Caulmert Limited

Engineering, Environmental & Planning
Consultancy Services

Bryn Posteg Landfill Site, MRF and Composting Facility

Potters Waste Management

Odour Management Plan

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DISCLAIMER

BRYN POSTEG LANDFILL SITE, MRF AND COMPOSTING FACILITY
ODOUR MANAGEMENT PLAN

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1 INTRODUCTION

1.1 Background

1.1.1 Potters Waste Management operates Bryn Posteg waste management disposal facility under the Environmental Permit (EP) BU7766. The disposal facility comprises a landfill site, landfill gas utilisation plant, landfill leachate treatment plant, a Material Recycling Facility (MRF) and an aerobic mechanical-biological treatment process (MBT). The site also includes recovery processes within the MRF and, on a dedicated slab, the composting of source segregated green waste. These recovery processes have their own permits.

1.1.2 An Odour Management Plan[1] is in operation at the site. This document is a replacement to the existing Plan, describing the company's current management provisions and supplementing them with further proposals to mitigate effects of potential malodours emissions.

1.1.3 This Odour Management Plan provides means of assessing the effectiveness of control measures. The proposed control measures should be implemented in cases of failure and odour events. This document also revises the current procedures for investigating odour events and includes reference information on the understanding of odour nuisance.

1.2 Objectives

1.1.4 The Plan has been prepared in reference to the Environment Agency's Technical Guidance Note H4 Horizontal Guidance for Odour[2] and the recommended Best Available Techniques (BAT) for odour control at waste management facilities. The Plan also makes reference to an industry guide for the prevention and control of odours at bio waste processing facilities, published by The Composting Association[3].

1.1.5 As a minimum this OMP will consider the following elements:

- An assessment of the risks of odour problems, from normal and abnormal situations at the facility;
- Identify the appropriate controls to manage the identified risks;
- Monitoring;
- Identify actions, contingencies and responsibilities when odour problems arise; and
- Regular review of the effectiveness of odour control measures.

[1] Caulmert Ltd. October 2014. Bryn Posteg Landfill Site and Material Recycling Facility. Odour Management Plan.
[2] Environment Agency. March 2011. Technical Guidance Note IPPC H4 Horizontal Guidance for Odour (Parts 1 & 2).
[3] The Composting Association. 2007. An industry guide for the prevention and control of odours at bio waste processing facilities.

1.1.6 The Operator intends to use this Plan during the facilities expected operational life. The Plan will be reviewed on a regular basis and when a new element of site infrastructure is introduced.

2 SITE BACKGROUND

2.1 Site Setting

2.1.1 Bryn Posteg Landfill Site is located approximately 3 km south east of Llanidloes in Powys and is centered at National Grid Reference SN 971 822. The site is accessed via the B4518, Llanidloes to Tylwch road. The B4518 runs parallel with the western site boundary.

2.1.2 The landfill site was developed from the surface void of a former lead mine. Controlled landfilling has taken place since 1982.

2.2 Process Description

2.2.1 The Site Plan; drawing 3033 -CAU-XX-XX-DR-S-1800 P1 shows the Site layout and general plant arrangements.

2.2.2 Vehicles enter the site from the B5418 (Tylwch Road) and proceed immediately to the weighbridge before moving on to the reception and offloading area, which is a large concrete slab, with a concrete wall backing. Municipal solid waste (MSW) is offloaded by the delivery vehicles to temporary stockpiles in this area. The stockpiles are then transferred by front-end loaders and a grab to the Municipals Recycling Facility (MRF) for screening and sorting.

2.2.3 Green waste deliveries are accepted in similar fashion in a designated area of the reception and offloading area as shown on the Site Plan. Green waste compost is managed under a separate, Standard Rules Permit (EPR/CB3834RQ).

2.2.4 Waste material is shredded and passed under a magnet (under the MRFs WML47120), the material then passes for treatment for disposal under the Landfill Permit. The first stage of this is the screening trommel at the MRF this sorts the material by size. Biodegradable fines are transferred to a stockpile prior to compost treatment, which is the main stage of the mechanical-biological treatment process (MBT). This compost waste forms part of the waste stream for the Bryn Posteg Landfill Permit. The oversize material from the trommel passes directly for landfill disposal.

2.2.5 The oversized material remaining after separation at the MRF is stockpiled for transfer to the active landfill cell. Recyclable materials are stockpiled in the designated area for transport off site in skips or walking floor trailers for further treatment and disposal.

2.2.6 The MBT fines stockpile is prepared for open windrow composting by initial turning to create a suitable feedstock for composting. Windrows are then formed in the Compost Maturation Pad. Compost treatment is typically complete after 2 weeks, following which the end product compost is loaded to delivery vehicles for landfilling on Site.

2.2.7 Residual waste to be landfilled is loaded into high sided trailers and deposited in the active cell of the landfill by tractors. The waste is immediately compacted and spread evenly by a landfill compactor. At the end of every working day, temporary day cover is applied.

2.2.8 Landfill cells that have temporarily ceased acceptance of waste are initially temporarily capped, prior to permanently capping in accordance with Environment Agency's 'how to comply with your environmental permit, Additional Guidance for; Landfill (EPR 5.02) with supervision for Construction Quality Assurance, upon approval by Natural Resources Wales (NRW).

2.2.9 The sources of odour at Bryn Posteg have been identified as landfill gas, leachate, waste materials (especially inherently 'smelly' biodegradable wastes). The main sources of odour at the site, their description and their risk potential are described in Tables 1 (Sources of Odour) and 2 (Operational Sources of Odour), which are contained within Appendix 1 of this document.

2.2.10 Unexpected circumstances, such as plant failure, human error or an act of vandalism could also trigger the release of odour from landfill gas, leachate, waste or compost. A review of current activities at the site has identified a number of such events in Section 4, and are summarised in Table 3 (Accidental Releases of Odour) contained in Appendix 1.

2.2.11 Landfill gas is slightly denser than air. This, combined with the elevated position of the site, could lead to the potential for odour nuisance to develop during light winds and/or calm weather conditions. Further, the diurnal temperature cycle leads to neutral and stable atmospheric stratification and a short-term drop in wind speeds during the night. These conditions may also trigger an odour nuisance at the down-gradient locations. Information derived from reference material[4] shows that the extent of the odour footprint under low wind conditions could extend up to 10km from the site boundary. In general, calm and light/variable wind conditions (wind speed <2m/s) in the Llanidloes area occur infrequently, therefore the risk of this type of nuisance is not considered to be significant.

2.2.12 The operation of the MRF and composting facility is also a significant potential source of odour at the site, which may arise during the following activities:

- Unloading of wastes accepted at the installation for treatment;
- Storage and treatment processing of waste accepted at the installation;
- Development of anaerobic conditions within the MSW composting heap.

2.2.13 The operation of the composting facility may also be a source of odour, which may potentially arise during the following activities:

- Unloading of fresh feedstock materials;
- Odours produced through the normal breakdown;
- Odours produced through anaerobic conditions.

[4] P. McKendry, J.H. Looney & A. McKenzie. 2002. Managing Odour Risk at Landfill Sites: Summary Report. SITA (UK) Ltd.

2.3 Potential Receptors

2.3.1 Bryn Posteg Landfill Site is situated in a rural area, with no close areas of dense population. The nearest town of Llanidloes is situated 2.8 km to the north-west of the site. A number of isolated properties surround the site. The closest properties to the site are: Bryn Posteg Farm (250 m west), Valley View (100 m north-west), Maes-Socyn (350 m south-west), Talan-Llwydiarth (450 m south-east), Rhoswen (200 m east), Pant (250 m east) and Penbryndu (300 m north). The properties Valley View, Rhoswen and Pant are within 250 m of the site boundary.

2.3.2 As potential receptors to the emissions from the site these properties will be influenced by the local wind direction and topography. The prevailing winds from south-westerly sector would blow any arisings towards properties in the eastern and north-eastern sectors, primarily Rhoswen and Pant.

2.3.3 The site is surrounded by grassland, which is managed for silage production and grazing. The results of the Impact Statement Report (CLA, 1999) concluded that flora and fauna associated with the agricultural land its margins are typical of modern agricultural land and had little nature conservation interest. The flora and fauna associated with the southern margins of the site extension exhibit greater diversity but do not contain any protected species or habitats. No rare or protected species were found on the site, and this constitutes an absence of ecological receptors.

2.3.4 Traffic on the adjacent B5418 single carriageway (Tylwch Road) and users of a number of the site adjoining public paths are most likely to be affected by fugitive emissions of odour.

3 PROCEDURES AND CONTROLS UNDER NORMAL CONDITIONS

3.1 General

3.1.1 The Operator has a number of working practices, operating procedures and control measures to contain and mitigate the potential odours. The available measures and procedures for dealing with landfill odour are utilised in this Odour Management Plan.

3.1.2 The potential odour sources identified at Bryn Posteg are detailed in this section below and are summarised in Tables 1 and 2 of Appendix 1.

3.2 Waste Operational Odour Controls

Odour Source/ Activity

3.2.1 The following activities have been identified as capable of producing odour during the reception, offloading and storage of MSW and green waste:

- MSW reception and offloading to the designated area
- Green waste reception and offloading to the designated area
- Sorting of MSW at the MRF followed by stockpiling of recyclable and non-recyclable materials

3.2.2 The potential for odour generation from the wastes accepted on site will be dependent on a number of factors including ambient weather conditions and the nature and age of the material imported to the site.

3.2.3 As a result of high ambient temperatures and/or prolonged storage periods prior to delivery, waste may be delivered which has commenced the degradation process and will have the potential to create odour.

3.2.4 A summary of the waste types handled at Bryn Posteg are presented in Table 1 in Appendix 1, details of the types of waste to be received regularly, the source of the waste and odour implications and the risk of malodourous emissions for that waste type. The inventory will be reviewed periodically, both to include any new regular waste streams and, if appropriate, to amend the management considerations for the particular waste streams based on practical experience of handling the waste at the facility.

Control Measures

3.2.5 The following management measures will be adopted at the Site to minimise odour release during the receipt, offloading, storage, treatment of compost and landfilling of the waste materials.

3.2.6 Potentially malodorous wastes will be identified prior to their arrival on-site, as a result of the professional knowledge of weighbridge staff and the maintenance of good communications

with customers. The weighbridge personnel are trained to recognise different waste types. The Operator provides internal training on the Duty of Care (DOC) and non-conforming waste. As part of the DOC, properties of waste including odour potential are identified by the producer, and this information is provided to the Operator in advance. Any loads of odorous waste which cannot be handled by the Operator are routed for direct burial in the waste within the landfill.

3.2.7 All waste deliveries, including green waste for composting, will be brought to the site via an approved delivery route from Tylwch Road in sheeted waste vehicles. Adequate odour sealing should be provided by the producer/haulier for deliveries of any malodorous wastes which are permitted at the site. The Operator will maintain regular dialog with waste producers on adequate odour control measures (e.g. rubber seals on doors, fully enclosed bins or solid sheets on open skips).

