WALLEYS QUARRY

Walleys Quarry Landfill: Landfill Gas Management Plan January 2022

Walleys Quarry Ltd
Cemetery Road
Silverdale
Newcastle-under-Lyme
ST5 6SB

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1.0 INTRODUCTION

This document provides a revision of the Landfill Gas Management Plan for Walleys Quarry Landfill Environmental Permit (ref EPR/DP3734DC).

Red Industries RM Ltd has owned and operated Walleys Quarry Landfill Site (the Site) located on Cemetery Road, Newcastle-under-Lyme, ST5 6SB, since November 2016. From 28 April 2021 the name of the legal entity changed to Walleys Quarry Ltd (hereafter referred to as the 'Operator'), its registered office being Borough House, Berkeley Court, Borough Road, Newcastle Under Lyme, England, ST5 1TT.

The Site has been accepting wastes since 2007, and accepts a range of non-hazardous waste materials comprising predominantly industrial and commercial waste materials and inert waste.

This Landfill Gas Management Plan (LFGMP or plan) follows the guidelines set out in the Environment Agency's Technical Guidance on the Management of Landfill Gas (LFTGN 03, 2004) and other relevant statutory guidance documents. The Plan describes on site gas management infrastructure and plant, management and monitoring procedures measures, an LFG Action Plan and provides relevant drawings.

This document replaces the LFGMP dated February 2020 and its November 2020 revision (Egniol report EEL.7745.R03.002) and all previous versions. This document was produced with the assistance of Gregory Environmental Consulting Ltd, Egniol Consulting Ltd (Egniol), and other experts operating in this field. The document has been produced through substantial consultation with the landfill gas management company, Cotesbach Energy Limited (CEL) (a subsidiary of CLP Envirogas Limited (CLP), who have provided much relevant information, but it is emphasised that as the permit holder, this is a Walleys Quarry Ltd document which reflects the landfill gas management requirements of Walleys Quarry Ltd.

The Plan should be read in conjunction with the latest Landfill Gas Risk Assessment (Egniol report EEL.7268.R03.001 (Rev C)).

2.0 SITE DESCRIPTION

2.1 Location and History

This operational landfill site is situated near Newcastle-under-Lyme in Staffordshire, at National Grid Reference SJ831 460. Access to the landfill site is gained via Cemetery Road which forms the western boundary to the landfill.

The Site is permitted to accept a variety of non-hazardous wastes, such as MRF residual waste, commercial, industrial and inert waste materials. The Operator is also permitted to accept stable non-reactive hazardous waste in the form of asbestos containing material, however no such hazardous waste has been nor is currently accepted at the Site.

The Site was originally developed as a quarry extracting clay. Engineering work for landfill operations commenced in 2006 and waste was first accepted in Cell 1 in January 2007. Since then, waste disposal operations have continued in Cells 1, 2 and 3 with engineering works complete to 110m AOD in Cells 1, 2 and 3. The upper part of Cell 1 sidewall was engineered in 2008 to provide a tipping area prior to completion of Cell 4. Cell 4 was constructed in 2010.

Lafarge sold the Site to the operator in November 2016. The operator commenced landfill operations in November 2016.

Under the current management the landfill continues to accept non-hazardous waste materials in compliance with its current permit. Stable non-reactive hazardous waste, although permitted to be deposited at the Site, is not accepted by the site operator.

2.2 Landfill Construction Details

The engineered lining systems in the basal sections of Cells 1, 2, 3 and 4 comprise 3 metres of engineered clay with the hydraulic conductivity of 1 x 10^{-10} m/s to 8.9 x 10^{-11} m/s (based on CQA reports for Cells 1, 2, 3 and 4).

Each cell has a leachate collection and extraction system comprising a 300 mm gravel drainage blanket together with collection pipework, a leachate collection facility, a remote leachate monitoring point and a concrete target pad to facilitate the installation (if required) of retro installed leachate infrastructure.

The sidewall construction of each cell comprises a metre-thick clay liner placed to provide engineered containment having a maximum permeability of 1 x 10^{-9} m/s, overlain by a 250 mm thick soils protection layer, to help reduce erosion due to weather.

The current proposal for the final height capping and restoration of the Site is the placement of a 1 mm LLDPE geomembrane overlain by a metre depth of restoration soils.

The landfilling base level is approximately 85 mAOD and the final site restoration height will be 145 mAOD.

2.3 Environmental Setting

The environmental settings of the Site are well understood and documented in the earlier permitting applications. For consistency with the previous risk assessment reports, the environmental settings are summarised and updated, below.

2.3.1 Local receptors

The Site is located 1km to the west of the centre of Newcastle-under-Lyme at approximately 120m Above Ordnance Datum (AOD). The surrounding area is a mixture of land uses which are typical of an urban fringe. These comprise residential areas, industrial and commercial units, a cemetery and a garden centre and green fields/grazing paddock. Local human receptors to amenity issues have been identified through a desk top assessment of their location and the minimum distance from the site boundary. Those receptors situated within a 1km radius of the site are listed in Table 1 and shown on Drawing 1: ECL.5569.GA.D11.

Table 1. Walleys Quarry Landfill Site – Local Receptors

Receptor	Min Distance, m	Direction
0-250m from the site boundary		
Garner's Garden Centre	20	North
Knutton Residential Dwellings along the B5044	110	North
Silverdale Housing Estate	90	East
Consented Residential Development Area on the site of the former Hampton's Scrapyard	30	South, SE
Silverdale Holidays Park	30	South
Recreational Grounds	250	SW
Allotments	80	West
Cemetery	60	West
Silverdale Business Park	60	West
250-500m from the site boundary		
Knutton Residential Dwellings along the B5044		North
Warehouse/Depot along the B5044	300	NE
Local Nature Reserve	420	East
Silverdale Housing Estate		East
Recreational Grounds		SW
Rosemary Wood Cottage	300	South
Allotments		West
Cemetery		West
Silverdale Business Park		West
Silverdale wider residential area	400	West
Industrial Area	220	North
500m – 1km from the site boundary		
Knutton wider residential area		North
Knutton St Mary's Primary School	500	North, NE
Local Nature Reserve		East
Silverdale Housing Estate		
Keele Road & Orme Road Housing Estate	470	East
Westlands wider residential area	600	East, SE, South
Keele University	830	South, SE
Recreational Grounds		
Silverdale wider residential area		West

2.3.2 Geology

The geological and hydrogeological settings are summarised in Table 2 below.

Table 2. Summary of the Geological Setting

Age	Formation	Local Thickness	Description
Quaternary	Glacial till	5-30m	Variable but mainly sandy clay
Carboniferous	Etruria Formation	Circa 70m	Soft mudstones with interbedded siltstone clay and occasional sandstone lenses/ band. Sandstone is not laterally persistent
Carboniferous	Upper Coal Measures	>80m	Cyclic mudstone siltstones, sandstones, seat earths and coal

The Upper Coal Measures underlie the Site and have been historically exploited by the Silverdale Colliery. These local coal measures are believed to be a source of background ground gas in the locality of the Site. Methane and carbon dioxide were detected in a number of perimeter gas monitoring boreholes installed before the waste disposal commenced on Site in 2007.

