Design Report for In-Ground Gas Migration Barrier

Marsden Avenue
Warrington

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November 2015
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<table>
<thead>
<tr>
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<th>EPG/WCC/2015/ML/Q3/1.1</th>
<th>Revision</th>
<th>Issue Date</th>
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# Design Report for In-Ground Gas Migration Barrier

**Marsden Avenue, Warrington**

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1. INTRODUCTION

1.1 Purpose

In 2013 The Environmental Protection Group Limited (EPG) was employed by Halebank Developments (Latchford) Ltd to review the available information of ground gas at a site in Marsden Avenue, Warrington and provide advice in relation to the risk of gas migration into the proposed buildings in the development and into existing off site buildings.

EPG’s letter report, entitled ‘Bulk Gas Risk Assessment – Marsden Avenue, Warrington (Reference EPG/2013/HDL/Q1/1, 14 March 2013), concluded that a number of mitigation measures were required to manage gas and vapour risks in relation to the development works proposed at the site. These included three lengths of Virtual Curtain gas migration barrier and installation of venting nodes in the public open space (POS).

This Design Report for the gas migration barriers and vent nodes explains the detailed design for the proposed system. The in-ground gas barrier is being installed as a precautionary measure, to manage risks associated with landfill gas migration toward existing off-site properties which may be caused by the development. It is stressed that EPG’s review did not identify any evidence that migration of gas could be currently occurring. However, it was recognised that during the construction works there may be an increased risk of landfill gas migration as a direct result of compacting or sealing the surface of the site.

The following report sets out the design process which has been implemented by EPG in order to specify the construction requirements for the in-ground gas barrier.

1.2 Information

This report is based on the following information, which are normative references for this document:

- CCG Report dated January 2012, Phase 1 Desk Study Report, Ref. 12-6520;
- CCG Report dated August 2012, Phase 2 Geo-Environmental Report, Ref. 12-6520.2;
- CCG Report dated December 2012, Addendum Report, Ref. CCG-C-12-6868;
- CCG Report dated January 2013, Supplementary Gas Risk Assessment, Ref. CCG-C-12-6868-2; and
2. SUMMARY OF AVAILABLE INFORMATION

The following sections summarise key information relating to the design of the in-ground barrier. For detailed information relating to the site the documents listed in Section 1.2 should be referred to.

2.1 Site Location

The site comprises a triangular shaped area, centred at National Grid Reference 363416, 287757. It is roughly vegetated and covers an approximate area of 3.1 hectares. The site has been artificially raised by around 2m and is essentially level with minor undulations. The site is located at a level of between approximately 10 and 12m AOD, with the surrounding land at approximately 8m AOD.

The site is bounded as follows:

- North: Morris Brook with an associated flood plain and reed bed open land beyond (former Northern Land Agricultural Improvements Landfill site);
- East: A drainage ditch (which feeds into Morris Brook) and open land (former Thelwall Lane Landfill site);
- South-west: Existing residential dwellings (with no known gas protection measures);
- South-east: New private residential dwellings under construction; and
- West: Open land (former Westy Tip), a nursing home (which is understood to have a vent trench to limit the potential for gas migration from the adjacent Westy Tip) and further residential dwellings (with no known gas protection measures).

A site location plan is presented as Figure 1.
2.2 History

The site was operated historically as a landfill, licensed to accept inert industrial waste. The site was historically known as the ‘Westy Lagoon’. It is understood that the ‘lagoon’ was constructed in the 1940’s, with 3m high clay bunds constructed around the periphery of the land – resulting in the level change which is now evident. Infilling of the lagoon comprised tannery waste slurry (from the lime treatment of cattle hides), which was subsequently capped with hardcore. It is understood that filling of the lagoon continued until the 1970’s, with the landfill license being surrendered in 1978. However, construction waste may have been deposited onto the site following surrender of the landfill license, up until the late 1980’s.
2.3 Ground Conditions