3.2.8 Green waste for composting is screened and then moved to the composting facility. Fines for MBT are stored and treated separately. Storage of compost waste is in temperature monitored windrows. The windrows receive frequent aeration by turning to avoid anaerobic conditions, which lead to the release of malodourous compounds. Any dampening of compost is done in small, frequent applications as moisture content is crucial to the maintenance of an effective windrow composting process and the avoidance of malodourous releases from the Site.

3.2.9 Fresh refuse odours are liable to emanate from the MRF during waste stockpiling, segregation and processing and the movement of residues to the landfill for final disposal. The Operator aims to remove waste accepted at site by the end of the working day.

3.2.10 All MSW arriving at the MRF is processed and screened. The fine element of the MSW is composted to allow for degradation of the most easily available material, thus reducing the weight of waste and the biodegradability of the waste being sent to landfill. Oversize waste goes directly to the landfill.

3.2.11 No compost movement will be initiated on Fridays and/or the day immediately prior to Public Holidays to ensure no disturbed composted waste is left over a weekend or other period. The final composted product will be disposed of as malodorous waste, i.e. will be rapidly buried (within 1 hour).

3.2.12 All waste loads sent to a landfill tipping area will be buried within the same working day. Any malodorous wastes will be buried rapidly (within 1 hour) at the lowest point of the operational area and covered with non-odorous waste. Odour from fresh waste will be further minimised by thorough compaction of waste and a provision of adequate daily cover. The alternative operational area will be used during unfavourable weather conditions further away from the local sensitive receptors, where practicable.

3.2.13 Surface emissions of waste and landfill gas (LFG) odours will be reduced by operating small operational area and limiting the size of the operational area to the practicable minimum. All

flanks will be constructed to a suitable gradient in order to ensure their thorough compaction and covering.

3.2.14 Fugitive emissions of landfill odours will be further minimised by rapid containment of the completed landfill areas with temporary cap using cohesive mineral material and a progressive capping of the completed cells with engineering cap. All non-operational landfill areas (including flanks) will be covered with a suitable cover. The application and the depth of the temporary cover should achieve reasonable resistance to erosion, and be free of holes or protruding waste, which would minimise odour emissions. Bulk quantities of material will be available on site for temporary cover use.

3.2.15 Re-excavation of old waste (including retro drilling operations into waste) or cap removal at the site will only be permitted when absolutely necessary. If particular sources of odour are identified, they will be referred to the Site Manager immediately and dealt with in accordance with the Remedial Action Plan (Section 6.4).

3.3 Landfill Gas Operational Odour Controls

Odour Source/ Activity

3.3.1 The decomposition of landfilled waste will lead to the generation of landfill gas. The primary components of this landfill gas are methane and carbon dioxide, which are odourless. Though only present in lower concentrations, the odorous compounds such as hydrogen sulphide can also be generated during the life cycle of the landfill.

3.3.2 The following activities have been identified as capable of producing odour during the extraction and utilization of landfill gas:

- A gas extraction wells and interconnecting manifolds are installed across the site which have the potential to leak and present a point source for odour emissions
- The gas utilisation plant consists of two landfill gas engines and one flare. Inefficient combustion could lead to odourous emissions

Control Measures

3.3.3 The Operator will continue to operate a positive gas extraction system to collect the generated landfill gas. All extracted gas is directed to the on-site landfill gas utilisation unit (power generator) under suction. The site also has a back-up gas flare.

3.3.4 The gas plant has an automatic control system to optimise the combustion process and minimise emissions. Gas abstraction rates are regularly adjusted on the basis of methane concentration, gas pressure and oxygen level. The quantity of emissions from gas flare and engine is monitored as per the Landfill Gas Management Plan[5].

[5] Caulmert Ltd. April 2012. Bryn Posteg Landfill Site. Landfill Gas Management Plan.

3.3.5 The provision of an active gas extraction system at the site is considered to be a Best Available Technique (BAT) for control of landfill gas odours.

3.3.6 The potential fugitive emissions of landfill gas odour from the gas extraction system will continue to be controlled as part of the Landfill Gas Management Plan. In particular, the following operational controls relevant to odour management will be used:

- connection of all available gas extraction points to the landfill gas extraction system and minimise the time when they are disconnected, such as during maintenance and engineering works;
- progressive and timely extension of landfill gas extraction system to the completed landfill areas;
- regular maintenance of the gas extraction system including checking the status of operational parts of the system, replacing consumable elements, such as seals and valves and checking for any leakages of the gas from the system;
- covering/sealing of extraction points, leachate wells/sumps and in-waste boreholes in order to prevent fugitive emissions, and
- adequate compaction and covering of waste around extraction wells, monitoring points and leachate risers.

3.3.7 Accidental releases of odour from the gas management system are addressed in Section 4.0.

3.4 Leachate Operational Odour Controls

Odour Source/ Activity

3.4.1 The degradation of waste in the landfill and the infiltration of rainwater will lead to the generation of landfill leachate. Leachate has a high potential to be odourous and is continuously managed according to the Leachate Management Plan.

3.4.2 The following activities have been identified as capable of producing odour during the extraction and utilization of landfill gas:

- A total of 12 leachate extraction wells and side wall risers are installed across the Site. These have the potential to present a point source of odourous emissions.

- Collected leachate and surface water runoff from the MRF is treated on site at the Leachate Treatment Plant (LTP). The LTP consists of 2 open aeration lagoons which have the potential to release fugitive odour emissions.

Control Measures

3.4.3 The Operator will continue to operate a leachate extraction system. Currently, there are twelve leachate abstraction wells installed at the site. The recently developed phase 9 contains five cells (9A – 9E) with each cell having its own leachate abstraction well. The existing collections sumps are constructed with concrete rings set on a specifically designed base.

3.4.4 Within the sumps are pneumatic pumps that are able to pump leachate to the site lagoon.

3.4.5 To insure that continuity of pumping can be maintained on the site there are replacement pumps that can be placed in the sumps should a pump break down.

3.4.6 The leachate treatment lagoon also receives water from the area of the Materials Recycling Facility (MRF). A previous impact assessment of the MRF[6] deduced that the process contributions for the measured pollutants from these sources are deemed to be insignificant.

3.4.7 The existing extraction system is designed to prevent a build-up of leachate and to reduce possible outbreaks of leachate leading to odour. Leachate levels in the landfill are regulated by the Installation Permit. The existing leachate management system will be progressively extended to cover future cells.

3.4.8 Control measures to mitigate leachate related odours will be carried out. The main odour control measures include the following:

- Inspection of pumps on a monthly basis. Regular maintenance of pumps, pipework system, compressor and leachate lagoon to avoid potential down-time problems that could lead to odour issues.
- Sealing all elements of the active extraction system and leachate monitoring points at all times. Leachate sumps are contained within concrete housings which are also sealed to reduce emissions
- Treatment of leachate in a lagoon (aerated biological treatments).
- Leachate treatment plant has a Dissolved Air Flotation (DAF) System to polish treated effluent prior to discharge to sewer.
- Discharge of the treated leachate to foul sewer.

3.4.9 Accidental releases of odour from the leachate management system are addressed in Section 4.0.

3.5 Engineering Works

3.5.1 Any odour-prone engineering works, such as excavation into previously deposited waste, extension and maintenance of LFG or leachate extraction systems etc. will be pre-planned in order to minimise the scale and duration of any odour releases. These works will be carried out during favourable weather conditions (refer to para 3.3.8). The duration of such works will be as short as possible and works will be carried out in small sections to reduce the exposure. Any exposed areas of odour prone works will be covered overnight.

[6] Bryn Posteg Waste Treatment Facility: Application for PPC Permit Variation – Impact Assessment Report. Egniol Consulting Ltd, June 2006.

4 PROCEDURES AND CONTROLS UNDER ABNORMAL CONDITIONS

4.0.1 In the unlikely event of odours being generated at the site due to circumstances beyond the Operator's control a proactive approach will be adopted towards a prompt remediation of the affected landfill area, infrastructure or a plant and minimisation of odour effects. The proposed action measures and remediation techniques are described below and summarised in Appendix 1 (Table 3). The repeated occurrence of an odour will lead to a review of the processes deemed responsible for the incidents.

4.0.2 In accordance with the current EA guidance the following abnormal situations have also been considered:

4.1 Landfill Gas Extraction Infrastructure Failure or Malfunction

4.1.1 The landfill gas management system could suffer failures with odour nuisance effects. These could include holes/cracks in the pipework and wells, under-abstraction of LFG due to blockages in pipework by condensate. Any such occurrences would result in fugitive emissions of the gas through leachate monitoring points, leachate risers, uncapped landfill surface or other preferential pathways. These potential occurrences are expected to be rare at the site, through the implementation of the robust gas management system, and the programme of proactive checks and maintenance of the infrastructure (refer to Landfill Gas Management Plan, Section 3.0).

Control Measures

4.1.2 Annual landfill and leachate extraction infrastructure emissions surveys are conducted as required by the Permit, in the form of Flame Ionisation Detector (FID) Surveys in accordance with the LFG Management plan and the EA Guidance LFTGN07. The methods employed by these surveys detect discreet features that would not necessarily be visible during a routine inspection.

4.1.3 In the event that the gas engine should be shut down for emergency repairs or due to a power cut, there is the potential for fugitive emissions of landfill gas odours to be generated.

4.1.4 Furthermore, any prolonged under-abstraction of gas would result in a built-up of the gas in the system which could also result in fugitive emissions.

4.1.5 Any inadequate combustion of the gas could result in higher emissions of VOCs and thus odours. These potential occurrences are expected to be rare at the site, as the back-up flare is available to be used during such events.

4.1.6 In the event of any failure of the gas management system, the Operator will apply the Gas Action Plan (refer to LFG Management Plan section 5.0). Natural Resources Wales will be notified of the detected failures resulting in accidental odour emissions, and advised on the likely duration of the remedial works.

4.1.7 Landfill gas and the associated odours could become fugitive as a result of failure or damage caused to the landfill capping system. Cracks with the temporary cover or the permanent cap could occur as a result of slipping of a part of a flank, incorrect application of the capping material or plant/vehicle damage. The extent and occurrence of such potential failures is difficult to predict, however these should be minimal if the completed areas of the landfill are routinely checked for any signs of erosion or cracks. Annual landfill cap surface emissions surveys are conducted as required by the Permit, in accordance with the LFG Management plan and the EA Guidance LFTGN07. The methods employed by these surveys detect discreet features that would not necessarily be visible during a routine inspection.

4.1.8 In the event of any failure of the landfill engineering system, the Operator will apply the following odour mitigation measures:

- Natural Resources Wales will be notified of any detected cap failures and consulted regarding the remediation works;
- Remediation of detected cracks on the cap will be carried out under the supervision of a Construction Quality Assurance (CQA) engineer.