2.3.3 ` Hydrogeology and Hydrology

The strata surrounding the Site contains permeable fissures, cracks, lenses and bands which may store and yield groundwater. The superficial deposits are classed as Secondary (Undifferentiated) or Secondary A aquifer, and Etruria Marl and Coal Measures bedrock are classed as a Secondary aquifer. Because of variable characteristics of the rock types, these strata have only a minor value for providing usable water supplies but may support rivers, lakes and wetlands.

The groundwater level data in the perimeter boreholes shows that there is no unsaturated zone beneath the base of the Site, however the groundwater lenses relate to discrete sandstone bands and mudstones rather than one aquifer unit across the Site. The groundwater levels in the deep boreholes vary between 67 metres Above Ordnance Datum (mAOD) to 113 mAOD, whereas the groundwater levels in the shallow boreholes range between 78 mAOD to 127 mAOD.

The groundwater is actively pumped out from a sump below the Site and following its pre-treatment (aeration and sedimentation), is discharged to Silverdale Brook, as stipulated by the Site Permit.

The Site lies in the catchments of Silverdale Brook which is located approximately 70 m north of the Site and flows in a generally west to east direction. The brook receives a discharge of the surface water and pumped groundwater from the Site.

3.0 LFG MANAGEMENT

3.1 General Considerations

Anaerobic breakdown of biodegradable waste results in the generation of landfill gas, the main components of which are methane and carbon dioxide. The actual quantity and rate of landfill gas generation in the fill are dependent on a number of factors, including the carbon content of the waste, the nature of the carbon (types of waste), and gradual reduction of the biodegradable waste deposited in landfills. Consequently, onset and production rates vary, not only between different landfill sites, but also within the same site. Landfill gas management at the facility has been contracted to Cotesbach Energy Limited (CEL) (a subsidiary of CLP Envirogas Limited (CLP), since July 2010.

The composition of landfill gas will vary over time but will typically consist of 50 – 60 % methane (CH_4), 40 – 50 % carbon dioxide (CO_2) as well as numerous trace compounds including H_2S. Landfill gas is a potential hazard due to its explosive and asphyxiating properties. This is of particular concern if landfill gas is found to be migrating off-site and towards any close-by buildings or structures. The trace gases are typically present at very low concentrations which are not hazardous to humans, however some trace gases are odorous and can be detected even at extremely low concentrations.

The Site has recently been experiencing elevated H_2S concentrations and this latest LFGMP sets out to address the management of H_2S and the additional gas collection which will arise from capping the Site:

- Across the Site there is a need to increase gas recovery to reduce surface emissions to a minimum, whilst maintaining safe levels of air ingress. This approach will mean that the Site will not be balanced simply to maintain high CH_4 concentrations and low O_2 ingress at the gas compound. Consequently, there will be greater likelihood of air ingress but by adopting a “flare” gas line and a separate “utilisation” gas line the cautious approach of maintaining a 1% threshold for O_2 at the compound can be limited to the “utilisation” gas line, and the gas quality abstracted at the wells on the “flare” gas line can have a higher O_2 content.
- As capping increases, then the gas collection efficiency will need to increase and we will need to capture that gas. We see this requiring an increase in overall ring main capacity because the existing spurs which deal with the bulk of the gas from the Site are already close to or at the EA’s maximum flow velocity of 6 m/s.
- We will shortly need to extend the western spur to the perimeter of the site to allow a perimeter ring main to be built to collect landfill gas from the western flank, while avoiding the use of more pylons supporting small pipes, as they are prone to collapse.
- We envisage additional built-up wells to recover gas from depth over the current operational area, as many wells have been lost here. Subsequently, drilled vertical wells can be interspersed between the built-up wells to capture gas from the upper layers, but getting deep wells into this area is important for gas recovery.
- As the Site is progressively capped and the gas field extended, we envisage this LFGMP being reissued regularly to keep pace with changes on-Site. All currently envisaged activities are recorded in Appendix A which should be considered a live document.

3.2 Gas Generation Potential

According to the most recent landfill gas risk assessment (Egniol report EEL.7268.R03.001 (Rev C)), the predicted volume of landfill gas produced at the Site continues to be at a level where active gas control and treatment are required.

In 2021, the Site was calculated to generate approximately 2,500 – 2,600 m^3/h of landfill gas. The peak landfill gas generation in 2024 could reach 3,080 – 3,250 m^3/h (50-95th %ile). After that point, and by approximately 2070, landfill gas levels will reduce exponentially to the benchmark levels of 50 – 100 m^3/h suggested in LFTGN03 Guidance on the Management of Landfill Gas, below which active gas control is not required.

It should be noted that the volumes forecast by GasSim do not include entrained air (oxygen and nitrogen, or balance gas) and currently this has been shown to be up to 27%. The capacity of combustion plant on Site is based on the modelled maximum gas yield plus 20% air ingress, which is to allow for at least 3,900 m^3/h flaring capacity on Site.

3.3 Landfill Design and Passive Gas Control

To minimise lateral migrations of landfill gas offsite, the landfill site has been constructed on the principle of containment, using an engineered low permeability perimeter and basal lining system. Cells 1, 2, 3 and 4 are constructed using three metres of engineered clay with the hydraulic conductivity of 1 x 10^{-10} m/s to 8.9 x 10^{-11} m/s (based on CQA reports for Cells 1, 2, 3 and 4).

Sidewalls of each cell are constructed using a metre-thick clay liner to provide engineered containment having a maximum permeability of 1 x 10^{-9} m/s, overlain by a 250 mm thick soils protection layer, to help reduce erosion due to weather. The entire landfill area is 130,629 m^2 but currently only 97,894 m^2 of this is landfilled.

To minimise fugitive emission of the gas, the Site is progressively capped with temporary cap on the landfill areas which are not used (mothballed) for over 6 months. Temporary capping comprises either 1mm LLDPE, clay, or PosiShell (cementitious bentonite). PosiShell is a new material in the UK, being used mainly in the US to date, and supplies of the material have been increased to the UK so that this temporary capping can be maintained if any surface remediation is indicated by walkover surveys. Permanent capping comprises 1mm LLDPE with a restoration layer above. Drawing 2, Drawing 30481/WLS/CP/07 Rev 0 shows the current permanent and temporary capping condition. The approximate percentage capping and areas under each cap type are as follows:

Permanent 1mm LLDPE cap	14.1%	13,759 m^2
Temporary 1mm LLDPE cap	8.2%	8,005 m^2
Temporary clay cap	18.6%	18,175 m^2
Temporary PosiShell Cap	16.3%	15,922 m^2

By mid-2021, 40.8% of the landfill area had been capped with either a temporary or permanent capping system, and with the PosiShell emplaced, this has increased to 57.1%. At the same time the Site operator intends to progressively infill landfill cells to the ‘top of waste’ levels to facilitate progressive permanent capping works.

