near Area 6)	600	SE
3. Site Boundary	20	E

For air dispersion, a wind rose with dominant flow direction from the southwest was input to the model, *as provided by JBA.* The values input are summarised in the following table:

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Wind Direction	Frequency
30	0.03
60	0.06
90	0.10
120	0.05
150	0.04
180	0.07
210	0.17
240	0.25
270	0.13
300	0.04
330	0.03
0	0.03

It was assumed that each receptor was down gradient of the predominant wind direction, thus providing a conservative assessment.

Default values of Pasquill data were assumed. These simulate aspects of atmospheric stability, wind speeds and mixing depths for gases.

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8 Model Results

8.1 Dispersion

Using the GasSim model the predicted atmospheric dispersion of landfill gas to each of the three receptors was modelled as follows.

8.1.1 Bulk Landfill Gas

The predicted methane (CH_4) and carbon dioxide (CO_2) concentrations at the receptors are summarised in the following table. These cover the period from 2005 onwards.

Year	CO_2 at Receptor 1 (mg/m^3)	CH_4 at Receptor 1 (mg/m^3)	CO_2 at Receptor 2 (mg/m^3)	CH_4 at Receptor 2 (mg/m^3)	CO_2 at Receptor 3 (mg/m^3)	CH_4 at Receptor 3 (mg/m^3)
2005	0.0096	0.0054	0.0068	0.0049	0.43	0.23
2006	0.028	0.016	0.017	0.013	1.32	0.72
2007	0.021	0.011	0.013	0.0094	0.95	0.52
2008	0.016	0.0089	0.01	0.0075	0.73	0.40
2009	0.013	0.0074	0.0087	0.0064	0.6	0.36
2010	0.011	0.0063	0.0076	0.0056	0.51	0.28
2011	0.0098	0.0055	0.0068	0.005	0.44	0.24
2012	0.0087	0.0049	0.0062	0.0046	0.39	0.21
2013	0.0078	0.0044	0.0057	0.0042	0.34	0.19
2014	0.0069	0.004	0.0052	0.0038	0.30	0.17
2015	0.0062	0.0036	0.0048	0.0035	0.27	0.15
2016	0.0055	0.0032	0.0044	0.0033	0.24	0.13

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Receptor 1 – Darkers Lane

The model results predict a maximum methane concentration of 0.016mg/m^3 at receptor 1, located 450m down gradient from the vent stack, with carbon dioxide reaching a maximum of 0.028mg/m^3. In comparison, methane is considered to be toxic by asphyxiation at concentrations in excess of 30% by volume (200,000 mg/m^3), a value approximately twelve million times greater than the maximum predicted. Asphyxiation from carbon dioxide can occur at concentrations in excess of 0.5% v/v (9,200 mg/m^3), a value approximately three hundred thousand times greater than the maximum recorded.

Receptor 2 – Residential Housing near Area 6

The model results predict a maximum methane concentration of 0.013mg/m^3 at receptor 2, located 600m down gradient from the vent stack, with carbon dioxide reaching a maximum of 0.017mg/m^3. In comparison, methane is considered to be toxic by asphyxiation at concentrations in excess of 30% by volume (200,000 mg/m^3), a value approximately twenty million times greater than the maximum recorded. Asphyxiation from carbon dioxide can occur at concentrations in excess of

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0.5% v/v (9,200 mg/m^3), a value approximately five hundred thousand times greater than the maximum recorded.

Therefore, based on the model predictions, the venting of methane and carbon dioxide from the engineered landfill should not pose a risk to public health of occupants in the nearby residential areas. The lower explosive limit for methane is 5% v/v (33333mg/m^3). This is approximately two million times greater than the maximum predicted methane concentration (0.016mg/m^3 at receptor 1) and hence there is likely to be no significant risk for any explosion at either receptor.

Receptor 3 – Site Boundary

When considering the nearest site boundary, the model predicts a maximum methane concentration of 0.72mg/m^3 at receptor 3, located 20m down gradient from the vent stack, with carbon dioxide reaching a maximum of 1.32mg/m^3. In comparison, methane is considered to be toxic by asphyxiation at concentrations in excess of 30% by volume (200,000 mg/m^3), a value approximately two hundred and fifty thousand times greater than the maximum recorded. Asphyxiation from carbon dioxide can occur at concentrations in excess of 0.5% v/v (9,200 mg/m^3), a value approximately seven thousand times greater than the maximum recorded. The lower explosive limit for methane is 5% v/v (33333mg/m^3). This is approximately five thousand times greater than predicted methane concentration and hence there is likely to be no significant risk for any explosion at the site boundary.