4.2 Leachate Extraction and Treatment Infrastructure Failure or Malfunction

4.2.1 The leachate management system could potentially suffer technical failures or damage which may result in fugitive emissions of odour. The potential occurrences include damage to leachate collection system (e.g. pipework, tank) or odour containment components (e.g. well head cover). A failure of leachate management system could result in leaks and areas of free-standing leachate, which are potential sources of odour. The extent and occurrence of such potential failures is difficult to predict.

Control Measures

4.2.2 In the event of any failure of the leachate management system with odour consequences the Operator will apply the following action measures:

- An investigation of the potential leachate outbreak will be instigated. The site manager and the site technical staff will examine leachate heads, inspect all elements of leachate infrastructure (pipework integrity, sumps, pumps, compressor, electrical connections) and assess the areas of the landfill where the breach took place. If a source of leachate outbreak is not clear then a specialist company will be called in for an in-depth investigation and remediation. Permanent remediation will be carried out as soon as possible.
- If an outbreak of leachate is detected on the landfill, leachate will be directed to the nearest leachate sump. Areas of free-standing leachate will be promptly pumped out to the nearest sump.
- In the event of a pump breakdown, a replacement pump is to be used to insure the continuity of pumping.

- Natural Resources Wales will be informed of a leachate outbreak and odour consequences in order to agree on the scope of remediation works and the control measures required.

4.3 Site Staff Shortage

4.3.1 A shortage of trained operational staff may result in waste material being stored for long periods without processing or prior to landfilling, increasing the risk of fugitive odour emissions.

Control Measure

4.3.2 In the event there is a shortage of trained operational staff at the Facility, alternative staff will be sourced from other Potters Waste Management facilities or hired in as necessary. If necessary, waste deliveries will be controlled until the situation can be rectified. Contingency arrangements are in place with third party treatment facilities, to enable the diversion of waste material.

4.4 Operational Plant Failure or Malfunction

4.4.1 Breakdown or malfunction of the loader and grab at the MRF, compost facility or landfill could result in unprocessed waste material being left in the reception area for extended periods of time, increasing the risk of further decomposition prior to processing.

Control Measure

4.4.2 In the event of a prolonged mobile plant failure or malfunction, alternative equipment will be sourced as soon as possible (typically within 48 hours) until the equipment can be repaired or hired in as necessary. Contingency arrangements are in place with third party treatment facilities, to enable the diversion of waste material if required.

4.4.3 All plant and equipment will be maintained and regularly serviced in accordance with the manufacturer's recommendations and planned maintenance procedures to minimise breakdowns.

5 ODOUR COMPLAINTS AND REPORTING

5.1 Complaints Procedure

5.1.1 As part of this OMP, engagement with the neighbours will be undertaken.

5.1.2 Typically any complaints received at the site are likely to be through NRW although Potters is willing to deal directly with the complainants, and where necessary the following can be implemented:

- Information can be provided to the local neighbours (via NRW) regarding the point and method of contact for the Site in the event an odour has been detected or they want to discuss any activities at the Site.
- The neighbours can be advised that any complaints / concerns will be addressed immediately following identification / notification and contingency action implemented.
- The neighbours can be advised of any corrective action and a follow up call carried out if required.

5.1.3 The primary point of contact at the site for complaints and liaison within the neighbours is the Site Manager who will ensure that the recording, investigation and close out of complaints is undertaken as described above and in accordance with company management procedures. The Odour Complaints Form is included in Appendix 2.

5.2 Dealing with Complaints

5.2.1 The Operator maintains an on-going dialog with local residents and Natural Resources Wales on environmental performance of the site and nuisance issues, such as odour, at the regular public liaison meetings. There is an established odour complaint logging system and the general understanding of the distribution of complaints and the potential factors (e.g. wind direction) which lead to complaints.

5.2.2 In the event of an odour complaint being validated in the investigation, the Operator will take the following decision-making steps:

- If the source of odour is operational, the site manager will assess the mitigation measures and control procedures in place (refer to Appendix 1 Odour Management Plan – Summary Table 2);
- If the source of odour is accidental, the site manager will assess the relevant mitigation measures and control procedures in place (refer to Appendix 1 Odour Management Plan – Summary Table 3);

- If there is a need for further controls, then the site manager or other suitably trained person will consider other relevant measures and implement the control measure(s) which are most suitable;

- If the additional control measures are not adequate, then alternative controls will be considered in consultation with Natural Resources Wales.

5.3 Odour Reporting

5.3.1 The Operator will continue to maintain a routine liaison with NRW regarding odour nuisance. In the event of odour complaint being received by NRW, the complaint is passed to the Operator for the investigation. Every complaint is recorded on designated form including the details of the nature of the complaint, the time of the day and the location of the perceived nuisance (ref to Appendix 2).

5.3.2 A complaints response system is already in place and includes reporting to NRW the findings of the odour investigation. It is proposed to enhance the existing investigation procedure and include the following elements:

- site walk-over coupled with olfactory monitoring along the site boundary (refer to Section 3 Odour Monitoring Plan);

- assessment of the site operations which took place prior to and at the time of the complaint in relation to their odour potential and other on-site sources of odours;

- assessment of the weather conditions prior to and at the time of the complaint.

5.3.3 A suitably trained person who is familiar with the site conditions and the 'sniff-testing' monitoring technique, described in Section 6.3, will carry out odour investigations at the site. In the event of a substantiated complaint being received, then mitigation measures will be used for the areas/activities which were cause of the particular odour event.

5.3.4 A follow up report on the investigation will be issued to NRW and, if requested, to the Local Authority. The report will identify improvements proposed to reduce the potential for future complaints. Any new recommendations will then be incorporated in the Odour Management Plan and the operating procedures.

6 ODOUR MONITORING PLAN

6.1 General

6.1.1 The Operator intends to carry out routine odour monitoring across along the site boundary. The aim of the proposed Odour Monitoring Plan is to (i) assess the effectiveness of odour control measures, (ii) prevent causing odour nuisance off site and (iii) investigate odour complains. The proposed Monitoring Plan includes the following elements:

- routine odour surveys of the site boundary, and
- odour monitoring surveys in response to odour complains.

6.1.2 The summary of the Odour Monitoring Plan is enclosed in Appendix 1 (Table 4).

6.2 Odour Monitoring Regime

6.2.1 The Operator will include weekly perimeter odour surveys into its daily environmental duties at the site. During these routine surveys the presence and location of the suspected sources of odour will be noted, perimeter odour survey will be carried out and any detected (at the boundary) odours and odour plumes will be ascertained. In addition, weather conditions will be noted at the time of monitoring. This information will be logged in the Odour Monitoring Template (refer to Appendix 2 – Key Reporting Parameters form) and used by the site manager in decision-making regarding application of the most suitable control measure(s) or to address any potential odour complaints.

6.2.2 Upon completion of each routine odour survey, all monitoring information will be logged in the site diary and assessed by the site manager for the overall performance of the environmental control measures.

6.3 Monitoring Methodologies

6.3.1 All odour surveys will be carried out using a technique of subjective olfactometry ('sniff-testing'). This technique is recommended by the Environment Agency as a suitable assessment tool for operations which generate fugitive odour, such as landfill sites. Monitoring works will be carried out in reference with the Environment Agency Guidance for the Regulation of Odour at Waste Management Facilities[7] (refer to Appendix 3).

6.3.2 The likely sources of odours will be ascertained via: (i) odour characteristics, and (ii) tracing odour plumes and (iii) FID monitoring if necessary. Suitably trained site personnel will carry out odour surveys to pinpoint the nature of odour and trace odour plume back to a source.

6.3.3 If a source of odour is identified as being landfill gas, leachate or waste related then a monitoring technician will provide a description of the detected odour(s) and assess the intensity of it. Knowledge of different types of odour will be used to allow general source identification, i.e. odour from landfill gas, fresh waste or leachate, or one derived from specific wastes. A published list describing such representative odours will be used to help recognise

odour source(s) and thus identify required control measures as presented in Sections 3 and 4 above.

6.3.4 For reference, waste related odours are distinctive for their garlic, "piggy", rotten cabbage odours. Landfill gas odours are described as being sweet, sulphurous, citrussy, gassy, sickly and pungent. Mature leachate tends to produce mild odours which resemble fuel, oil and farm odours. Young and poorly decomposed leachate smells very sweet, sugary, sulphurous and pungent.

6.3.5 Intensity of odour strength is often assessed on the scale of 1 to 5 (1-low, 5-strong). Within this scale the odour strength of raw organic waste is 3-5, whereas leachate odour strength could vary from 1-2 (mature, well decomposed leachate) to 5 (young, very organic poorly decomposed leachate). The presence of persistent pungent leachate odour would indicate an unsealed leachate well or free-standing young leachate. Odour strength from landfill gas also depends on the properties and age of the gas. Gas from young and rapidly decomposing waste is often strong (odour strength 4-5), whereas older mature gas tends to be less offensive (odour strength 2-5). If detected, landfill gas odour would indicate fugitive emissions from unrestored landfill surfaces or cracks in the cap.

6.3.6 If sources of odour are not readily identified due to possible odour interference, then a monitoring technician would undertake tracing odour plumes. Tracing odour plumes aims to follow the identified odour plume (e.g. wide or narrow plumes and strong or faint plumes) upwind until its source is found. This is particularly useful for identifying point sources of odour, such as leachate wells which tend to generate narrow strong plume of odour. If a source is detected at the site boundary then there is a potential for odour nuisance among downwind receptors. This technique would also be used during odour monitoring in response to odour complaints, and follow an odour plume downwind to note the distance at which a particular source can be smelt.

6.3.7 A portable Flame Ionisation Detector (FID) will be used to ascertain findings of odour surveys (if necessary) and delineate the source(s) of landfill gas odours. The instrument would be used to detect the presence and concentrations of methane in the air, at surface level and at point sources. Methane is an odourless bulk compound of landfill gas and is also a marker compound of landfill gas odours. Presence of methane in elevated concentrations (several hundred ppm) in the ambient air on a landfill is sufficient to result in odour being noticed.

6.3.8 Weather conditions will be noted at a time of an odour survey, and assessed in terms of any odour effects beyond the site boundary. This would indicate which local receptors lie downwind of the site. The following weather conditions are considered to be unfavourable with regard to the effects of the potential odour emissions and should be considered when assessing odour events:

- Weather conditions, especially wind speed and direction, are important factors which influence odour dispersion. Stronger winds (>6m/s) reduce the impact of odours due to greater dilution and dispersion than lighter winds, whereas wind direction determines the direction of odour dispersion.

- The greatest risk of poor odour dispersion tends to occur on cool nights, with low wind speed, during anti-cyclonal conditions and in the presence of a temperature inversion. These conditions often happen during the cold part of the year and result in landfill gas (or other) odours transported over long distances from the source.

- Calm weather spells (wind speed <0.1m/s) results in omni-directional dispersion of odours from the site as it is regulated largely by diffusion in the air. Under such conditions, all locations directly adjacent to the source would be expected to be impacted by fugitive emissions.