Site investigation works completed at the site by CC Geotechnical (CCG, 2012) have indicated relatively consistent ground conditions, as summarised in Table 1 below:

Table 1 Summary of ground conditions

<table>
<thead>
<tr>
<th>Geological Unit</th>
<th>Typical Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Made Ground</td>
<td>Dark brown, silty, very gravelly sand with much brick and concrete and some wood, plastic, rubber, glass and metal. <em>Most likely construction waste deposition.</em></td>
<td>Approximately 2.5m thick</td>
</tr>
<tr>
<td>Silt</td>
<td>Grey / green / blue sandy organic SILT. <em>Often reported with malodor - possibly impregnated with tannery waste liquor.</em></td>
<td>Approximately 1.0m thick</td>
</tr>
<tr>
<td>Peat</td>
<td>Fibrous peat. <em>Strong organic odour – possibly impregnated with tannery waste liquor.</em></td>
<td>Approximately 1.5m thick</td>
</tr>
<tr>
<td>Sand</td>
<td>Red/brown SAND with variable gravel and silt content. With clay bands toward base.</td>
<td>Increasing from 10m thick on northern portion of site to 18m thick on southern portion of site</td>
</tr>
<tr>
<td>Glacial Till</td>
<td>Stiff, silty CLAY.</td>
<td>Decreasing from 10m thick on northern portion of site to 2m thick on southern portion of site</td>
</tr>
<tr>
<td>Sherwood Sandstone</td>
<td>Very weak, clayey SANDSTONE interbedded with bands of Mercia Mudstone. <em>Becoming stronger with depth.</em></td>
<td>Encountered at approximately 20mbgl across the site</td>
</tr>
</tbody>
</table>

The ground conditions encountered during the intrusive works completed by CCG in 2012 are generally consistent with historical phases of intrusive works, as completed by CCG in 2001 and 2004 (reported in 2012 Phase 1 Desk Study Report).

Two distinct groundwater bodies are present beneath the site:

- Shallow groundwater was encountered at between 3m and 4m depth within the organic silt. This water body is continuous through the drift geology on site, perched on top of the cohesive Glacial Till; and

- Deep groundwater was encountered in the Sherwood Sandstone, sub-artesian with a head-rise to approximately 3mbgl.
An west-east diagrammatic cross section through the southern portion of the site is presented as Figure 2.

![Diagrammatic Cross-Section](image)

**Figure 2: Diagrammatic Cross-Section**

### 2.4 Landfill Gas

Review of the gas data collected by CCG indicates monitoring events to span between May and November 2012, including 26 No. individual visits. The monitoring visits cover a wide period of conditions, including low and falling atmospheric pressures.

Ground gas monitoring on the site has identified up to 80% total bulk gas (i.e. combined methane and carbon dioxide) to be present beneath the site. Flow rates associated with these concentrations have remained consistently low, <0.1l/hr.

CCG’s assessment of the gas monitoring data has indicated a trend for increased bulk gas concentrations on the south-western corner of the site and generally along the western side of
the site – decreasing in an easterly direction. This has previously been interpreted to indicate on-site migration of ground gas from a source to the west of the site, i.e. Westy Tip.

EPG concurs with CCG that concentrations of bulk gases appear to be higher on the south-western portion of the site. However, this portion of the site is closer to the older body of the former landfill, i.e. where waste was tipped in the 1930’s. A 1930’s waste stream and the ground model prepared for the site (see Figure 2) indicate that it is unlikely that the bulk gas concentrations identified on the south-western portion of the site are actually from this source.

With regard to the interpretation that total bulk gas concentrations are higher on the western portion of the site than elsewhere, EPG’s review has indicated that this assessment may have been slightly skewed by utilising the Gas Screening Value (GSV) calculation to assess the possible source of gas in the site. This is because the different classifications cover a wide range of gas concentrations and flow rates. EPG have used total landfill gas (i.e. the sum of methane and carbon dioxide) to analyse the data for the site.