Cell 1 was temporary capped in 2010 but was reopened in 2020 for landfilling until reaching planned ‘top of waste’ levels. The first phase of final capping was completed in May 2021 and

it is estimated that the entire area of the cell will be permanently capped by the end of 2022, as filling moves generally clockwise around the Site. Currently the Site is filling in the east of the Site in Cell 3, and the aim is to complete filling within the core of the Site in the next quarter. Filling will then continue in Cells 3 and 4 in the former valley void.

On particularly windy days, filling in the higher parts of the site has been diverted to the lower areas on the eastern boundary. As winter approaches, the aim is to complete the core of the Site before moving into the valley void, so that there is only one operational area during the winter months.

The pattern of filling through to 2023 is shown in Drawing 3, Drawing No 30484/WLS/PP/01. This shows operations completing in the crown of the Site, moving to the eastern valley in Winter 2021, and a new filling area in the Western valley being filled from Q1/Q2 2022. The aim of this is to allow the entire northern half of the Site to have landfill gas collection by a complete ring main system by the end of Q2 2022.

In order to improve gas collection on the western flank of Cell 2, this area will also be landfilled once the core of the Site is completed on the eastern slope. Filling on the west of the Site will temporarily alleviate some of the perceived impacts of landfilling on the eastern boundary, closest to the Galingdale estate. This western flank of Cells 1 and 2 will be capped in 2022/23, and Cells 3 and 4 aim to be permanently capped by the end of 2025, while the remaining areas in Cell 2 will be the last filled. This is projected to be infilled by the end of 2026 and capped in 2027.

The temporary and permanent cap will comprise of 1mm LLDPE geomembrane with a maximum permeability of 1 x 10^{-9} m/s. The permanent cap will be overlain by a 300mm protection layer followed by a metre depth of restoration soils.

The landfilling base level is around 85 mAOD and the final Site restoration height will be 145 mAOD.

3.4 Active Gas Control – Landfill Gas Fixed Plant

Active landfill gas control began in 2009 when a temporary Hofstetter 500m^3/h gas flare was installed. This flare was replaced with Flare A3, a 2000 m^3/h high temperature flare, in 2010 (see Table 4).

A temporary flare was hired in the period 2016 – 2018, but this only had a capacity of 200 m^3/h. It is no longer at Site. This was replaced by the permanent Small Biogas flare installed in the gas compound to cover the possibility of having both engine on and excess gas yet not enough gas flow to run the main flare (due to the turn down ratio). This flare is rarely used currently.

At the request of the Environment Agency, a 1000 m^3/h flare has been hired by CEL in 2021 to aid the control of landfill gas. CEL is currently refurbishing a 2000 m^3/h flare to replace this permanently by the end of 2021.

There are three 1067kWe Jenbacher (JGS320 GS-L.L) gas engines installed on site. The first was commissioned in early 2011. The second in 2014, and the third in 2017. Each has the capacity to recover 525 m^3/h of landfill gas at 50% CH_4 and convert this to electricity.

There is a grid connection with 2MWe capacity, so the third gas engine acts as a standby for when one of the others is being serviced.

The variation in the gas flow to each engine is related to the CH_4 content at the time and can vary dependant on the energy content of the gas flow. At a higher CH_4 content, the gas engines need less flow, but at a lower CH_4 content, more flow is needed. The O_2 level at the compound is kept under 1% in normal operations and the gas field system is balanced to achieve this. As such the volume of gas sent to each gas engine can be between to be 680 – 750 m^3/h.

Across the Site, however, there is a need to increase gas recovery to reduce surface emissions to a minimum, whilst maintaining safe levels of air ingress. This approach will mean that the Site will not be balanced simply to maintain high CH_4 concentrations and low O_2 ingress at the gas compound. Consequently, there will be greater likelihood of air ingress but by adopting a "flare gas" line and a separate "utilisation gas" line, the cautious approach of maintaining a 1% threshold for O_2 at the compound can be limited to the "utilisation" gas line, and the gas quality abstracted at the "flare" line wells can have a higher O_2 content.

This will need to be monitored carefully as it should be noted that the CO threshold of 100ppm currently used by CEL cannot be used reliably as an indicator of an incipient landfill fire at this Site, as the CO sensor suffers from high H_2S cross interference on the portable gas analysers. This means more care in gas field balancing will be required going forward. Any CO readings that exceed 100 ppm need to be confirmed by bag samples or Draeger tubes. As a rule, gas field balancing is undertaken by site based staff, and staff respond to system changes with knowledge of the entire system rather than in response to barometric pressure fluctuations.

The locations of these sources of emissions to air are shown on Drawings 4 and 5: Egniol Drawing 5883.GA.D02 Monitoring & Extraction Point Plan. Part 1: In-waste Points; and Egniol Drawing 5883.GA.D03.D. Monitoring Plan Part 2: External Points.

Full technical specifications of the gas utilisation plant are provided in Appendix B.

3.5 Landfill Gas Collection Infrastructure – Medium Term Strategy

The on-site gas collection infrastructure comprises of a network gas of wells drilled in every landfill cell. These are connected, via transmission pipework, to the gas utilisation plant.

Currently, there are approximately 40 vertically drilled landfill gas extraction wells with a casing diameter of 160mm to 250mm. The majority installed in the last 5 years are 250mm as the wells need to be accessible for pumps and this size last longer and gives fewer trapped pumps. There are currently 22 temporary pin wells. The wells are drilled no closer than 3m from the base of the landfill to ensure there is no interference with the basal lining system. They are typically situated with a nominal spacing of approximately 30m with a maximum spacing of 40m. The wells have been spaced with a radius of influence to ensure that the landfill gas is drawn back towards the centre of the Site and away from the side slope liner.

There are at present 4 operational horizontal wells installed to assist odour control measures in the active area of the valley on the edge of the site. These were essentially simple horizontal trenches with a well casing pipe laid within. Since HOR3 has failed within just a few months of installation, all future horizontal gas wells, whether radial, to recover gas from the operational areas prior to drilling of deep wells, or concentric, to recover gas from the shallow parts of the Site where vertical wells are not practicable, will be constructed as horizontal trenches with a stone aggregate used as the base of the trench and to cover the gas well to a depth of 0.5m both above and below the installed horizontal well, before waste is emplaced above the gravel trench. A geotextile may be used to also help stop fines blocking the horizontal gas wells.