- Conversely, high temperatures during the warm part of the year may often lead to increased stale waste (dustbin-like) odours due to acceptance of waste which was stored in warm conditions up to 2 weeks before being delivered on site, and could result in increased complaints from residents living near the site.

6.3.9 Odour perception is an important consideration when investigating odour complaints. There is often no real pattern as to the length of time that the odour would prevail. Sometimes the odour is present for 30 seconds, at other times the odour is present for up several hours.

6.3.10 The potential local receptors to odour include residential properties to the east and north-east of the site, primarily Rhoswen and Pant. These receptors will be addressed during odour surveys along the landfill boundary where 'sniff-testing' monitoring will be carried out along the boundary of the site.

6.4 Complaints Monitoring

6.4.1 Any complaints received directly by the Operator or via the regulatory bodies, including NRW and Local Authority, will be recorded on the Odour Complaints Form (Appendix 2) and will instigate further olfactory monitoring at the location of the complaint and on site to determine the extent and location of the plume and the source of the odour will be identified.

6.4.2 If necessary monitoring will also be carried out at the nearest sensitive receptors to the Facility and the monitoring results recorded.

6.5 Remedial Action Plan

6.5.1 Following receipt of a complaint or identification of an odour at the Facility, the following action plan will be undertaken, including:

- Additional olfactory monitoring as detailed above to identify the extent of the plume and potential cause for the odour i.e. waste material and / or process activity;

- Examination of the operational activities at the Facility at the time of the odour complaint or odour identification;

- Examination of the meteorological conditions at the time of the complaint or odour identification;

- Carry out a review of the operational procedure and process controls as detailed within Section 4 detailed above and instigate any control measures immediately following identification of the problem;

- Further olfactory monitoring will be carried out to ensure the issue has been addressed and to monitor the effectiveness of any control measures undertaken.

6.6 Record Keeping and Reporting

6.6.1 The Odour Complaints Form (Appendix 2) will be completed as per the procedure detailed above. The forms will be maintained free from damage and kept within the Site office and will be made available to NRW on request. The record keeping will form part of the Facilities Management System.

6.7 OMP Review

6.7.1 This OMP will be reviewed on a regular basis or following a number of complaints at the Site.

APPENDIX 1

Odour Management Plan - Summary Tables

APPENDIX 1

Table 1: Odour Management Plan – sources of odour

Description of the activity or process in which odorous materials are generated	Location of the activity or potential release points
Transport and deposit of potentially malodorous waste	Deliveries along Tylwch Road, weighbridge area/site access road, unloading of waste at Material Recycling Facility (MRF) and tipping area in Cell 9D (all fugitive emissions)
Leachate extraction and treatment	Treatment Plant (northern corner of installation), leachate wells
Landfill gas release from landfill	Active tipping faces, all fugitive emissions
Landfill gas release from gas management infrastructure	Gas utilisation plant/flare (northern corner of installation), carrier mains/gas wells (point)
Placement of waste / active waste cells	Fugitive emissions from the active tipping area
Engineering works of landfill gas management system	All Cells
Engineering works on leachate management system	All Cells
Accidental releases as a result of failure (Table 3)	Fugitive emissions
Act of vandalism	Fugitive emissions
Storage and treatment processing of waste	MRF and composting facility
Development of anaerobic conditions within the composting heap	MRF and composting facility

List of Waste types which may be malodorous.			
European Waste Code	**Description (with odour levels were known) * relative strength (1 – low, 5 - strong)**	**High or Medium Risk**	**Justification for selection of Risk level**
19 08	Wastes from waste water treatment	High	High odour strength, close to sensitive receptors
02 02	Wastes from preparation & processing of meat, fish & other food of animal origin (4-5)*	High	High odour strength, close to sensitive receptors
02 05	Wastes from dairy products industry (4-5)*	High	High odour strength, close to sensitive receptors
19 05	Wastes from aerobic treatment of solid wastes	Medium	Moderate odour strength, small volumes of waste, nearby receptors
19 06	Wastes from anaerobic treatment of solid wastes	High	High odour strength, close to sensitive receptors
various	Effluent treatment sludges (2-5)	Medium	Bulk volumes, moderate odour strength, nearby receptors
20 03	Other municipal wastes (3-4)*	High	High odour strength, close to sensitive receptors

APPENDIX 1

Table 2: Odour Management Plan – operational sources of odour

Description of the activity, process and the source of odour on site	Proposed BAT to mitigate odour release	Reference to the proposed BAT
Transport of malodorous waste	- Sheeting of delivery vehicles for all loose waste loads. - Adequate odour sealing of high odour strength wastes during the delivery to the site is to be agreed with waste producers and hauliers. - Inspection of incoming waste for any not-permitted waste or any other malodorous waste; turn away any non-permitted loads. - Prompt clean up of any spillages of waste. - Use of the designated delivery route (via Llanidloes), approved on the technical grounds by Powys CC. Actions will be taken against carriers who do not adequately cover their loads. Warning and if continued refusal to accept waste loads from them.	1. Environmental Permit (BU7766IC); 2. Operational Procedures and Practices
Deposit of waste into cells	- Rapid burial (within one hour) and covering of all malodourous waste and "MBT compost" from the MRF. - Adequate compaction of waste to minimise air ingress. - Adequate compaction of waste around wells and sumps. - Covering of fresh waste at the end of the day with an adequate daily cover. - Covering any non-operational landfill areas and flanks with cohesive material (clay- type). External flanks will be covered with sufficient layer of inert material to construct temporary cover which is free of any protruding waste or holes. - Provision of bulk volumes of clay-type material on site for use as a temporary cover material. - Operating small active landfill face. - Tipping faces and flanks will be constructed to a suitable gradient to ensure that the daily cover can be placed effectively on this gradient. - Use of alternative tipping face during unfavourable weather conditions. - Use of odour neutraliser topically across active landfill. -Progressive and timely capping and restoration of completed landfill cells. Use of the approved capping and restoration materials to provide negligible emission and its installation according to the CQA plan.	1. Environmental Permit (BU7766IC); 2. Operational Procedures and Practices

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Landfill gas release from landfill	- Progressive capping and restoration of the completed cells with the engineered cap (typically within a year), and phased capping of the landfill site. -Use of the approved capping and restoration materials with low gas permeability. -Regular inspection of the areas under the permanent cap or temporary cover for any signs of cracks and fissures. Prompt repairs of any identified faults.	1. Landfill Gas Management Plan, October 2008
Landfill gas release from gas management infrastructure and the gas flare	- Progressive extension of the gas extraction system onto the completed cells. - Operation of a positive gas extraction system on the completed cells coupled with the gas utilisation plant and a backup flare. This system has been designed to take into account the existing and the proposed landfill gas production. - Covering wells, boreholes and monitoring points when not in use to prevent fugitive emissions and implementation of the gas emission monitoring programme. - Adequate compaction and covering of waste around chambers, wells and sumps. - Operation of the plant in accordance with the design specifications, provision of telemetry. - LFG ground flare should be equipped with the fully automatic control system to maintain adequate combustion control. - Regular balancing of gas abstraction rates. - Daily checks of the conditions of the gas infrastructure. - Prompt service and repair of faulty parts.	1. EA Guidance on the flaring of landfill gas, 2002 2. Landfill Gas Management Plan, October 2008 3. Greenfield Services Ltd Report 4. Finnings Power Report
Leachate release from landfill	- Progressive extension of the existing leachate extraction system as the site progresses. - Rapid phased capping of cells to prevent the built-up of leachate. - Inspection of landfill areas for signs of leachate break-out and prompt remediation of any areas of identified standing leachate. - Any residual seepages will be diverted into the extraction system.	1. Leachate Management Plan, October 2008

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Leachate extraction & transport	- Active leachate extraction system minimises perched leachate on site and reduces possible outbreaks. - Inspection of pumps on a daily basis. Regular maintenance of pumps, pipework system, compressor and leachate lagoon to avoid potential down-time problems. -Maintenance of low leachate heads in monitoring points by continuous extraction. - Use of automatic control system to regulate the level of leachate head and switch pumps on/off when necessary. -Sealing all elements of the active extraction system and leachate monitoring points at all times. -Covering any leachate trenches with geo-composite drainage liner. -Treatment of leachate in a lagoon operating a Sequential Batch Reactor (biological and aerobic treatments). Odours from the treated leachate have not caused problems to date. -the leachate treatment plant has been supplemented with a heat exchanger and a centrifugal clarifier. -Discharge of the treated leachate to foul sewer.	1. Leachate Management Plan, October 2008
Engineering works of landfill gas and leachate infrastructure	- Pre-planning and management of any engineering works which could cause odour release. Limiting the duration of such works to the minimum and undertaking works in small sections to reduce the exposure - Limiting any such works during adverse weather conditions (southern winds, calm weather).	1. Landfill Gas Management Plan, October 2008 2. Leachate Management Plan, October 2008
Storage and treatment processing of waste at MRF and composting facility	- Rejection of odourous materials at pre-acceptance stage screening - Aeration of composting piles to minimise the risk of creating anaerobic conditions and therefore odour - Odour neutralising/masking agent spray system surrounds the site to mitigate the risk that an odour may impact a receptor - Covering of the MSW compost windrows with Goretex cover to minimise the release of fugitive emissions from composting processes	1. Bryn Posteg Materials Recycling and Treatment Facility. Application for PPC Permit. Operational Techniques Report, June 2006. 2. Composting Management Plan, October 2008.
Storage and treatment processing of green waste at composting facility	- Rejection of odourous materials at pre-acceptance stage screening - Aeration of composting piles to minimise the risk of creating anaerobic conditions and therefore odour - Odour neutralising/masking agent spray system surrounds the site to mitigate the risk that an odour may impact a receptor	1. Composting Management Plan, October 2008. 2. An industry guide for the prevention and control of odours at biowaste processing facilities, 2007.