Trends observed by EPG may be summarised as follows:

**Trend 1:** Cable percussive boreholes which target the Made Ground deposits show generally consistent total bulk gas concentrations of ~10% to ~30% (figure 3), this is irrespective of their location on the site (e.g. concentrations recorded in BH105).

![Figure 3](image-url)
**Trend 2:** Cable percussive boreholes which target a combination of Silt and Peat deposits generally show a trend similar to the boreholes targeting the Made Ground, whereby total bulk gas concentrations are typically between ~10% and ~30% (Figure 4). These consistent concentrations within the two sources (e.g. Organic Silt / Peat and overlying Made Ground (construction waste)) are considered likely to indicate that the source of the gas is the underlying natural material, with the gas diffusing into the overlying Made Ground deposits. The exceptions to this trend are BH110 and BH109. BH110 recorded initially high gas concentrations – although since mid-June 2012 the results are much more consistent with those generally collected across the site. This initial peak of bulk gas concentrations is consistent with short term generation of gas following disturbance of a low risk gas source (e.g. Peat). The gas concentrations recorded in BH109 are more difficult to explain, however consistent with similar readings in WS109 and WS111 may well represent local variation in the Peat, potentially via increased natural organic content on the south-western portion of the site.

![Cable Percussive Boreholes Only Targeting Silt and Peat Deposits](image)

**Figure 4**

**Trend 3:** Probehole boreholes which target the Made Ground and silt deposits show generally consistent total bulk gas concentrations of <10% (Figure 5). This includes locations WS101 and WS104, which are arguable on the western portion of the site and should be detecting higher bulk LFG concentrations if gas migration from the adjacent historic landfill was occurring. It is unclear why the probeholes targeting the Made Ground / Silt are consistently detecting lower gas concentrations than the cable percussive boreholes which are independently targeting the Made Ground or combined Silt and Peat. However, this may well be associated with installation construction processes.
Figure 5

**Trend 4**: Probehole boreholes which target a combination of Made Ground, silt and peat deposits generally show a similar trend to both the probeholes (which target the Made Ground and silt only) and deep boreholes, whereby total bulk gas concentrations are generally <10% and consistently <30% (Figure 6). The exceptions to this are WS109 and WS111 – although as noted previously this may well represent local variation in the Peat composition on the south-western portion of the site, most likely via increased natural organic content.

Figure 6

In summary, the review of available gas monitoring data from the site has concluded the following:
The source of the total bulk gas concentrations observed on site is unlikely to be from an off-site source, e.g. Westy Tip;

The source of the total bulk gas concentrations observed on site are considered likely to be from generation within the Organic Silt / Peat deposits at depth beneath the site, which have diffused into the overlying Made Ground (construction waste). The monitoring data collected by CCG is consistent with this being the primary source of bulk gas, i.e. anaerobic conditions induced via saturation of the organic soil mass induces methane dominance of the gas yield, under low pressures (as demonstrated by the low flow rates) reflecting that the gas is trapped within the soil matrix and a result of historic degradation processes; and

The monitoring results do indicate a trend for increased total bulk gas concentrations on the south-western portion of the site – most likely associated with natural variation in the Peat, although this is difficult to confirm due to the depth of the material and groundwater conditions which preclude detailed examination.

Further information on the gas generation potential of the various sources the potential migration pathways are provided in the EPG review of 2013.
3. IN-GROUND GAS BARRIER DESIGN INFORMATION

3.1 Rationale for barrier

The previous EPG review concluded that higher bulk gas concentrations were present below the south-western portion of the site. The source of these higher concentrations is likely to be local variation of the organic Silt / Peat – although due to the depth of this material and encountered groundwater conditions this is difficult to confirm. There may be a very minor contribution from the adjacent landfill site. As such it was recommended that a precautionary approach was adopted for assessment of this portion of the site, which it is understood will be designated Public Open Space (POS). This was largely in part to expedite obtaining planning permission for the development.