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8.1.2 *Odorous Emissions*

The emission of landfill gas was also considered in terms of odour thresholds being exceeded at each receptor. The predicted concentrations of trace compounds considered to represent the most odorous emissions from landfills are provided in the tables below, benzene concentrations were also recorded.

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Receptor 1 – Darkers Lane

Predicted Trace Gas Concentrations (mg/m^3) at Receptor 1											
	Carbon Disulphide	Diethyl Disulphide	Dimethyl Sulphide	Ethanethiol	Hydrogen Sulphide	Limonene	Methanethiol	Propanethiol	Toluene	Xylene	Benzene
2005	1.4e-7	9.8e-11	7.6e-7	2.2e-7	1.5e-5	2.6e-6	4.9e-7	9.2e-8	6.9e-6	2.3e-5	4.3e-9
2006	4.3e-7	9.5e-11	2.3e-6	8.0e-7	4.1e-5	7.6e-6	1.4e-6	2.6e-7	2.2e-5	6.6e-5	1.2e-8
2007	2.5e-7	8.1e-11	1.5e-6	4.8e-7	2.5e-5	4.5e-6	7.6e-7	1.5e-7	1.1e-5	3.8e-5	7.7e-9
2008	1.6e-7	7.0e-11	9.9e-7	3.1e-7	1.4e-5	2.9e-6	5.0e-7	9.9e-8	8.0e-6	2.5e-5	5.3e-9
2010	7.7e-8	5.1e-11	5.0e-7	1.5e-7	7.1e-6	1.4e-6	2.4e-7	4.6e-8	4.5e-6	1.2e-5	3.0e-9
2012	4.1e-8	3.7e-11	2.2e-7	8.5e-8	4.1e-6	7.5e-7	1.3e-7	2.8e-8	2.4e-6	5.6e-6	1.8e-9
2014	2.4e-8	2.7e-11	1.0e-7	4.9e-8	2.0e-6	4.1e-7	6.3e-8	1.7e-8	1.4e-6	3.1e-6	1.2e-9
2016	1.4e-8	2.0e-11	4.7e-8	2.8e-8	1.2e-6	2.1e-7	3.4e-8	1.0e-8	7.5e-7	1.7e-6	7.3e-10
Odour Threshold	0.7	3.0e-4	3.7e-3	4.6e-4	1.0e-4	2.0e-2	2.0e-4	1.4e-4	0.7	0.54	*
1% of EAL	6.4e-4	*	*	1.3e-4	1.4e-3	*	1e-4	*	1.9e-2	4.4e-2	1.6e-4

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In all cases the predicted individual trace gases were below 1% of the EAL's taken from the EA's H1 Guidance and were well below the associated odour thresholds.

Recent gas monitoring of Area 6 (JBA, April 2004, see Appendix H) was undertaken and the values recorded for the odorous trace gases were found to be below the default values already modelled using GasSim, with the exceptions of dimethyl sulphide (recorded at 0.07mg/m^3), limonene (2.5mg/m^3), toluene (1.1mg/m^3), xylene (0.009mg/m^3) and benzene (0.93 mg/m^3). To provide a more conservative prediction, the default values for the odour suite were replaced with these monitoring levels for the above trace gases and the model was re-run. Again in all cases the predicted trace gases were predicted below the associated thresholds at receptor 1. Therefore odorous trace gases should pose no significant risk to human health and cause no nuisance.

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Receptor 2 – Residential Housing near Area 6