APPENDIX 1

Table 3: Odour Action Plan (accidental releases of odour)

Description of the activity, process and the source of odour on site	Potential failures with odour consequences	Potential outcome of odour episode	Mitigation measures	Reference to the proposed measures
Transport and deposit of malodorous waste	2. generally more odorous deliveries during the warm weather. 3. no tarpaulin used on waste wagons and skips. 4. delivery of non-permitted malodorous waste. 5. human error in failing to recognise unacceptable waste.	Likely odour nuisance for local residents, esp. at Valley view along the delivery route (there is no history of complaints) and Pant Rhoswen and Penbryn-du. Occurrence: infrequently	- Daily instructions by the site manager to the weighbridge staff regarding the incoming waste. The existing logistics system on site allows knowledge of accepted waste types to come on site to avoid unacceptable loads. - Training the site staff on understanding and recognising different waste types. - "sniff test" odour monitoring along the site perimeter to verify the effectiveness of the mitigation measures.	Operational Management Procedures

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Description of the activity, process and the source of odour on site	Potential failures with odour consequences	Potential outcome of odour episode	Mitigation measures	Reference to the proposed measures
Waste cells / landfill	1. inadequate cover or failure of a cap due to adverse weather or incorrect application. 2. erosion/slipping of temporary cover any failures which result in need of excavation of waste or cap replacement. 3. adverse weather conditions (e.g. wind direction towards the nearby receptors, temperature inversion, no wind) which would either create a preferential pathway for odours or result in an omni-directional dispersion of odour.	As a result of any landfill structural failures, local residents, esp. Valley View, Pant, Rhoswen and Penbryn-du may experience odour annoyance. The extent and occurrence of such potential failures are often difficult to predict. Occurrence: infrequently.	- Pre-planning waste inputs in terms of space availability and cover material supply. - Routine check-ups for any cracks in the cap by the site manager. - Areas of temporary cover will be remediated to the required standards within 1 week if cover has been eroded. - Notification to the EA of any cap failures to agree on the scope and duration of remediation works. - Remediation of the detected cracks on the cap under the supervision of the CQA engineer and as agreed with NRW. - Application of odour neutralising agent on the affected area and/or peripherally. - MET-FAX or similar weather forecasts will be used to pre-plan operations during the predicted adverse weather conditions in terms of odour nuisance potential. - “sniff test” odour monitoring along the site perimeter to verify the effectiveness of the mitigation measures.	Operational Management Procedures

APPENDIX 1

Description of the activity, process and the source of odour on site	Potential failures with odour consequences	Potential outcome of odour episode	Mitigation measures	Reference to the proposed measures
Landfill gas release from LFG infrastructure and the gas plant	1. failed power supply resulting in gas fugitive emissions. 2. un-planned shut-down of the flare for repairs (e.g. gas pump failure, condensation extraction pumps). 3. under-abstraction of LFG, resulting in the build-up of gas within the landfill and emission through preferential pathways. 4. below optimum combustion temperature resulting in higher VOCs emissions. 5. cracks/gaps in the gas infrastructure. 6. blockages in pipework by condensate.	Any gas under-abstraction or shutdown of the gas flare may create the major emissions of raw landfill gas through point sources such as leachate monitoring points, wells and other preferred pathways. Complaints are likely. Occurrence: infrequently.	- Any failure of flare will be dealt with by the Operator through the provisions listed in Gas Action Plan (Section 5.0 Landfill Gas Management Plan). - Emergency repairs will be undertaken immediately by site staff, backed up by complete repairs undertaken promptly by qualified engineers and local electrician. Critical spares will be held on-site. - The engine or flare servicing contactors will be called in if necessary and NRW will be notified of any major failures which cannot be promptly rectified. - If the engine is not operational within 48 hours, then alternative/replacement equipment will be provided by the plant suppliers. The existing backup flare has sufficient capacity to deal with all of the gas abstracted from the site. - If power fails for over 24 hours then an alternative power supply will be brought into action. - Pumping out any detected blockages from the condensate sumps (detected by a pressure drop) within 24 hours. - Sealing the detected cracks with foam. - Local residents will be notified of any major repair work to remediate odour nuisance. - Application of odour neutralising agent on the affected area and/or peripherally. - “sniff test” odour monitoring along the site perimeter to verify the effectiveness of the mitigation measures.	1. Landfill Gas Management Plan, October 2008. 2. Operational Management Procedures

APPENDIX 1

Description of the activity, process and the source of odour on site	Potential failures with odour consequences	Potential outcome of odour episode	Mitigation measures	Reference to the proposed measures
Leachate release from landfill	1. leaks and/or spillages of leachate resulting in areas of free-standing leachate. 2. inadequate integrity of the capping layer resulting in build-up of young odorous leachate.	Complaints possible depending on the scale of the potential spill Occurrence: very infrequently	- Daily inspection of the site for the presence of any areas of free-standing leachate. - Prompt pumping out of such potential areas to nearest leachate sump. - Regular check-ups by site staff for any gaps/cracks in the capping layer. - Remediation of the detected cracks under the supervision of the CQA engineer and to specifications agreed with NRW. - Application of odour neutralising agent on the affected area and/or peripherally. - “sniff test” odour monitoring along the site perimeter to verify the effectiveness of the mitigation measures.	1. Leachate Management Plan, October 2008. 2. Operational Management Procedures

APPENDIX 1

Description of the activity, process and the source of odour on site	Potential failures with odour consequences	Potential outcome of odour episode	Mitigation measures	Reference to the proposed measures
Leachate extraction infrastructure & treatment plant	1. accidental or structural damage to leachate collection wells. 2. failed power supply (greater than 12 hours at a time) resulting in build-up of leachate head. 3. inadequate capacity of leachate pumps and/or aeration system. 4. failure of leachate collection system, incl. pumps, pipe-work etc. 5. Failure of odour containment infrastructure components for the treatment plant which might fail and release odours (i.e. sump cover, pipework).	Any potential failure could result in complaints among local residents esp. residents of Pant and Rhoswen due to their close proximity to the leachate treatment plant. Occurrence: very infrequently	- In the event of leachate outbreak to pump it out to the holding tanks. Covering leachate trenches with geo-composite drainage liner. - Inspection of pumps on a daily basis. - In event of a pump break down then replacement pumps to be used to insure the continuity of pumping On-site supply of spare pipework, repair kit and pumps. - Reporting any failures to the site manager and the EA to agree on the scope of remediation works and the response time. - Use of the on-site diesel pump in case of the power failure to continue pumping leachate - Check the efficiency of the used measures by the site manager. - Tankering leachate off site if the correction measures are not sufficient. - Application of odour neutralising agent on the affected area and/or peripherally. - “sniff test” odour monitoring along the site perimeter to verify the effectiveness of the mitigation measures.	1. Leachate Management Plan, October 2008.

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Description of the activity, process and the source of odour on site	Potential failures with odour consequences	Potential outcome of odour episode	Mitigation measures	Reference to the proposed measures
Engineering works of landfill gas and leachate infrastructure	1. accidental damage to the cap or pipework	Possible short-term release of odour depending on the nature of works.	Initiate immediate repair work by the site personnel or a specialist contractor depending on the nature of damage. Ensure all valves are closed while carrying out repair works. Application of odour neutralising agent on the affected area and/or peripherally. "sniff test" odour monitoring along the site perimeter to verify the effectiveness of the mitigation measures.	Operational Management Procedures
Act of vandalism	1. arson attack on waste, plastic liner, cap, pipework or the gas plant. 2. other deliberate physical damage to the infrastructure of the site.	Possible release of odour, the actual scale is not possible to predict. A major fire would trigger all emergency services, site emergency plan into action Occurrence: has not happened in the past	- Prompt notification to the EA of any act of vandalism and the environmental consequences (no record of such incidents to date). - Electrical damage to the gas plant will be rectified by the local electrician and any major damage will be dealt with by plant supplier (Finnings 24-hr telephone line 0800 028 7778) - Agree with the EA the scope and duration of the remediation works. - "sniff test" odour monitoring along the site perimeter to verify the effectiveness of the mitigation measures.	1. Operational Management Procedures 2. Site Emergency Plan

APPENDIX 1

Table 3: Odour Monitoring Plan

Nature of Monitoring	Frequency	Personnel	Description	Quality Assurance Procedures	Results compared against
Waste characterisation, for odour potential	Each load	Weighbridge operator	Assessment of DOC documents for the properties of waste loads and the potential for odour (refer to Table 1 – Sources of Odour).	In-house and external training provided for the recognition of waste material.	Comparative assessment used to notify of the site manager of highly odorous materials.
Odour Walk-over Survey	Daily	Trained on-site personnel	1. Subjective olfactory (sniff -testing); 2. FID monitoring (if necessary).	1. Monitoring is to be carried out in accordance with Odour Monitoring Plan (based on the H4 Odour Management).	In principal as Odour Description, Intensity and Extent. Olfactory monitoring results will be assessed in accordance with the Protocol for subjective testing (H4 Odour Management, Appendix 1, Forms).
Perimeter Odour Survey	Weekly	Trained on-site personnel	1. Subjective olfactory (sniff -testing); 2. FID monitoring (if necessary).	1. Monitoring is to be carried out in accordance with Odour Monitoring Plan (based on the H4 Odour Management).	In principal as Odour Description, Intensity and Extent. Olfactory monitoring results will be assessed in accordance with the Protocol for subjective testing (H4 Odour Management, Appendix 1, Forms).
Investigation of a Complaint	As received on site	Trained on-site personnel	1. Subjective olfactory (sniff -testing); 2. FID monitoring (if necessary).	1. Monitoring is to be carried out in accordance with Odour Monitoring Plan (based on the H4 Odour Management).	Olfactory monitoring results will be assessed in accordance with the Protocol for compliant investigation (H4 Odour Management, Appendix 1, Forms).
Detection of cracks in capping layer or other areas of localised potential odour release	As soon as possible after detecting the fault	Trained on-site personnel	1. Subjective olfactory (sniff -testing); 2. FID monitoring (if necessary)	1. Monitoring is to be carried out in accordance with Odour Monitoring Plan (based on the H4 Odour Management).	In principal as Odour Description, Intensity and Extent. Olfactory monitoring results will be assessed in accordance with the Protocol for subjective testing (H4 Odour Management, Appendix 1, Forms).

APPENDIX 2

Odour Forms

ODOUR COMPLAINT FORM

COMPLAINANT DETAILS

Complaint Received By:		**Date :**		**Time :**	
Name :		**Address :**			
Phone :		**Email**		**Feedback Y/N :**	

COMPLAINT DETAILS / DESCRIPTION

Odour type		**i.e., waste, sewage, burning, chemical, fuel, other**	
Odour location		**Time**	
Duration		**Extent**	
Other details			

SITE ACTIVITY / OPERATIONS DETAILS

Area of Site		**Odorous wastes received?**		**Removed ASAP?**	
Any odorous activities? :					
Odour control measures? :					

ON SITE + OFF SITE ODOUR INSPECTION

	Odour Strength	Description		Odour Strength	Description
Site Entrance			Receptor 4		
Site Boundary			Receptor 5		
Receptor 1			Receptor 6		
Receptor 2			Receptor 7		
Receptor 3			Receptor 8		

Odour detected elsewhere? :			
Offsite odorous activies? :			
Where?		Where detectable?	
On-site odour inspection :			
Downwind boundary of site :		Any odour detected? :	

ACTIONS TAKEN / ARISING

Most likely cause of odour :			
Actions taken on site :			
Future actions to be taken :		By	
Best measures to prevent future re-occurrence:			

Intensity		**Receptor sensitivity**
0 No odour	4 Strong odour	Low (e.g. footpath, road)
1 Very faint odour	5 Very strong odour	Medium (e.g. industrial or commercial workplaces)
2 Faint odour	6 Extremely strong odour	High (e.g. housing, pub/hotel etc)
3 Distinct odour	Ref: German Standard VDI 3882, Part 14	

APPENDIX 3

Reference Information

APPENDIX B - PROCEDURE FOR CARRYING OUT AN ASSESSMENT OF ODOUR AT WASTE MANAGEMENT FACILITIES

PROCEDURE FOR CARRYING OUT AN ASSESSMENT OF ODOUR FROM WASTE MANAGEMENT FACILITIES BY AGENCY OFFICERS

B1 OBJECTIVE

B1.1 To provide a clearly written procedure for a consistent, albeit subjective, assessment of odours around licensed waste management facilities.