There are three main issues when considering gas concentrations associated with the south-western portion of the site;

- Any gas present could migrate toward the proposed on-site residential houses;
- Any gas present could migrate toward the existing off-site residential houses; and
- Any gas present could diffuse to out of the surface of the POS.

With respect to items 1 and 3, given the anticipated nature of the gas source it is considered highly unlikely that diffuse migration of gas would occur from the south-western portion of the site toward proposed or existing residents if the site was left undisturbed. However, construction activities, covering over the site with a capping layer and lifting the levels could all potentially cause off site migration. It is difficult to predict how and when this might occur but it has certainly been seen on similar sites.

In order to facilitate prompt commencement of the development a precautionary approach to site assessment has been adopted. In this relation it is recommended that some form of system be installed which will collect any gas present on the south-western portion of the site and allow it to be vented passively and in a controlled manner thus limiting the potential for migration toward the residential receptors. A ‘Virtual Curtain’ is proposed and a schematic of a typical Virtual Curtain layout is presented as Figure 7.
Figure 7  Schematic of Virtual Curtain

3.2 Location and Length of barrier and vent nodes

An extract of the proposed development plan for the site is presented as Figure 8. The approximate location of the in-ground gas barrier and vent nodes from the previous outline design has been annotated onto this drawing.
Figure 8. Line of Proposed In-Ground Gas Barrier from outline design (note this has been amended based on the detailed design – see Figure 9 for final design).
There are three sections of virtual curtain and a series of individual vent nodes alongside the access road.

### 3.3 Depth of barrier

**Virtual Curtain 1**

This section is required to isolate any gas in the ground below the POS from the development area. On review of the data during this detailed design it is considered that the base of the nodes should extend to a bottom toe level of 5.5m AOD which is within the peat deposits. The barrier would not fully penetrate the peat which extends to 3.2m AOD but will provide a preferential pathway for gas to be released from the peat if it is compressed. The reason for this is that the Peat is saturated and the groundwater will help limit the migration of gas. The partial penetration by the nodes allows for any future drop in groundwater levels.

Depending on final development levels this will give a node depth of 5.3m based on the ground levels at the site during the site investigation by CCG. The precise depths to meet the toe level of 5.5m shall be confirmed by the installation contractor with Winworth Construction and the developer. Ground levels along the line of the VC shall be surveyed immediately prior to installation to confirm the installation depths required to meet the required toe level. This information shall also be passed to EPG to check the design calculations remain valid.

**Virtual Curtain 2 and 3**

This section is required to isolate any gas in the ground below the POS from the existing houses adjacent to the site. On review of the data during this detailed design it is considered that the base of the nodes should extend to a bottom toe level of 7m AOD which is just under 1m below the typical groundwater levels in this part of the site as shown in Table 2.
Table 2 Ground water levels in area of VC2 and 3

<table>
<thead>
<tr>
<th>Exploratory hole</th>
<th>Approx ground level (taken from CCG location plan) (mAOD)</th>
<th>Depth to water (m bgl)</th>
<th>Groundwater level (m AOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS109</td>
<td>10.8</td>
<td>2.3</td>
<td>8.5</td>
</tr>
<tr>
<td>TP 101</td>
<td>10.2</td>
<td>2</td>
<td>8.2</td>
</tr>
<tr>
<td>TP102</td>
<td>10.8</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>VC3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WS108</td>
<td>10.8</td>
<td>2.3</td>
<td>8.5</td>
</tr>
<tr>
<td>BH108R</td>
<td>10.0</td>
<td>2.2</td>
<td>7.8</td>
</tr>
<tr>
<td>TP103</td>
<td>10.7</td>
<td>0.8</td>
<td>9.9</td>
</tr>
<tr>
<td>TP104</td>
<td>10.2</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Depending on final development levels this will give a node depth of 3.0m based on the ground levels at the site during the site investigation by CCG. The precise depths to meet the toe level of 7m shall be confirmed by the installation contractor with Winworth Construction and the developer. Ground levels along the line of the VC shall be surveyed immediately prior to installation to confirm the installation depths required to meet the required toe level. This information shall also be passed to EPG to check the design calculations remain valid.