Wellheads and pipework in all cells are currently located above ground. The wells are connected to spur lines via 63 mmOD flow lines if they are positioned above the spur connection, where operational factors mean gas lines may need to be regularly moved, or 90 mmOD flow lines if it is positioned below the spur connection, on permanent capping. 90 mmOD flow lines will be installed on the outermost wells on the permanent capped areas when the ring main is completed around the north of the Site. Each flow line is connected to the spur via an electrofusion saddle. A 2" ball valve or angle seat valve connected on the flow line allows the well to be balanced. Each flow line has a sample point and flow measuring point fitted at the junction to the Spurs or Ring Main, to allow individual gas well measurement and balancing.

The leachate towers are usually connected to the system but have two valves the nearest to the tower is used to isolate the tower for works and is fully open in normal operation and the second is the control valve which is used to balance the towers gas flow and will be set during gas monitoring this layout allows the tower to be isolated for regular works such as pump exchange by site or contractors and not require a resetting of the balancing valve on reconnection and avoids towers being left off line awaiting attention of gas operations or being put on full flow and losing the balanced setting.

The current gas field layout with 27 new or replacement gas wells were installed between September and December 2021 is shown on Drawing 6: CLP Drawing CLP3573 Walleys Landfill Site Infrastructure Update dated 14 January 2022. The itemised works for these 27 new and replacement gas wells is set out in Appendix A and the Construction Quality Assurance Plan for these works is attached at Appendix D.

The current layout for gas transmission pipelines comprises a horseshoe layout of a large diameter 315 mmOD partial ring main off the waste mass to the east, and a pair of central Spur lines. The ring main has not yet been laid to the west. The Spur transmission lines are 250 mmOD gas lines and are generally operating at the Environment Agency's preferred maximum landfill gas abstraction velocities of 6 m/s [1].

The eastern 315 mmOD partial ring main has been in place for some years awaiting landfill operation and is to be extended to collected gas from the central and eastern area of the site. This gas transmission line has recently been connected and commissioned and has been recovering small volumes of landfill gas from four horizontal wells (HOR1 – HOR5 on Drawing 6). The two Spurs are located on built up bunds to cross the valley to the gas compound each has sealed knockout (K/O) pots and fitted air pumps.

The active gas extraction system is progressively upgraded as waste infilling progresses. Additional or replacement wells are regularly installed as required to ensure both an optimal gas extraction for utilisation and low environmental risks.

The risk for odour resulting from any fugitive emissions of landfill gas is managed in accordance with the Odour Management Plan for the Site. Each gas well is inspected during each gas field balancing exercise. If any defects are noticed, repairs are undertaken, immediately if practicable, otherwise addressed as soon as possible.

Hydrogen sulphide (H_2S) gas concentrations are elevated in parts of the Site. As a generalisation across active landfill sites, leachate towers can act as conduits for hydrogen sulphide emission. Pin wells, like the leachate towers, may also draw in more air into the gas

[1] Landfill Gas. Industry Code of Practice. Environmental Services Association, March 2012.

collection system than may be ideally required for utilisation, and these wells have been generally closed or on low flow to limit oxygen ingress into the gas transmission system to meet CEL's criterion for 1% oxygen at the gas compound for utilisation.

It is prudent and best practice to maximise gas collection and control with economic energy generation by increasing the volume of gas which is recovered from the body of the Site in a manner which allows different sources of gas to be either flared or utilised. Only gas to be used in engines on the pressure side the system is treated.

Because of the elevated H_2S concentrations, an ideal approach would be to only scrub the gas with a lower hydrogen sulphide content for the purposes of utilisation, and the remainder of the gas can be simply flared without prior treatment, subject to maintaining air quality objectives at the local receptors from the combination of exhaust gases from the Site.

Twenty-seven new and replacement gas wells have been installed between September and December 2021 (See Appendix A and Drawing 6), and from previous experience a reservoir of gas may be tapped from these gas wells which will require flaring. To deal with this, and the potential increase in recovered gas volumes, the proposed changes to the gas management infrastructure separate the gas into two streams:

- **The "Utilisation Gas" partial ring main.** The existing 250 mmOD gas transmission lines are retained for recovering gas for gas utilisation purposes. These 250 mmOD gas lines will collect gas from wells in the main body of the site where gas quality is generally better for utilisation purposes. Generally, this will be assessed upon H_2S content. These 250 mmOD gas lines will ultimately be joined to make an inner ring main to collect the gas from the older parts of the Site. These gas lines will be operated at 1% oxygen ingress to meet CEL's gas engine inlet gas criterion.
- **The "Flare Gas" partial ring main.** A second 250 mmOD gas transmission line will be laid close to the existing lines on both the eastern and the western flanks; be extended to the northern boundary of the Site to allow its future extension to the east to connect to the 315 mmOD gas line, and westwards to allow gas to be recovered from the waste to be filled on the western flank. This gas line will take the gas from all the pin wells and leachate towers across the Site. These structures often show higher oxygen and balance gas concentrations and the gas in these structures can then be collected without the risk of compromising the gas quality in the utilisation gas line. We have observed that new gas wells, pin wells and leachate towers may also contain elevated concentrations of H_2S, and so within the main body of the site, we propose the gas wells will have saddle connections at the ring mains allowing the gas to be switched between either ring main depending upon the gas quality within the gas well at the time of monitoring.
- **Ring main flexibility.** Each permanent gas well which is inboard of both ring mains will have a saddle fitting and two control valves where the transmission line reaches the two ring mains, to allow routing of the gas from the well to either the "Utilisation Gas" line or to the "Flare gas" line, as required. As the waste ages, the hydrogen sulphide loading will change and the gas from each main gas well can be routed to either ring main as required. We envisage the gas from freshly drilled wells will first be collected in the "Flare Gas" lines, and after the gas quality has improved, these can be transferred to the "Utilisation Gas" lines, to maintain the gas volumes required to operate two nominal 1Mwe gas engines in preference to flaring.

- Both new “flare gas” lines will cross the valley in parallel with the existing valley crossings and have their own knock-out pots.

In order to accommodate the Environment Agency’s requirement for continuous flow monitoring, three flow meters have been fitted. One will be used to measure the flow to the gas engines, one to the flares, and one the overall gas flow into the compound.

The flow meters have been installed by Uniflare and have a display/recording unit and telemetry for remote access.

As another measure required by the Environment Agency, CEL has installed an Ambisense unit to record CH_4, O_2, CO_2, and suction. This approach has been used on CEL’s remote sites previously. It will require added treatment for inlet gas to the unit to avoid damage by H_2S.

The gas wells and extraction infrastructure are installed according to Construction Quality Assurance (CQA) principles and a CQA plan is produced and followed for each installation and replacement phase of the gas management system. The CQA plans are held at CEL's office in Bolton for reference and are submitted to the Site operator and the Environment Agency for approval before any installation.

In order to achieve the medium-term strategy for landfill gas recovery and the long-term goal for air quality management, initially a number of short-term works for the gas transmission lines are proposed by CEL. These will need to be developed into the medium-term strategy set out herein. The points below refer to locations on Drawing 6: CLP Drawing CLP3573 Design 1 dated 20 September 2021. Infrastructure Works.