Predicted Trace Gas Concentrations (mg/m³) at Receptor 2											
	Carbon Disulphide	Diethyl Disulphide	Dimethyl Sulphide	Ethanethiol	Hydrogen Sulphide	Limonene	Methanethiol	Propanethiol	Toluene	Xylene	Benzene
2005	1.3e-7	6.3e-11	6.7e-7	2e-7	1.3e-5	2.3e-6	4.3e-7	7.9e-8	6.2e-6	2e-5	2.6e-9
2006	3.2e-7	6.1e-11	1.7e-6	6e-7	3e-5	5.5e-6	1e-6	1.9e-7	1.6e-5	4.8e-5	7.3e-9
2007	1.9e-7	5.3e-11	1.1e-6	3.8e-7	1.9e-5	3.4e-6	5.8e-7	1.2e-7	8.5e-6	2.9e-5	4.7e-9
2008	1.3e-7	4.5e-11	7.8e-7	2.5e-7	1.1e-5	2.2e-6	3.9e-7	7.7e-8	6.2e-6	1.9e-5	3.2e-9
2010	6.6e-8	3.3e-11	4.1e-7	1.3e-7	6.1e-6	1.2e-6	2e-7	3.9e-8	3.7e-6	1e-5	1.8e-9
2012	3.7e-8	2.4e-11	1.9e-7	8e-8	3.8e-6	6.8e-7	1.1e-7	2.4e-8	2.2e-6	5.1e-6	1.1e-9
2014	2.3e-8	1.8e-11	9.5e-8	4.9e-8	1.9e-6	3.9e-7	5.9e-8	1.6e-8	1.3e-6	3.1e-6	7.0e-10
2016	1.4e-8	1.3e-11	5e-8	3.1e-8	1.2e-6	2.3e-7	3.7e-8	1e-8	7.8e-7	1.1e-6	4.4e-10
Odour Threshold	0.7	3.0e-4	3.7e-3	4.6e-4	1.0e-4	2.0e-2	2.0e-4	1.4e-4	0.7	0.54	*
1% of EAL	6.4E-4	*	*	1.3e-4	1.4e-3	*	1e-4	*	1.9e-2	4.4e-2	1.6e-4

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In all cases the predicted individual trace gases were below 1% of the EAL's taken from the EA's H1 Guidance and were well below the associated odour thresholds.

Recent gas monitoring of Area 6 (JBA, April 2004, see Appendix A) was undertaken and the values recorded for the odorous trace gases were found to be below the default values already modelled using GasSim, with the exceptions of dimethyl sulphide (recorded at 0.07mg/m³), limonene (2.5mg/m³), toluene (1.1mg/m³), xylene (0.009mg/m³) and benzene (0.93 mg/m³). To provide a more conservative prediction, the default values for the odour suite were replaced with these monitoring levels for the above trace gases and the model was re-run. Again in all cases the predicted trace gases were found to be below the associated thresholds at receptor 2. Therefore odorous trace gases should pose no significant risk to human health and cause no nuisance.

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Receptor 3 – Site Boundary

	Predicted Trace Gas Concentrations (mg/m^3) at Receptor 3										
	Carbon Disulphide	Diethyl Disulphide	Dimethyl Sulphide	Ethanethiol	Hydrogen Sulphide	Limonene	Methanethiol	Propanethiol	Toluene	Xylene	Benzene
2005	6.6e-6	4.9e-10	3.6e-5	1.0e-5	7.2e-4	1.2e-4	2.3e-5	4.4e-6	3.3e-4	1.1e-3	3.3e-7
2006	2.0e-5	4.7e-10	1.1e-4	3.8e-5	1.9e-3	3.6e-4	6.6e-5	1.2e-5	1.0e-3	3.1e-3	9.3e-7
2007	1.2e-5	4.0e-10	6.9e-5	2.3e-5	1.2e-3	2.1e-4	3.6e-5	7.3e-6	5.4e-4	1.8e-3	6.0e-7
2008	7.7e-6	3.4e-10	4.7e-5	1.5e-5	6.5e-4	1.4e-4	2.3e-5	4.7e-6	3.8e-4	1.2e-3	4.1e-7
2010	3.6e-6	2.5e-10	2.4e-5	7.3e-6	3.6e-4	6.6e-5	1.1e-5	2.2e-6	2.1e-4	5.8e-4	2.3e-7
2012	1.9e-6	1.8e-10	1.1e-5	4.0e-6	1.9e-4	3.5e-5	5.9e-6	1.3e-6	1.2e-4	2.6e-4	1.4e-7
2014	1.1e-6	1.4e-10	4.8e-6	2.3e-6	9.6e-5	1.9e-5	3.0e-6	8.1e-7	6.5e-5	1.5e-4	9.0e-8
2016	6.6e-7	1.0e-10	2.2e-6	1.3e-6	5.6e-5	9.9e-6	1.6e-6	4.7e-7	3.6e-5	8.0e-5	5.7e-8
Odour Threshold	0.7	3.0e-4	3.7e-3	4.6e-4	1.0e-4	2.0e-2	2.0e-4	1.4e-4	0.7	0.54	*
1% of EAL	6.4E-4	*	*	1.3e-4	1.4e-3	*	1e-4	*	1.9e-2	4.4e-2	1.16e-4

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The shaded cells show predicted levels that exceed associated thresholds. The model predicts significant levels of hydrogen sulphide (greater than the odour threshold) between the years 2005 and 2012 at the nearest site boundary.