**POS nodes**

These nodes are simply intended to provide a preferential pathway from the peat and can extend to the same level as the nodes in Virtual Curtain 1, ie 5.5m AOD.

### 3.4 Selection of In-Ground Gas Barrier Type

In EPG’s experience, where ground conditions are conducive, the most cost effective way of installing shallow in-ground gas barriers is by construction of a Virtual Curtain (VC). More information relating to the VC system is provided at [www.virtual-curtain.com](http://www.virtual-curtain.com). Subject to detailed review of this Design Report by Specialist Contractors who install the VC solution, it is considered likely that the VC will prove a viable application for adoption at Marsden Avenue. On this basis Design Parameters are provided in the following sections of this report for the installation of a VC in-ground gas barrier. However alternative design solutions (such as a 600mm wide gravel filled vent trench) could be costed by installation contractors if they are
considered more appropriate and cost effective. The alternative solutions would need to extend to the same depths and would need to be agreed with the local authority.

### 3.5 Design Criteria

Design calculations for the in-ground barrier have been undertaken assuming a maximum permissible equilibrium concentration of gas within the dilution-duct construction of 0.25%v/v. A factor of safety of 1.0 has been applied. The vent nodes must have sufficient capacity to manage gas flowing through the ground towards the barrier or nodes.

*Note: The design calculations are based an assumption of steady state conditions. This does not occur in reality and so there will be times when the gas concentration within the vents exceeds 0.25%v/v (due to still wind conditions, etc.). However at the outlet itself in the fresh air any gas will be diluted immediately and should not pose any risk of explosion.*

### 3.6 Design Parameters

The design parameters that have been used for the design of the in-ground gas barriers between the public open space and the development and also along the southern edge of the development are summarised in Table 3

| Table 3. General Input Parameters for Virtual Curtain 1, 2 and 3 |
|--------------------------|-----------------|----------------|
| Parameter                | Value           | Justification  |
| Receptor Sensitivity     | Very high       | Protection of residential buildings, off-site |
| Ground Permeability of migration pathway | 1.0x10^{-6} m/s | Reflects descriptions of materials below the site |
| Gas regime Design gas concentration | 78% | Maximum concentration recorded by CCG on SW portion of site |
| Design flow rate          | 0.1 l/hr        | Reflecting monitoring data collated by CCG |
| Design gas pressure       | 100Pa           | Considered reasonable based on known information regarding source |
| Wind Wind speed           | 4.0 m/s         | From BS 5925:1991 for this location |
| Wind direction            | south-west      | Predominant direction in UK – makes little difference to results |
| System                    |                 |                 |
## 3.7 Design Calculations and Installation Requirements

The design calculations for the virtual curtain barrier have been undertaken using the parameters summarised in the previous section and are based on the guidance provided by Wilson and Shuttleworth (2002)\(^1\). The design calculation outputs are presented in Appendix A. Calculations are not provided for the individuals vent nodes in the POS as these act purely as a pressure relief system. On detailed assessment it is considered that the spacing can be increased to 15m.

The installation requirements for the VC, based on the results of the calculations are summarised in Table 4.

---


<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venting components</td>
<td>0.9m high vent bollards</td>
<td>Less intrusive on a residential site</td>
</tr>
<tr>
<td>Constrictions to venting</td>
<td>None that are significant</td>
<td>No significant bends or other restrictions in system</td>
</tr>
<tr>
<td>Height inlet between inlet and outlet</td>
<td>0.9m</td>
<td>See above</td>
</tr>
<tr>
<td>Overall factor of safety</td>
<td>1.5</td>
<td>Worst case assumptions made in design</td>
</tr>
</tbody>
</table>
### Table 4. Summary of Virtual Curtain Requirements