B1.2 It is intended that this guidance lays down a framework of principles which can be applied consistently. It is realised that there will be a need for local adaptation of monitoring procedures according to conditions at the site in question, its location and local surroundings, the nature of any complaints, and reporting procedures according to management arrangements and resource availability.

B2 PROCEDURES

B2.1 General

B2.1.1 To carry out the assessment, the inspector uses his own sense of smell to try and detect odours, which may arise from the site being assessed. Each inspector likely to be involved in carrying out odour assessments should initially accompany a more experienced inspector on an assessment to ensure that the nature and offensiveness of any odours detected are being perceived similarly. In addition, two or more officers should occasionally carry out assessments together to ensure that assessments continue to be carried out to the same perceptions. If an inspector has a cold, sore throat, sinus trouble etc. they should not carry out the assessment.

B2.1.2 Assessments should be carried out both routinely and in response to specific complaints. In addition assessment should be carried out which are targeted to weather conditions likely to lead to adverse odour at identified receptors. To this end, each inspector involved in carrying out odour assessments must have regard to the weather forecasts for the area, including wind strength and direction, barometric pressure, rainfall, temperature and humidity.

B2.1.3 Specific attention to the following points of detail should be noted:-

- The inspector should not smoke or consume strongly flavoured food or drink, including coffee, for at least half an hour before the assessment is carried out.
- The consumption of confectionery or soft drinks should be avoided immediately before and during the assessment.
- Scented toiletries, such as perfume/aftershave should not be applied immediately before or during an assessment.
- The vehicle used during the assessment should not contain any deodorisers.

B2.1.4 Any complaint or contact regarding odour should be recorded in the appropriate manner, be it incident form, contact form, log book or diary and responded to in accordance with the targets set in the Agency's Customer Charter. Section 5.7 indicates what, ideally, should be recorded when a complaint is received. The licence holder should be informed when a complaint has been received and should be aware, on a general basis, that an odour assessment is likely to be undertaken by an inspector on the day of receipt of the complaint, if practicable.

B2.1.5 Where complaints are received on a regular basis, an odour assessment should be carried out on each site visit and statistics of complaints received and odour assessments carried out should be kept and maintained by those involved.

B2.2 At the Assessment Location

B2.2.1 The assessment involves the inspector walking, as far as access allows, from a point, at a distance from the site, towards the site boundary (or onto the site itself) and then continuing on away from the site again. Where the assessment is being carried out routinely, the starting point should be down wind of the site, progressing towards the site boundary and then away from the site in an up wind direction. Where the assessment is being carried out in response to a specific complaint, the starting point will be the location from which the complaint was made. When arriving to carry out an assessment, the inspector **should not go straight to the site**, but rather to the intended starting point.

B2.2.2 In carrying out the assessment, the inspector should walk slowly and breathe normally. If odour cannot be detected in this way, the inspector should periodically stand still and inhale deeply. (Note: If odour but can only be detected by inhaling deeply, the intensity should be noted as 2 (faint). If odour is detected while walking, the intensity should be recorded as at least 3 – see B3.3.1)

B2.2.3 At appropriate intervals, the intensity, extent, i.e. persistence, and a description of the odour, together with the location from site boundary, should be recorded. In addition the sensitivity of the location where the assessment is being made, with regard to receptors, should be noted (see B3.3), as well as any external activities such as agricultural practices that could be the source of the odour. The possibility that an odour may change with distance due to dilution effects should be taken into consideration.

B2.2.4 Periodically, the odour assessment around sites considered to be sensitive should include fixed location assessments. The inspectors responsible for the site should determine a number of receptor-sensitive locations. These locations will be determined from analysis of existing data and of complaints received.

B2.2.5 A fixed location assessment should incorporate measurements reported over a standard time period, say 5 minutes per location. The intensity and extent can then be evaluated over a time period. Either, the intensity and duration of odour should be measured each time odour is perceived, or measurements should be made at fixed time intervals, over a 5 minute period every 30 seconds would be the minimum requirement. For the latter method, a standard yes/no response would be required as well as indication of intensity, but extent measurements would not be necessary.

B2.2.6 On eventual arrival at the site the atmospheric conditions prevalent at the time, **See Appendix C,** should be evaluated if possible and recorded against site-specific factors, such as the location and nature of site activities and location of sensitive receptors. A compass and hand-held anemometer would be useful but is not essential

B2.2.7 The appropriate part of the site boundary relative to wind direction or complaints should first be walked to detect any odour. Once again the inspector should walk slowly and breath normally. When odour cannot be detected in this way, the inspector should again periodically stand still and inhale deeply facing upwind. In this respect, a common sense approach should be taken

and the inspector should not inhale deeply over any boreholes. Particular care should be taken if any sulphidic (rotten eggs) odours are perceived.

B2.2.8 In order to determine the extent of the odour "plume" in sensitive areas, it may become necessary to carry out assessments away from the site at points perpendicular to the plume axis and equidistant from the source. The results should be plotted onto an appropriate plan. In some circumstances it may be difficult to conduct such a survey because of the lack of access to land in the vicinity of the site.

B2.2.9 Following an odour assessment a site inspection should be carried out seeking to trace any observed odour back to source and to evaluate any potential odour-producing activities or locations. **Appendices A and C** may prove useful in the respect.

B2.3 How to report the results

B2.3.1 All observations should be noted on the odour assessment report, following the classification system for odour parameters. Observations should be reported to a member of the site's technically competent management following the inspection. A report form is suggested in Section B3 of this appendix. However, this paper does not seek to impose yet another form on Agency officers if there exists already adequate alternative means of recording necessary information.

B2.3.2 The odour inspection report should be passed to the appropriate senior inspector for signing and recording what further action is required, e.g. letter to licence holder requiring odour control or enforcement of licence condition requiring no odours beyond site boundary. The result of the odour assessment, and any action required, should be confirmed on the completed assessment report and the impact of odour arising from the site should be discussed with the licence holder at regular liaison meetings.

B2.3.3 Consideration should be given to carrying out periodic VOC surveys with the licence holder at sites where particular problems have been identified. The inspector should discuss this with his Line Manager before approaching the licence holder. Sampling for analysis of odorous trace gases should not be carried out routinely but may be considered if a significant odour problem is being disputed by the licence holder or proving difficult to resolve.

B2.3.4 A spreadsheet file can be set up for storing odour assessments for identified sites and responsibility for inputting collected data should lie with the primary inspector.

B2.3.5 Data should be input at least monthly, and sorted by date and location. Each inspector should be trained in the use of all applicable input and output functions.

B2.3.6 A bar chart for intensity, extent and sensitivity can be set up for one location at each site. The chart should be revised monthly, by altering the range, and output for appropriate locations printed as required. Other graphical methods, including time-series XY plots, should be used as required, for example, for discussion at liaison meetings or to evaluate changes in operational practices.

B2.3.7 A rose diagram can set up to display wind direction for each site. This should be updated daily and output printed on a monthly or quarterly basis, depending on the number of assessments carried out.

B2.3.8 Output for each site should be assessed at a frequency dependent on conditions encountered and complaints received, but at no less than once per quarter.

B2.3.9 Odour assessments should be carried out at a frequency determined by the potential for odour to cause a problem and number of complaints received, and this frequency should be reviewed by the line manager, in consultation with Licensing Officer and the responsible Area Functional Manager on a regular basis.

B2.4 Training and calibration

B2.4.1 All inspectors responsible for assessing odour should be trained in the use of this procedure.

B2.4.2 For each sensitive and high risk site, and at a frequency no less than twice a year, two inspectors should carry out an odour assessment independently but simultaneously. The completed assessment reports should then be sent to the responsible officer, to evaluate for consistency. Such exercises can be used to confirm how representative the odour assessments are.

B2.4.3 Consideration may also need to be given to evaluating the sensitivity of each inspector's sense of smell using olfactometry methods.

B3 ODOUR ASSESSMENT REPORT

B3.1 Report Pro-forma

B3.1.1 A suggested pro-forma for reporting the results of the Odour Assessment is shown on the following pages.

B3.2 Notes on Completing Proforma

B3.2.1 To complete the entry on 'General Air Stability' reference should be made to appendix C.

B3.2.2 The entry for 'General Air Quality' should include whether or not the air quality is good, average or poor as this may influence odour perception on the day.

B3.2.3 The entry for 'Ground Conditions' should record whether the ground is wet as a result of recent rainfall as this may influence odour dispersion.

B3.2.4 'External Sources of Odour' refers to activities, not associated with the waste management facility being assessed, that could be a source of odour.

B3.2.5 For entries on 'Odour Intensity', 'Odour Extent' and 'Location Sensitivity', the classification system presented in B3.3 below should be used.

B3.3 Classification System for odour Parameters

B3.3.1 **Intensity**

1 No detectable odour
2 Faint odour (barely detectable, need to stand still and inhale facing into the wind)
3 Moderate odour (odour easily detected while walking and breathing normally, possibly offensive)
4 Strong odour (bearable, but offensive odour - will my clothes/hair smell?)
5 Very strong odour (this is when you really wish you were somewhere else)

B3.3.2 **Extent (assuming odour detectable, if not then 0)**

1 Local and impersistent (only detected during brief periods when wind drops or blows)
2 Impersistent as above, but detected away from site boundary
3 Persistent, but fairly localised
4 Persistent and pervasive up to 50 m from site boundary
5 Persistent and widespread (odour detected >50 m from site boundary)

B3.3.3 **Sensitivity of Location where Odour Detected (assuming detectable, if not then 0)**

1 Remote (no housing, commercial/industrial premises or public area within 500 m)
2 Low sensitivity (no housing, etc. within 100 m of area affected by odour)
3 Moderate sensitivity (housing, etc. within 100 m of area affected by odour)
4 High sensitivity (housing, etc. within area affected by odour)
5 Extra sensitive (complaints arising from residents within area affected by odour)

ODOUR ASSESSMENT REPORT **FILE NO.**

Site		Assessment Date	
Assessment Start Time		Assessment Finish Time	

Complaint Received	Yes/No	Date	
Location of Complaint Area		Grid Reference (where location is not a property)	

Weather		Wind (strength and direction)	
Temperature (deg. C)		Bar Pressure (mbar) (rising/falling)	
% Cloud Cover		General Air Stability (see appendix C)	
General Air Quality		Ground Condition	

Enter results of assessment overleaf

Plan attached showing location and extent of odour Yes/No

Additional comments

Action required

Reported to on site :

Signature :

ODOUR ASSESSMENT REPORT contd.