In all other cases the predicted individual trace gases were below 1% of the EAL's taken from the EA's H1 Guidance and were well below the associated odour thresholds.

Recent gas monitoring of Area 6 (JBA, April 2004, see Appendix A) was undertaken and the values recorded for the odorous trace gases were found to be below the default values already modelled using GasSim, with the exceptions of dimethyl sulphide (recorded at 0.07mg/m^3), limonene (2.5mg/m^3), toluene (1.1mg/m^3), xylene (0.009mg/m^3) and benzene (0.93 mg/m^3). To provide a more conservative prediction, the default values for the odour suite were replaced with these monitoring levels for the above trace gases and the model was re-run. No further predicted trace gases were found to be above the associated thresholds.

To provide a more accurate simulation for predicted levels of hydrogen sulphide, the model was again re-run using the most recent monitoring results as outlined above.

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For this odorous gas levels were found to be less than detection at all locations. Therefore the detection level was input into the model to replace the GasSim default values, i.e. 1ppb for hydrogen sulphide (0.00142mg/m^3). When modelling the on-site recorded level, predicted concentrations at the nearest site boundary were found to be well below the associated thresholds.

8.2 Lateral Gas Migration

Lateral gas migration was also modelled using GasSim. The model simulates lateral migration using a one dimensional flow model, which is emitted uniformly from all sides of the landfill. It uses an advection and dispersion equation to simulate the migration of gas through the landfill liner. Using the model the predicted lateral migration of landfill gas in relation to the nearest site boundary (to the east of the landfill) was investigated.

8.2.1 Bulk Landfill Gas

Concentrations of methane and carbon dioxide just outside the landfill boundary were calculated to be 383,000mg/m3 (52%) and 501,000mg/m^3 (25%) respectively. However, at a distance of 12m from the proposed landfill methane concentrations become zero, and at a distance of 11m away carbon dioxide concentrations become zero. The nearest site boundary is approximately 20m from the edge of the proposed landfill position, and therefore there should be no significant risk to any potential future development from lateral migration.

8.2.2 Odorous Emissions

When considering odorous trace gases and benzene, the model predicted that for all species the concentration would be zero beyond 8m from the landfill boundary. Again there should be no significant risk to any potential future development from the lateral migration of odorous trace gases.

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The output graphs showing the lateral migration of landfill gas are provided within Appendix G.

Irrespective of the above findings, the installation of the proposed venting measures should intercept any lateral migration of gas and disperse it into the atmosphere.

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9 Summary of Air Dispersion Modelling

Risk assessment undertaken using the GasSim model indicates that the risks posed to housing development from the predicted generation of methane and carbon dioxide in the proposed engineered landfill are likely to be insignificant. Modelled receptor concentrations of these gases are significantly below accepted limits of explosion and asphyxiation, and therefore the risk to human health at the receptors is likely to be insignificant. The landfill engineering design is therefore regarded to provide a large safety margin in this respect.

Modelled concentrations of odorous trace gases and benzene generated by the landfill are unlikely to pose a significant problem for the residents of the nearby housing developments when considering public health and potential nuisance. However when considering odorous trace gas modelled at the nearest site boundary, significant volumes of hydrogen sulphide are predicted (i.e. greater than threshold levels) when using GasSim default source levels.

When the model was re-run using actual recorded values, all of the odorous trace gases and benzene were found to be well below threshold levels at the nearest site boundary. As this scenario provides a more accurate picture of site conditions, it is anticipated that there should be no significant risk to public health or public nuisance to any potential future development at the site boundary from odorous landfill gas.

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It is recommended that gas monitoring is carried out monthly during the operational phase of the landfill to provide a safety margin during operations and to provide information for any further GasSim modelling work, if required. All model results assume passive venting of gas, however, it is understood that flares will be incorporated into the landfill design for the management of landfill gas. Therefore, should monitoring indicate a potential for flaring, the landfill flares can then be operated.

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10 Appendices

Appendix A	Figure 2.2 Site Infrastructure Layout
Appendix B	GasSim Input Parameters
Appendix C	GasSim Project Details
Appendix D	Composition of 1980's to 2010 Waste Streams
Appendix E	Single Vent and Generated Landfill Gas Output Graphs
Appendix F	GasSim Trace Gas Default Inputs for Odorous Gas
Appendix G	Lateral Migration Graphs
Appendix H	Monitoring Results

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