<table>
<thead>
<tr>
<th>Detail</th>
<th>VC 1</th>
<th>VC2 and VC3</th>
<th>POS nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>210m (approximate – to be confirmed by contractor)</td>
<td>110m (VC2) and ?? (VC3)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Depth</strong></td>
<td>Vent nodes to extend to 5.5mAOD, approx 4.8m below the dilution duct construction. Final depth to be confirmed by contractor based on development levels</td>
<td>Vent nodes to extend to 7.0mAOD, approx 3.5m below the dilution duct construction. Final depth to be confirmed by contractor based on development levels</td>
<td>Vent nodes to extend to 5.5mAOD, approx 4.8m below the dilution duct construction. Final depth to be confirmed by contractor based on development levels</td>
</tr>
<tr>
<td><strong>Dilution Duct Construction</strong></td>
<td>All nodes terminate at the underside of a dilution duct constructed with an invert at 0.5m below ground level Dilution duct to comprise 150mm high by 354mm wide Permavoid units. Ventilation duct to be wrapped in a geotextile.</td>
<td>Single vent manhole at the top of each node (or bollard)</td>
<td></td>
</tr>
<tr>
<td><strong>Spacing of Vent Nodes</strong></td>
<td>2.5m centres. Vent nodes to be 50mm thick geocomposite units wrapped in geotextile with an intrinsic permeability of $1.15 \times 10^{-5}$ m$^2$ or greater</td>
<td>1.5m centres. Vent nodes to be 50mm thick geocomposite units wrapped in geotextile with an intrinsic permeability of $1.15 \times 10^{-5}$ m$^2$ or greater</td>
<td>15m along each side of access road</td>
</tr>
<tr>
<td><strong>Inlets</strong></td>
<td>Low level inlets, positioned at 25m centres. These are part of the vent stack construction.</td>
<td>Low level inlets, positioned at 30m centres. These are part of the vent stack construction.</td>
<td>Vent manhole or bollard</td>
</tr>
<tr>
<td><strong>Outlets</strong></td>
<td>0.9m high vent bollards, positioned at 25m centres.</td>
<td>0.9m high vent bollards, positioned at 30m centres.</td>
<td>Vent manhole or bollard</td>
</tr>
</tbody>
</table>

#### 3.8 Virtual Curtain Layout

EPG design drawings for the Virtual Curtain installation are presented in Appendix B. A summary of the installation requirements is shown in Figure 9. This should not be used for construction or costing purposes.
Figure 9 Summary of virtual curtain requirements after detailed design (supersedes previous outline design)
3.9 Installation

Method

The initial stage in the construction process will be ensuring that a firm, level platform has been achieved along the line of the installation. From this level the dilution duct leader trench should be excavated, constructed with an invert level at 0.65mbgl. The vent nodes should be extended through the base of the dilution duct leader trench, vibrated into position using a mandrel attached to an excavator. Locally some pre-digging of vent node locations may be required, e.g. where obstructions in the waste are encountered. The VC process results in very little spoil generation. Any spoil generated by the excavation of the dilution duct may be nominally mounded on top.

Further details of the installation process are provided in the paper by Wilson and Shuttleworth in Ground Engineering, January 2002.

The vent nodes and collection duct are constructed using robust geosynthetic units that are able to be driven over by construction plant with only minimal protective soil cover.

Vibration

The installation technique for the drilling of the vent nodes uses a high frequency excavator mounted vibrator to vibrate the mandrel into the ground. This has been used on numerous sites close to existing structures (within 5m) without causing structural damage. All 3rd nearby party infrastructure and buildings should be monitored during the VC installation process.

The use of high frequency vibrators is common practice for installing sheet piles etc. to reduce the effects of vibration in urban areas and minimise the risk of damage (it is low frequency vibrations that cause damage to buildings).

The frequency of the vibrator to be used is around 46Hz and thus the risk of resonance in the ground is minimised (it usually occurs at a frequency of less than 30Hz).