315mm Outer Link Line

- Point 1: Connect 315mm to existing 250mm.
- Point 2: install road crossing at location shown on Drawing 6. This will involve digging down and installing 540mm steel tubes followed by sliding the 315mm pipe through. Hardcore will be installed on the bed and above the steel tube to give full protection for the ring main.
- Point 3: KOP to be installed.
- Point 4: 315mm main will be extended and connected to existing 315mm main.

These works will create an inner ring main with 1 x 315mm spur and 2 x 250mm spurs.

250mm Separation or “Flare Gas” Line

- Point 5: 250mm tee with valve will be installed onto existing 250mm line.
- Point 6: New section of 250mm main will be installed to run parallel with existing 315mm main.
- Point 7: KOP to be installed at low point of the main. This is a sealed pot, and condensate will be tied into the existing line that runs from the main KOP at the compound.
- Point 8: 250mm tee to be installed into existing 250mm flare line.

These works will give the option to isolate the separation line to the flare if the new wells contain high H_2S.

The proposed methodology for the control and balancing of landfill gas, used for the "Utilisation Gas" or "Flare Gas" lines will be that the overall suction and gas parameters will be the same as set out in CEL's procedures, since the gas wells are all in the same waste. Inevitably some wells could be in the zone of wells on the other system and be affected. Should a dual system be in place and if one well was gaining H_2S from another, it would meet the condition for swapping lines - if all flows and other parameters were balanced. If spaced correctly, all wells will affect others, and so the new wells will be added to the gas reports and the monitoring will simply expand to cover this and reports will be made as existing on any changes.

The "Flare Gas" line is currently directed to the standby booster, so there will not be any change in the compound systems. CEL have stated the design will allow separate flow for the new wells to the standby flare which has its own booster and a flow measuring point. Once the 28 new wells are on line, further gas management decisions will be made on the basis of gas quality and flow data from this part of the gas field.

Drawing 6: CLP Drawing CLP3573 Design 1 dated 20 September 2021. Infrastructure Works., show the current agreed gas field proposals. We are awaiting updated layout drawings of the gas compound and these will be issued when available, but P&ID drawings for the gas compound and for the scrubbing silos are attached at Drawing 7 and 8. Additional Drawings for the changes to the gas system will be submitted as part of the ongoing CQA process.

Appendix A lists the proposed activities for the gas field infrastructure development in detail.

3.6 Installing New/Updating Existing Gas Collection Infrastructure

Prior to the development of each phase of installation of gas well or other gas collection and control infrastructure, details on how the gas extraction system will be progressively upgraded as waste filling progresses will be produced in the form of a CQA plan. The CQA Plan will include a detailed method statement for progressively upgrading the gas control infrastructure (sacrificial, horizontal, pin wells and full extent gas wells), including in the operational areas, to ensure efficient gas extraction is maintained at all times. No operational gas extraction well or critical part of the gas control system will be disconnected, unless a risk assessment has been undertaken to demonstrate that measures are being taken to prevent uncontrolled gas emissions causing an environmental impact.

The infilling of the landfill, in areas where void is available will be undertaken in a progressive and phased manner. This occurs up to pre-consented levels, in line with the Sites permissions. Alongside this process, it is necessary to ensure that effective gas control maintained and therefore the Landfill Gas collection and control infrastructure required to achieve this is subject to variation over time as the site develops. It will be necessary to extend the gas infrastructure, as the site progresses, to ensure that there is effective coverage. In addition, existing infrastructure already installed may be subject to alteration, amendment and extension in line with the process of infilling available void within the site.

Installation of new wells within the site will be subject to a detailed and specific CQA plan, pre-approved with the Environment Agency. This will detail the methodology, type of installation and depths of drilling, amongst other parameters. Once works are complete, a subsequent CQA report will be issued to the Environment Agency, detailing the installations undertaken and requesting comments and their specification.

Connective Landfill Gas infrastructure is installed in line with the LFGMP. This is submitted at appropriate intervals to the Environment Agency for review and approval. The LFGMP explains

the installed and proposed infrastructure required to effectively manage the landfill gas produced from the site. Additionally, where it is necessary to relocate the infrastructure, either temporary or permanent in nature, this is notified to the Environment Agency in advance and may lead to the LFGMP being updated.

As the void is progressively infilled, it is necessary in areas of significant depth to increase the length of installed wells. This is to ensure that they remain in situ and commensurate to the landfill surface at any particular time. This maintains effective extraction during the infilling phase of operations. In order to achieve this, the Environment Agency and the specialist gas contractor (CLP Envirogas Ltd) are informed in advance of wells requiring extension. Typically, well extensions are undertaken by our specialist contractor (CLP Envirogas or a contractor on their behalf). Where wells require isolating, the principles of isolating the fewest wells necessary, for the shortest time period possible is adhered to.

3.7 Condensate Management

The gas field is designed with condensate removal facilities placed in low spots in the system. These consist of sealed knock out pots (KOP) that are in effect sealed and pumped sumps. Pumped sumps are sealed units usually situated outside the waste mass.

There are a few gravity drain legs designed to drain condensate directly into the waste mass and use a barometric lance to prevent air ingress.

The compound also has a pumped sump in the gas utilisation compound.

The 63 mmOD gas pipework is sized to enable manhandling during the operational phase and larger 90 mmOD pipework will be installed to minimise blockage by the accumulation of condensate on the wells installed in final capped areas. The risk of blockage on 63 mmOD gas lines is minimised by ensuring that pipework is laid to suitable falls.

Each gas transmission line is passively dewatered at designed low points where expansion vessels are used to slow gas velocity and aid de-watering. Any condensate collected is pumped via air or electric pump back to the waste mass.

3.8 Gas Management Responsibilities

The scope of gas management and monitoring works is outlined in Table 3 below.

3.9 Competence and Training

The Site is run by a technically competent manager who has a Certificate of Technical Competence (CoTC) issued by the Waste Management Industry Training and Advisory Board (WAMITAB) for managing Landfill Hazardous Waste (Level 4) – 4LH along with a continuing competence certificate. The Site manager will remain qualified to supervise the landfill operation by undertaking re-testing every two years.

Site operatives are fully trained in operational procedures, undertaking site surveys and reporting non-operational conditions. All site users (including the site operatives) are inducted on their first visit to Site.

Walleys Quarry training records are kept at the Site office, and CEL training records are kept at their head office in Bolton. They can be made available for inspection on request.