Location	Odour Intensity	Odour Extent	Location Sensitivity	Odour Description	External sources of odour	Waste sources of odour

Odour Intensity

1 -No detectable odour
2 -Faint odour (barely detectable, need to stand still and inhale facing into the wind)
3 -Moderate odour (odour easily detected while walking and breathing normally, possibly offensive)
4 -Strong odour (bearable, but offensive odour - will my clothes/hair smell?)
5 -Very strong odour (this is when you really wish you were somewhere else)

Odour Extent (assuming odour detectable, if not then 0)

1 -Local and impersistent (only detected during brief periods when wind drops or blows)
2 -Impersistent as above, but detected away from site boundary
3 -Persistent, but fairly localised
4 -Persistent and pervasive up to 50 m from site boundary
5 -Persistent and widespread (odour detected >50 m from site boundary)

Location Sensitivity (assuming detectable, if not then 0)

1 -Remote (no housing, commercial/industrial premises or public area within 500 m)
2 -Low sensitivity (no housing, etc. within 100 m of area affected by odour)
3 -Moderate sensitivity (housing, etc. within 100 m of area affected by odour)
4 -High sensitivity (housing, etc. within area affected by odour)
5 -Extra sensitive (complaints arising from residents within area affected by odour)

APPENDIX C - METEOROLOGICAL DATA

METEOROLOGICAL DATA

C1 GENERAL

C1.1 This appendix is included as general guidance since it is useful, and usually necessary, to take account of meteorological conditions in determining causes and patterns of odour problems, where they exist. The transport of pollutants from the source to receptor are affected by meteorological variables, or state of the atmosphere in terms of; wind speed and direction; insolation (amount of sunlight); lapse rate (temperature variation with height); mixing depth, and precipitation. The non-meteorological factors such as type and quantity of odorous substances, topography and individual susceptibility must also be considered. It is not intended that full meteorological monitoring should take place at every site.

C2 ATMOSPHERIC STABILITY

C2.1 When considering the dispersion of air pollution or odour plumes, it is convenient to classify the possible states of the atmosphere into stability categories originally defined by Pasquill[10]. An assessment of the stability category should be made when odour monitoring as this describes the potential for dispersion of odours from a source.

C2.2 Table C2.1 illustrates typical features of each category and the extent of dilution that may be expected under different atmospheric conditions.

C2.3 Stability Categories range from A, the most unstable, though to G, the most stable.

- Category A corresponds to the most unstable atmospheric conditions and results in the greatest amount of plume spreading. Surface heating effects caused by direct sunlight act as an extra source of turbulence over and above that caused by the wind.

- Category D, a “neutral” category is one where the turbulence is generated entirely by the wind and the degree of mixing will be less than Category A.

- Category F/G are stable categories which result in the least spreading of a plume as the mechanical (wind induced) turbulence is suppressed in these conditions.

[10] F Pasquill and F B Smith, “Atmospheric Diffusion”, Chichester, Ellis Horwood, 1983

Table C2.1 Atmospheric Stability Categories

Category	Stability	Dispersion*	Occurrence (% time in year)	Wind speed km/h	Time of day	Sunshine or cloud cover
A	Very Unstable	Very good	<1	< 5	Day time only	Strong sunshine Most common in summer
B	Unstable	Good	5 to 10	7 to 18	Day time only	Slight to moderate sunshine
C	Slightly Unstable	Moderate	20	>7	Mainly day time	Moderate sunshine
D	Neutral	Moderate	45 to 60	7 to 29	Day or night	Slight sunshine or overcast
E	Stable	Poor	5-10	7 to 18	Night time only	Clear or overcast
F/G	Very Stable	Very poor	10	<11	Night time only	Clear (inversion)

* These are generalisations – e.g. Category A, while on average it may result in good dispersion, fluctuations in plume rise may result in localised short-term plugs of odour in the vicinity of the site.

C2.4 The term stability refers to the tendency of the atmosphere to resist or enhance vertical motion and therefore turbulence. Stability is related to both the change of temperature with height, which is often dependent on wind speed and the amount of sunlight and will therefore differ between daytime and nighttime. The turbulence of the atmosphere is important determining the amount of dilution of odours. As a general rule, the more unstable the atmosphere, the greater the dilution and the lower the odour impact of the site. Odour problems are more likely to occur when wind speeds are low and skies are overcast, and at night when stable conditions are more common.

Table C3 The Beaufort Wind Scale

Force	Description	Observation	km/hour
0	Calm	Smoke rises vertically	< 1
1	Light air	Direction of wind shown by smoke drift, but not wind vanes	1 - 5
2	Light breeze	Wind felt on face; leaves rustle, ordinary vane moved by wind	6 - 11
3	Gentle breeze	Leaves and small twigs in constant motion	12 - 19
4	Moderate breeze	Raises dust and loose paper; small branches are moved	20 - 29
5	Fresh breeze	Small trees in leaf begin to sway, small branches are moved	30 - 39
6	Strong breeze	Large branches in motion; umbrellas used with difficulty	40 - 50
7	Near gale	Whole trees in motion; inconvenience felt when walking against wind	51 - 61
8	Gale	Twigs break off trees; progress generally impeded	62 - 74
9	Strong gale	Slight structural damage occurs (chimney pots and slates removed)	75 - 87
10	Storm	Trees uprooted; considerable structural damage occurs	88 - 101

C3.1 The above table provides a rough approximation of wind speed in the absence of an anemometer. A rough idea of wind direction can be obtained by observation, e.g. of smoke plumes if appropriate, and reference to OS maps.

APPENDIX D - ODOUR DESCRIPTORS

ODOUR DESCRIPTORS

D1.1 The following information is included principally for background interest but also as an aid to officers in their own assessment of odours, particularly in establishing the source of odours other than those from waste management facilities.

D1.2 As indicated in section 5.7, it is useful, when recording information from a complainant, to seek their description of an odour that is offending them. Tables D1 and D2 are derived from American research work[11] on odour descriptors which also concludes, as suggested at 2.1.3 in the main body of this document, that both pleasant and unpleasant odours may become offensive.

D1.3 Table D1 lists odour descriptors generally found as pleasant in decreasing order of pleasantness based on "Hedonic scores" allocated by 150 participants in the American research. Similarly, Table D2 lists unpleasant odours in increasing odour of unpleasantness.

D1.4 Table D3 presents the same odour descriptors in alphabetical order so that their pleasant or unpleasant rating is not indicated and would not therefore influence the use of a particular descriptor.

D1.5 Figure D1 presents an "Odour Wheel" which attempts to link recognised waste derived odours with possible sources on waste management facilities.

[11] Dravnieks A, Masurat T, Lamm R A, "Hedonics of Odours and Odour Descriptors":, in *Journal of the Air Pollution Control Association*, July 1984, Vol. 34 No. 7, pp 752-755

Table D1 "Pleasant" Odour Descriptors and "Hedonic" Score

Description	Hedonic Score	Description	Hedonic Score	Description	Hedonic Score
Bakery (fresh bread)	3.53	Spicy	1.99	Eucalyptus	0.99
Rose	3.08	Peanut butter	1.99	Laurel leaves	0.97
Strawberry	2.93	Perfumery	1.96	Soapy	0.96
Orange	2.86	Grapefruit	1.95	Woody, resinous	0.94
Floral	2.79	Coconut	1.93	Light	0.91
Chocolate	2.78	Nutty	1.92	Dill	0.87
Fruity, citrus	2.72	Clove	1.67	Warm	0.78
Violets	2.68	Cooked vegetables	1.58	Grainy (as grain)	0.63
Peach	2.67	Raisins	1.56	Geranium leaves	0.57
Apple	2.61	Cool, cooling	1.53	Beany	0.54
Pineapple	2.59	Aromatic	1.41	Mushroom	0.52
Vanilla	2.57	Tea leaves	1.40	Eggy (fresh eggs)	0.45
Cherry	2.55	Green pepper	1.39	Raw potato	0.26
Cinnamon	2.54	Celery	1.36	Musky	0.21
Fried chicken	2.53	Crushed grass	1.34	Black pepper	0.19
Fragrant	2.52	Hay	1.31	Cork	0.19
Lemon	2.50	Raw cucumber	1.30		
Minty, peppermint	2.50	Leather	1.30		
Popcorn	2.47	Seasoning (for meat)	1.27		
Melon	2.41	Oak wood, cognac	1.23		
Meaty (cooked, good)	2.34	Anise (liquorice)	1.21		
Coffee	2.33	Bark, birch bark	1.18		
Caramel	2.32	Soupy	1.13		
Pear	2.26	Caraway	1.06		
Maple syrup	2.26	Malty	1.05		
Lavender	2.25	Incense	1.01		
Fruity, other than citrus	2.23	Molasses	1.00		
Fresh green vegetables	2.19				
Cologne	2.16				
Herbal, green, cut grass	2.14				
Cedarwood	2.11				
Honey	2.08				
Grape juice	2.07				
Buttery, fresh butter	2.04				
Sweet	2.03				
Almond	2.01				
Banana	2.00				

Note: The higher the positive "score", the more pleasant the odour descriptor and similarly below, the greater the negative figure, the more unpleasant the odour descriptor.

Table D2 "Unpleasant" Odour Descriptors and "Hedonic" Score

Description	Hedonic Score	Description	Hedonic Score	Description	Hedonic Score
Dry, powdery	-0.07	Seminal, sperm-like	-1.04	Stale	-2.04
Yeasty	-0.07	Animal	-1.13	Burnt milk	-2.19
Burnt candle	-0.08	Gasoline, solvent	-1.16	Mouse-like	-2.20
Beery	-0.14	Mothballs	-1.25	Wet wool, wet dog	-2.28
Rope	-0.16	Sour, vinegar	-1.26	Household gas	-2.30
Garlic, onion	-0.17	Creosote	-1.35	Sharp, pungent, acid	-2.34
Crushed weeds	-0.21	Bitter	-1.38	Sulfidic	-2.45
Alcoholic	-0.47	Oily, fatty	-1.41	Ammonia	-2.47
Cardboard	-0.54	Burnt paper	-1.47	Sweaty	-2.53
Camphor	-0.55	Burn, smoky	-1.53	Dirty linen	-2.55
Sauerkraut	-0.60	Etherish, anaesthetic	-1.54	Fermented (rotten) fruit	-2.76
Fresh tobacco smoke	-0.66	Disinfectant, carbolic	-1.60	Stale tobacco smoke	-2.83
Kippery-smoked fish	-0.69	Tar	-1.63	Sour milk	-2.91
Turpentine (pine oil)	-0.73	Chemical	-1.64	Burnt rubber	-3.01
Paint	-0.75	Blood, raw meat	-1.64	Rancid	-3.15
Heavy	-0.79	Kerosene	-1.67	Urine	-3.34
Nail polish remover	-0.81	Cleaning fluid	-1.69	Sickening	-3.34
Varnish	-0.85	Sooty	-1.69	Faecal (like manure)	-3.36
Chalky	-0.85	Musty, earthy, mouldy	-1.94	Cat urine	-3.64
Medicinal	-0.89	Fishy	-1.98	Sewer odour	-3.68
Wet paper	-0.94			Putrid, foul, decayed	-3.74
Metallic	-0.94			Cadaverous (dead animal)	-3.75
New rubber	-0.96				