The amplitude of the vibrations is also small and thus it is almost never sufficient to cause even cosmetic damage to nearby buildings. It should however be noted that some people are very sensitive to vibrations and although structural damage is very unlikely there may be some residents who can feel the vibrations and perceive there to be vibrations. These effects are however minimised because the vibrations will not be continuous and there will be a break between each node installation.
The likely impact of the vibrations has been assessed in accordance with British Standard BS 5228-2:2009 (see Appendix C) and the calculations indicate that the vibrations are likely to be within acceptable limits. However, it is recommended that local residents are made aware of the installation process and potential for vibration, consistent with Table B:1 of BS5228-2:2009.

3.10 Constraints to Installation

Contractors should ensure that they are fully aware of the anticipated ground conditions along the line of the proposed VC construction – notably by review of the supplementary works discussed in Section 3. It is possible that local obstructions will be encountered within the waste material. Where such obstructions are encountered Contractors should ensure that sufficient allowance has been made for over-digging of these areas, in order to loosen the waste, prior to installation of the vent nodes.

In the proximity of the in-ground gas barrier there is a wall (possibly retaining) which runs parallel to the north-eastern boundary of the site. Two garage structures are also present on the north-eastern corner of the site. Contractors are responsible for ensuring that these structures are not undermined or damaged during the installation process of the in-ground gas barrier.

The proposed location of the VC is currently very uneven. Contractors may well need to construct a level platform for construction of the VC, located at 193mAOD.

3.11 Chemical Resistance

The nodes are constructed using geo-composites manufactured from high density polyethylene (core) and polypropylene (geotextile).

Polypropylene outperforms almost all other plastic materials in terms of chemical resistance. The saturated olefinic chains yield resistance to most oils and solvents as well as water based chemicals, soaps and moderate acids and bases.
Polypropylene is a chemically static thermoplastic polymer (\( \text{C}_3 \text{H}_6 \)) and does not lose plasticisers like some other plastics so it does not leach chemicals into the environment. It is non-toxic, will not biodegrade and does not react with most chemicals. It is widely accepted in the chemical industry for pipework, tanks and corrosion resistant parts and is used in parts for cars. It is used to manufacture membranes that are used to line landfills. It is resistant to most chemicals that are likely to be present in landfill leachate or landfill gas at this site such as hydrocarbons, phenols, acids, metals, grease and pesticides at the concentrations and temperatures likely to be encountered within a typical landfill leachate or landfill gas. (Note contact with some chemicals that can be present as components of landfill leachate can cause surface crazing and material swelling, but polypropylene has no known solvent at room temperature).

The adverse effects are reported for pure solutions and/or elevated temperature conditions which do not reflect the exposure conditions that nodes will be subjected to when exposed to leachate.

High density polyethylene is routinely used as a landfill liner and in landfill leachate drainage systems and should not be significantly affected by any leachate on this site.
3.12 Maintenance

All gas protection systems require maintenance. In the case of the VC system on this site maintenance will comprise simply checking that the low level vent bollards (inlets) and high level vent stacks (outlets) have not been vandalised or blocked and are still operational. This should be undertaken annually and repairs undertaken as necessary. Under normal conditions no other maintenance is required.

The risk of clogging of the virtual curtain system is extremely low as show in Figure 10.

![Figure 10 Risk of clogging](image)

A framework for the inspection and maintenance of the system is provided in Table 5.
### Table 5 Inspection and Maintenance of Virtual Curtains.