Table 3. Landfill Gas Management Responsibilities at Walleys Quarry Site

What	Who	When
NORMAL OPERATING CONDITIONS		
Gas collection	CEL	Continuous
Gas utilisation (energy production)	CEL	Continuous
Gas flaring	CEL	When collected gas cannot be utilised
Gas system inspection	CEL	Daily with monthly recorded inspections
Gas field balancing in in-waste LFG quality monitoring	CEL	Monthly
Ensuring EP compliance	The Operator / CEL	Continual
Preparation & submission of monitoring reports to EA	The Operator	As per Schedule 4 of the EP
Perimeter borehole monitoring	The Operator	Monthly
Perimeter borehole maintenance	The Operator	When required
Engine Emission Testing	CEL	Annual using MCERT contractors, quarterly using in house monitoring equipment
Flare Emission Testing	CEL	Annual if run >10% of the year
Trace Gas Testing	CEL	Annually
LFG Surface Emissions monitoring	The Operator	Currently reduced to every 2 months from annually
SCHEDULED GAS SYSTEM MANAGEMENT ACTIVITIES		
Gas system design	CEL approved by The Operator	As required
Gas system installation/alteration	CEL	As required
CQA inspection & validation	CEL	As required during gas system installation/alteration
Gas system commissioning	CEL	As required
Gas pipework connection/disconnection	CEL	As required
Gas system maintenance	CEL	As per maintenance schedule
Condensate removal from gas system	CEL	As required
UNSCHEDULED AND EMERGENCY OPERATING CONDITIONS		
Resolving mains power supply failures	CEL / The Operator	Automatic monitoring system to alert CEL and WQ (see Appendix A) so that CEL can attend and start back-up generator. WQ can alert EA and other parties.
Resolving gas system failures	CEL	Arrive at site within 3 hours (as per gas agreement) and resolve as soon as possible
Resolving gas engine failures	CEL	Arrive at site within 3 hours and resolve as soon as possible
Resolving gas flare failures	CEL	Arrive at site within 3 hours and resolve as soon as possible
Resolving gas well failures	CEL	Arrive at site within 3 hours and resolve as soon as possible
Dealing with in-waste fires/explosions	The Operator / CEL	Immediately
Investigating and responding to gas-related odour complaints	The Operator / CEL	Immediately upon receipt of complaint
Unscheduled monitoring	The Operator / CEL	As soon as possible

4.0 LANDFILL GAS MONITORING PLAN

4.1 General

This Monitoring Plan details the monitoring and assessment carried out in accordance with the Site's environmental permit against the relevant assumptions, parameters and results of the gas risk assessment submitted in relation to this landfill site.

On Site, landfill gas emissions are regulated to control and minimise lateral migration of landfill gas and surface emissions, and gas plant emissions to air. Routine landfill gas monitoring was carried out in accordance with the relevant provisions of the EP Schedule 3, as follows:

- Table S3.2 Point source emissions to air
- Table S3.5 Landfill gas in external monitoring boreholes
- Table S3.8 Landfill gas emissions from capped surfaces for cells that have accepted non-hazardous biodegradable waste
- Table S3.10 Landfill gas – other monitoring requirements (in-waste monitoring points, gas collection system, input to LFG utilisation compound).

4.2 Point Source Emissions to Air

Monitoring of the landfill gas flare and landfill gas engine emissions to air at Walleys will be carried out as per Schedule 3 of the site Environmental Permit requirements as detailed in Table S3.2 replicated in Table 4 below.

Table 4. Point source emissions to air (EP Table S3.2)

Emission Point Reference	Parameter	Source	Limit	Reference Period	Monitoring Frequency
Landfill gas engines A1, A2 and A4	Oxides of Nitrogen	Gas utilisation plant	500 mg/m^3	Hourly mean	Annually
	CO		1400 mg/m^3		
	Total VOCs		1000 mg/m^3		
Fixed gas flare A3	Oxides of Nitrogen	Landfill Gas Flares	150 mg/m^3	Hourly mean	Annually*
	CO		50 mg/m^3		
	Total VOCs		10 mg/m^3		
Mobile gas flare, and temporary gas flare	Oxides of Nitrogen	Landfill Gas Flares	150 mg/m^3	Hourly mean	Annually*
	CO		50 mg/m^3		
	Total VOCs		10 mg/m^3		

*Monitoring of the flare is unnecessary where the flare is active for <10% of the year.

The locations of these sources of emissions to air are shown on Drawings 4 and 5: Egniol Drawing 5883.GA.D02 Monitoring & Extraction Point Plan. Part 1: In-waste Points; and Egniol Drawing 5883.GA.D03.D. Monitoring Plan Part 2: External Points.

Point source emission monitoring for the engine will be carried out in accordance with the Environment Agency's technical document M2, v.10 (2013) or such other subsequent guidance as may be agreed in writing with the Environment Agency.

A designated sampling port on the gas engine and flare(s) will be used for stack gas monitoring and gas sampling. A temporary platform will be erected to allow access to the sampling port. Sampling will be carried out when the engine/flare is operating normally.

Sampling will be carried out by a specialist company which is endorsed by the Source Testing Association (STA) and have UKAS accreditation coveting on-site testing. All analysis will be undertaken by a UKAS accredited environmental laboratory.

A two-man sampling team will carry out monitoring works to comply with Health and Safety requirements for working at height and hot surfaces.

4.3 Landfill Gas in External Monitoring Boreholes

Landfill gas concentrations are monitored at 61 external monitoring boreholes (deep and shallow standpipes) as per Schedule 3 of the Site's environmental permit Table S3.5, replicated in Table 5 below.

Table 5. Landfill gas in external monitoring boreholes (EP Table S3.5)

Monitoring Point Reference	Parameter	Limit	Monitoring frequency
Landfill gas monitoring points	Methane	1% v/v	Monthly
	Carbon Dioxide	7% v/v	
	Oxygen	[no limit]	
	Atmospheric pressure	[no limit]	
	Differential Pressure	[no limit]	

Monitoring borehole locations are shown on Drawing 5: Egniol Drawing 5883.GA.D03.D. Monitoring Plan Part 2: External Points.

4.3.1 Background Concentration Assessment

The above limits are not based on background concentrations (as referenced in The Environment Agency's Technical Guidance Note on the Management of Landfill Gas LFTGN03). This presents difficulty in regulating lateral emissions at the Site due to other proven off-site sources.

Industry Code of Practice (ICoP)[2]: Perimeter Soil Gas Emissions Criteria and Associated Management provides a reference method to establishing background concentrations of CH_4 (methane) and CO_2 (carbon dioxide) at landfill sites ahead of and following, the placement of waste in any engineered cell. Statistical techniques are used to define background limits on a well-by-well basis rather than a site wide basis.

The ICoP advises that *"the presence of strata such as the Coal Measures near the site can make setting background concentrations problematic. Coal Measures strata produce methane and carbon dioxide. The mechanisms for release of methane and carbon dioxide from these*

[2] Industry Code of Practice (ICoP): Perimeter Soil Gas Emissions Criteria and Associated Management. January 2011

strata are poorly understood, with perhaps their own 'coal gas' cycle. However, when mines gases appear in landfill monitoring wells the increase in concentrations are often short lived and may or may not be linked to external influences such as the weather."