Table D3 Odour Descriptors without "Hedonic" Score

Alcoholic	Eggy (fresh eggs)	Oak wood, cognac
Almond	Etherish, anaesthetic	Oily, fatty
Ammonia	Eucalyptus	Orange
Animal	Faecal (like manure)	Paint
Anise (liquorice)	Fermented (rotten) fruit	Peach
Apple	Fishy	Peanut butter
Aromatic	Floral	Pear
Bakery (fresh bread)	Fragrant	Perfumery
Banana	Fresh green vegetables	Pineapple
Bark, birch bark	Fresh tobacco smoke	Popcorn
Beany	Fried chicken	Putrid, foul, decayed
Beery	Fruity, citrus	Raisins
Bitter	Fruity, other than citrus	Rancid
Black pepper	Garlic, onion	Raw cucumber
Blood, raw meat	Gasoline, solvent	Raw potato
Burn, smoky	Geranium leaves	Rope
Burnt candle	Grainy (as grain)	Rose
Burnt milk	Grape juice	Sauerkraut
Burnt paper	Grapefruit	Seasoning (for meat)
Burnt rubber	Green pepper	Seminal, sperm-like
Buttery, fresh butter	Hay	Sewer odour
Cadaverous (dead animal)	Heavy	Sharp, pungent, acid
Camphor	Herbal, green, cut grass	Sickening
Caramel	Honey	Soapy
Caraway	Household gas	Sooty
Cardboard	Incense	Soupy
Cat urine	Kerosene	Sour milk
Cedarwood	Kippery (smoked fish)	Sour, vinegar
Celery	Laurel leaves	Spicy
Chalky	Lavender	Stale
Chemical	Leather	Stale tobacco smoke
Cherry	Lemon	Strawberry
Chocolate	Light	Sulfidic
Cinnamon	Malty	Sweaty
Cleaning fluid	Maple syrup	Sweet
Clove	Meaty (cooked, good)	Tar
Coconut	Medicinal	Tea leaves
Coffee	Melon	Turpentine (pine oil)
Cologne	Metallic	Urine
Cooked vegetables	Minty, peppermint	Vanilla
Cool, cooling	Molasses	Varnish
Cork	Mothballs	Violets
Creosote	Mouse-like	Warm
Crushed grass	Mushroom	Wet paper
Crushed weeds	Musky	Wet wool, wet dog
Dill	Musty, earthy, mouldy	Woody, resinous
Dirty linen	Nail polish remover	Yeasty
Disinfectant, carbolic	New rubber	
Dry, powdery	Nutty	

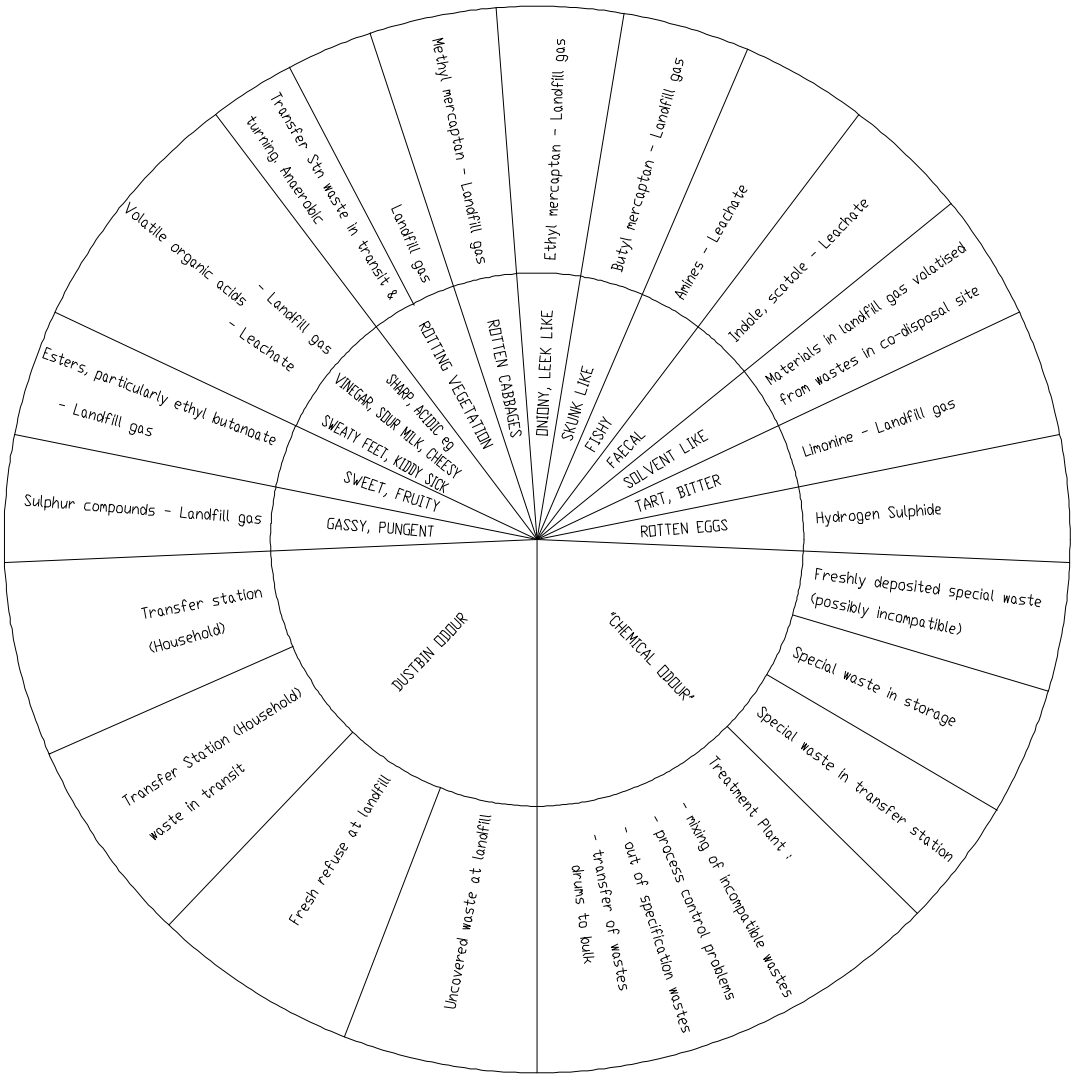

Figure D1 Odour Wheel

The odour wheel above makes an attempt to link commonly used descriptors of odours around waste management facilities with the most likely chemical cause and/or origin(s).

Note: Butyl mercaptan is listed in the original version of WMP26 as an identified likely constituent of landfill gas. Being a mercaptan, it is highly odorous but the Merck Index merely describes its odour as "Skunk like."

There are very few people who have experienced skunk odour but the author is indebted to the Head Keeper of Exeter Zoo for his colourful descriptions having had first hand experience of the odour. These simplify to "an intense clinging combination of rotting cabbages and rotting onions."

APPENDIX E - UNDERSTANDING SMELL

UNDERSTANDING SMELL

This document concentrates on subjective odour monitoring as the initial regulatory procedure for assessing the nature, strength and extent of any odour problems originating from waste management facilities. However, it is important to realise that the ability to detect, and often describe, smells varies from person to person in much the same way as the ability of other senses vary, e.g. sight and hearing.

The following is therefore intended as background reading endeavouring to put the perception of smell into perspective and indicate how, at times, it can be misleading or even fail.

E1 Realistic expectations of the nose

Some facts [12]

- The nose is considered to be the organ of the sense of smell for the body, but its main function is to adjust inhaled air to body temperature and to humidify it before it goes down into the delicate linings of the lungs. It does this by passing the air through its narrow vascular passages.
- The average person breathes about 8 litres of air (23,000,000 molecules) every minute and the weight of the daily intake of air has been calculated to be about 13.5 kg.
- The olfactory chambers, containing the smell receptors, are found at the top of the nose, behind the bridge. The area of the olfactory epithelia (smell cells) is about the size of a postage stamp with half at the top of each nostril. A sniff causes an eddy of air to pass into the upper chamber and any odorous molecules can then come into contact with the olfactory receptors and be detected as smell.
- In order to be odorous a compound must have a molecular mass of between 15 and 300. For example, alcohol (C_2H_5OH) with a molecular mass of 46 is odorous, whereas sucrose ($C_{12}H_{22}O_{11}$), with a molecular mass of 342, is not. So in order to be smelt, molecules must lie within a certain size range, but in order to penetrate the mucous layer covering the smell cells, they must also be soluble in water and lipids.
- The average person can detect by smell 1 g (7×10^{12} molecules) of butanoic acid (a sweaty, cheesy smell) dispersed uniformly throughout a ten-storey building.
- The *Guinness Book of Records* lists vanilla aldehyde (4-hydroxy-3-methoxy benzaldehyde) as the most pungent smell, detectable at 2×10^{-8} mg/litre of air. About 1 drop (2.75×10^{-3} g) would be detectable in an enclosed space 13.7 m high and with the floor area of a football pitch.
- From the olfactory cells the nerve impulses pass into a complex circuit in the brain called the limbic system. This system is now known to be vital for emotion and motivation states as well as thought and memory processes. People can rapidly say how they feel about a particular smell.
- The limbic system, although crucial to behaviour, is a non-verbal part of the brain. This fact results in people having difficulty when asked to name a smell.
- The way the sense of smell links to our brain means that it is primarily controlled by the non-verbal, unconscious stages, and therefore it can affect our behaviour in ways of which we may not be consciously aware.

[12] Source: **What the Nose Knows,** Steve Van Toller, Biological Sciences Review, May 1995, pp 2-5

- Perfumers, who are often chemists, and other professionals for whom the sense of smell is critical, learn to use smell classifications to communicate information about odours, but in general, people perform poorly when asked to name odours.

- To show just how difficult it is to describe and name smells, ask a person to name ten smells and time how long it takes them to produce their list. Then ask the same person to name ten colours, also against the clock. With another person, reverse the process asking them to name colours first and then smells. You will usually find a great discrepancy in the time it takes for people to list ten items in these two categories, with the smells taking longer to produce.

- One reason contributing to the difficulty in naming smells is that while colour names are taught to children at a very early age, it would be very unusual, apart from the rather basic "nice" and "nasty", for a child to be taught smell names.

E2 Odour fatigue

Odour fatigue can take a number of different forms:-

- At one extreme there is the action of gases such as hydrogen sulphide. In hazardous concentrations, the first action of hydrogen sulphide is to paralyse the olfactory nerves rendering the nose unable to detect its rotten egg odour, thus increasing the hazardous potential.

- At a different level, it is likely that if you wear perfume or aftershave you will quickly become unaware of the perfume given off by your own toiletry. However, you are still likely to be aware of the perfume given off by the toiletry being worn by someone passing close to you and vice versa.

- In the same way, people working in an odorous situation, such as a waste management facility, will quickly become unaware of their odorous surrounding possibly to the extent that they are unable to detect regular odours.

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