<table>
<thead>
<tr>
<th><strong>Marsden Avenue Latchford, Planning Ref: 2012/20529.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
</tr>
<tr>
<td>To provide a framework of inspections and maintenance of virtual curtain installations to ensure their continued functioning over the required lifetime of the installed system. The required lifetime will be determined in collaboration with WBC by future site assessments of potential risks to human health and/or residential occupancy arising from gassing levels prevailing at the time of the assessment.</td>
</tr>
<tr>
<td><strong>Periods Between Assessments</strong></td>
</tr>
<tr>
<td>It is proposed that the periods between gas risk assessments will initially be 10 years until the elapse of 20 years (i.e. 2 periods of assessment), reducing thereafter to 5 yearly periods. In the event that gassing levels have attenuated to the point where consideration is given to the cessation of inspections and maintenance of the virtual curtains, more frequent gassing assessments may be required by WBC in the short term to confirm the validity of the observed attenuation over a duration acceptable to WBC. Within this duration, assessments at monthly intervals may be appropriate, ceasing when 6 consecutive readings confirm the assessment.</td>
</tr>
<tr>
<td><strong>Frequency of inspections within Periods</strong></td>
</tr>
<tr>
<td>It is proposed that a frequency of 1 inspection annually be implemented.</td>
</tr>
<tr>
<td><strong>Specifics of inspections</strong></td>
</tr>
<tr>
<td>The only part of the VC system which is visible above ground is the low level vent bollards. There is no mechanical element to the vent bollards. The inspection process will therefore entail visually checking each of the vent bollards to confirm it is still present and has not been subject to any damage / vandalism.</td>
</tr>
<tr>
<td><strong>Envisaged maintenance activities</strong></td>
</tr>
<tr>
<td>As discussed above, the only part of the VC system visible above ground level is the low level vent bollards. The vent bollards have no mechanical element. Therefore, maintenance will only be required if a vent bollard has been damaged (e.g. knocked over) or vandalised. In this situation an improved installer of the VC system will be contacted and the vent bollard either repaired or replaced.</td>
</tr>
<tr>
<td><strong>Reporting obligations</strong></td>
</tr>
<tr>
<td>A report on each annual inspection and/or maintenance event will be prepared for submission to WBC</td>
</tr>
<tr>
<td><strong>Responsibilities</strong></td>
</tr>
<tr>
<td>It is envisaged that the registered provider assumes responsibility for the inspection, maintenance, and reporting described above.</td>
</tr>
</tbody>
</table>
3.13 Post Construction Monitoring

This report sets out the design requirements of the in-ground gas barrier. The in-ground gas barrier is being installed as a precautionary measure. There are also sources of methane and carbon dioxide on either side of the barrier. Given the precautionary nature of the in-ground gas barrier, and the robustness of the design solution, no post installation verification monitoring is considered to be required. However, the local authority has requested that monitoring be carried out in the south west of the site (the open space) on completion of the scheme and then at five yearly intervals until gassing in the south west of the site reduces to levels which are safe for residential development when assessed in line with guidance prevailing at that time. The layout of the permanent monitoring wells is to be agreed with Warrington Borough Council.

3.14 Alternative Design Strategy

As discussed in Section 4.4, the VC is considered likely to provide the most cost-effective installation technique for the construction of an in-ground gas barrier. However, for cost comparison purposes the following more traditional method of constructing an in-ground gas barrier may also be considered:

- Install 600mm wide vent trenches to the same depths as the Virtual Curtain;
- Trench to be backfilled with 40mm single size gravel or similar; and
- The gas collection trench should have a perforated pipe within the gravel that is connected to vent bollards at the same spacing as the Virtual Curtain solution.
4. CDM HEALTH AND SAFETY ASSESSMENT

A health and safety risk assessment for the design of the VC system on this site is provided in Appendix D. The design of the barrier has been undertaken taking account of the need to design out hazards during construction or maintenance wherever possible.

On this site there are no residual hazards that would not be anticipated by a competent contractor.

If the alternative solution is adopted the Contractor should provide a health safety assessment. Not that conventional excavation of a trench into waste will increase the risk of exposure of the workforce to contamination from the ground when compared to the VC solution.
Appendix A

Calculations for Virtual Curtain Design
Appendix B

Construction Drawings
Appendix C

Vibration Assessment
Appendix D

CDM Health and Safety Assessment