Also, the ICOP advised that "*CO_2 is not an appropriate choice of gas to use to regulate emissions from landfills because there are alternative sources in the subsurface environment."*

The ICoP recommends using monitoring records to determine background concentrations based and borehole specific basis Action Levels. Action Levels are set for landfill operator's management purposes and form an early warning which should instigate an investigation, additional monitoring and/or emergency procedures. The Environment Agency does not need to be informed of an exceedance of the Action Level. Action Level is the gas concentration between the background concentration and the Compliance Limit.

The ICoP follows an approach based on a methodology detailed in the Environment Agency Guidance P1-471[3] to establish the maximum background level of CH_4 and CO_2. The P1-471 multiple outlier test is a screening tool which 'cleans up' data to estimate baseline statistics. The method standardises and ranks the data (No. - Mean / Standard Deviation) and compares the maximum value (Tmax) to a critical value at P = 1%. If the Tmax is not greater than the critical value (specific to the size of the dataset), then the Tmax is not an outlier and should be used for setting background level. Otherwise, the highest point value should be removed from the dataset and the Tmax value becomes the second highest value of the standardised dataset, and the second highest Tmax should be used setting background levels.

The Action Levels should be augmented where applicable by a Factor of Safety (FoS) to make a clear distinction between background and other sources of gas. The application of a FoS is dependent on the stability of the ground gas data set. An unstable data set is suggested to occur when *'…the range in concentration values (between high and low data) is > 8% v/v, but this will be decided on a site-by-site basis'*. *A stable data set can therefore be presumed when for example the majority of data points are located within the range 0 – 5 % v/v, 5 – 10 % v/v and so on."* A FoS is not applied to unstable data sets and instead

The multiple outlier test identifies and 'removes' data points assumed to be erroneous to the wider data set (be they high or low) leaving a statistically significant distribution of data.

An unstable data set will be reflected by the majority of values appearing to be randomly distributed between the maximum and minimum values which may be at least > 8 % v/v apart. An objective assessment of the data set us therefore required (informed by the statistical analysis) to justify whether a Tmax / FoS based Action Level is appropriate.

Table 6a and 6b summarise the approach for setting up Action Levels for methane and carbon dioxide in ground gas.

In addition to operator's Action Levels, the ICoP proposes setting borehole specific Compliance Limits to allow pragmatic regulation of the landfill gas emissions.

[3] Techniques for the Interpretation of Landfill Monitoring Data. Guidance notes. Technical Report P1-471 (Environment Agency 2002)

Table 6a. CH4 and CO2 Action Levels (stable concentrations)

CH4 Action Level	CO_2 Background Concentration	CO_2 Action Level (incl FoS)
Tmax +0.5%	Tmax CO2 concentration in range 0 - 5%	Tmax + 1%
Tmax +0.5%	Tmax CO2 concentration in range 5 – 10%	Tmax + 2%
Tmax +0.5%	Tmax CO2 concentration in range 10 – 20%	Tmax + 3%
Tmax +0.5%	Tmax CO2 concentration in range 20 – 25%	Tmax + 4%
Tmax +0.5%	Tmax CO2 concentration in range >25%	None*

* If background CO_2 concentrations are routinely greater than 25 % v/v, then setting Action Levels is unlikely to be appropriate when trying to assess migration from landfills.

Table 6b. CH4 and CO2 Action Levels (unstable concentrations)

CH4 Action Level	CO_2 Background Concentration	CO_2 Action Level
Tmax	Non applicable	Tmax

In addition to operator's Action Levels, the ICoP proposes setting borehole specific Compliance Limits to allow pragmatic regulation of the landfill gas emissions.

Compliance Limits are a regulatory requirement, and they are set out by the Environment Agency in the Environmental Permit and are designed to show the gas control system and the liner, are performing properly. Any breach of the Compliance Limits for methane as a potential indication that a failure of gas control has occurred. Above a Compliance Limit there will be a presumption that the elevated methane is from the landfill until proved otherwise. Compliance Limits are a regulatory requirement, and they are set out by the Environment Agency in the Environmental Permit and are designed to show the gas control system and the liner, are performing properly. Any breach of the Compliance Limits for methane as a potential indication that a failure of gas control has occurred. Above a Compliance Limit there will be a presumption that the elevated methane is from the landfill until proved otherwise.

The ICoP proposes the Compliance Limits to be included into the Environmental Permit for the site, as follows:

- *No compliance limits are suggested for scenarios where background methane concentrations are > 10% v/v.*
- *For every well under post-critical gas production conditions, the compliance limit will be 1% methane above the Tmax methane concentration (the justification of an alternative statistical tool may be applicable on a site-by-site basis).*

4.3.2 Background Concentration Assessment Results

A 22-month monitoring data set (Jan. 2018 – Oct. 2019) for both bulk gases was used to assess and determine the background concentrations. The dataset was prior screened for anomalies using the appropriate statistical method. Specifically, for borehole 17D in which

elevated levels of both methane and carbon dioxide were detected prior to landfilling at the Site, a long-term data set (2008-2019) was used to establish the above assessment levels.

Methane

Long-term monitoring data shows that methane is not detected in perimeter boreholes (apart from BH17D) at concentrations in excess of the current Compliance Limit of 1%v/v. Borehole 17D was known to detect methane (and carbon dioxide) at variable concentration prior to commencing landfill operations and also during the operational period of the Site. Therefore, apart from this monitoring point it is considered appropriate to continue using the current Compliance Limit for methane of 1%v/v for all perimeter boreholes.

Borehole specific Action Level and Compliance Limits for borehole 17D are detailed below.

Table 7. Proposed CH4 Action Level and Compliance Limit in Borehole BH17D (based on a 140-month data set 2008-2019)

Monitoring Point	CH_4 Tmax (%v/v)	CH_4 Action Level (%v/v)	CH_4 Compliance Limit (%v/v)
17D	6.2	4.4*	6.2

*Action Level of 4.4%v/v was set up in agreement with the Environment Agency to provide an assessment level that is below the LEL in order to provide a reasonable safeguard.

Carbon Dioxide

Application of the current Compliance Limit for carbon dioxide of 7%v/v was revised taking into account the background concentrations of the gas. Certain boreholes required a risk-based specific Action Levels for CO2 to be adopted. The results of the assessment are summarised below. The proposed borehole specific Action Levels for CO2 are highlighted in Red. The remaining boreholes will continue to be assessed using the current CO_2 Compliance Limit of 7%v/v.

Table 8. Proposed CO2 Action Levels in Perimeter Boreholes (based on a 22-month data set 2018-October 2019)

Monitoring Point	CO_2 Tmax (%v/v)	CO_2 Action Level (%v/v)*	CO_2 Data Stability	Risk Level and Justification	Receptor to LFG
WAL_104	1.2	2.2	Stable	Active gas management by extraction and utilisation. Low risk of gas migration off site via engineered landfill liner and clay-based geology. Compliance limits: 1% CH_4, 7% CO_2 in BHs other than those where	Dwelling and public amenity sites as listed in LFGRA.
209AS	2.5	3.5	Stable		
209AD	2	3	Stable		
201S*	3.3	4.3	Stable		
201D*	1.9	2.9	Stable		
202S	1.1	2.1	Stable		
202D	0.9	1.9	Stable		
203S	2	3	Stable		
203D	0.5	1.5	Stable		
204S	0.3	0.4	Stable		

Monitoring Point	CO_2 Tmax (%v/v)	CO_2 Action Level (%v/v)*	CO_2 Data Stability	Risk Level and Justification	Receptor to LFG
204D	0.2	1.2	Stable	BH specific CO_2 Action Levels are proposed. As above	As above
205S	3.8	4.8	Stable		
205D	1.2	2.2	Stable		
206S	4.4	5.4	Stable		
206D	1.1	2.1	Stable		
207S	1.2	2.2	Stable		
207D	2	3	Unstable		
01S	2.8	3.8	Stable		
01D	3.6	4.6	Stable		
02S	1.2	2.2	Stable		
02D	4.4	5.4	Stable		
03S	4.6	5.6	Stable		
03D	8.8	8.8	Unstable		
04S	8.1	10.1	Stable		
04D	2.8	3.8	Stable		
05S	8.4	8.4	Unstable		
05M	7.1	9.1	Stable		
05D	13.6	13.6	Stable		
06S	1.5	2.5	Stable		
06D	2.6	3.6	Stable		
07S	0.5	1.5	Stable		
07D	1.9	2.9	Stable		
08S	3.6	4.6	Stable		
08D	3.6	4.6	Stable		
09S	4	5	Stable		
09D	3.5	4.5	Stable		
10S	3.3	4.3	Stable		
10D	0.3	1.3	Stable		
11S	1.6	2.6	Stable		
11D	0.5	1.5	Stable		
12S	0.6	1.6	Stable		
12D	0.4	1.4	Stable		
13S	4.2	5.2	Stable		
13D	1.3	2.3	Stable		
14S	2.0	3.0	Stable		
14D	2.8	3.8	Stable		
15S	0.8	1.8	Stable		
15D	2.3	3.3	Stable		
16S	6.2	8.2	Stable		
16D	4.5	5.5	Stable		
17S	6.8	8.8	Stable		
17D**	11.3	11.3	Unstable		
18S	5.3	7.3	Stable		
18D	4.8	5.8	Stable		
19S	6.6	8.6	Stable		

Monitoring Point	CO_2 Tmax (%v/v)	CO_2 Action Level (%v/v)*	CO_2 Data Stability	Risk Level and Justification	Receptor to LFG
19D	2.1	3.1	Stable	As above	As above
20S	7.3	9.3	Unstable		
20D	1.5	2.5	Stable		
21S	0.9	1.9	Stable		
21D	0.7	1.7	Stable		
22S	1.4	2.4	Stable		
22D	9.4	9.4	Unstable		
23S	7.5	9.5	Stable		
23D	3.8	4.8	Unstable		

* Levels updated incl. monitoring data for 2021 after the borehole has been reinstated: 201S (29 entry data set), 201D (9 entry data set).

** based on 140 entry data set

4.3.3 Monitoring Methodologies and Equipment

The monitoring will be undertaken in accordance with the Environment Agency's Technical Guidance LFTGN03 (September 2004) or such other subsequent guidance as may be agreed in writing with the Environment Agency.

Meteorological conditions will be recorded at the time of the gas monitoring and include the general weather conditions, atmospheric pressure prior to and following field work, and ground conditions (waterlogged, frozen, snow covered) at the site of gas monitoring.

Field monitoring of landfill gas will be carried out using a real-time landfill gas analyser capable of measuring concentrations and recording results for methane, carbon dioxide and oxygen (GA5000 or similar, with H_2S and CO sensors with appropriate concentration span settings). The landfill gas monitoring procedure used at the Site is included in Appendix C.

The monitoring equipment will be maintained in good working condition and serviced according to manufacturer's recommendations. The calibration certificate and a log of any maintenance will be retained on Site. Instrument service and calibration dates will be provided should the Environment Agency so request. CEL hold Calibration gases on site for routine checks between services.

All landfill gas monitoring data will be entered directly onto an electronic database system and checked against Action Levels, after every survey. If the levels are exceeded, the cause should be investigated. In particular, the gas plant operation shall be verified, and a review against recent changes in leachate head shall be investigated. If required, the Action Plan (Section 5) will be instigated.

4.3.4 Borehole Access and Maintenance

Maintenance of borehole headworks, locks, signs/identification labels and sampling ports will be the responsibility of the site manager.

Any faults will be repaired promptly following detection of the faults. Details of faults should be noted during the routine gas monitoring by the monitoring personnel and reported to the site

manager. An identified need for maintenance of a particular installation should not reasonably prevent routine sampling and monitoring data being obtained.

A safe access to all gas monitoring boreholes shall be provided at all time. Vegetation should be cut as necessary from around both flush and raised headworks. The boreholes shall be clearly visible and clearly identified on the ground.

4.4 Landfill Gas Surface Emissions

4.4.1 Monitoring Requirements

Surface emission monitoring will be undertaken as per Schedule 3 environmental permit Table S3.8, replicated in Table 9 below.

Table 9. Landfill gas emissions from capped surfaces for cells that have accepted non-hazardous biodegradable waste (EP Table S3.8)

Monitoring point reference	Parameter	Monitoring frequency
Permanently capped zone	Methane concentration	Every 12 months
Temporarily capped zone	Methane concentration	Every 12 months
Whole site	Total methane emission	As agreed with the Environment Agency
Uncapped areas	Methane concentration	Every 12 months

4.4.2 Methodology and Equipment

This gas monitoring will be carried out in accordance with Environment Agency Technical Guidance on the monitoring of landfill gas surface emissions LFTGN07 (v2 2010).

The flame ionisation detector (FID) walkover will be undertaken with a laser methane detector or gas-chromatograph infra-red detector to reduce interference from other flammable gases, such as volatile hydrocarbons. Within the context of landfill monitoring, these detectors are calibrated to methane (CH_4) and have a detection limit of 1ppm. They also include GPS mapping for greater accuracy.

Earlier technologies for surface emissions surveys using true flame FIDs should only be used on an ad-hoc basis and not for compliance reporting, due to their results which can be positively skewed due to elevated levels of other VOCs.

The EP annual “FID” walk-over survey will be carried by systematically traversing the area of interest in order identify the reference zones of the site surface. During the survey methane concentrations will be continuously monitored close to the surface. In addition, any landfill gas and leachate management installations which are present within the assessment area will be individually assessed.

FID surveys have been increased in frequency to every two months to identify points of landfill gas emission for subsequent action. Any defects or emission points identified will be remediated within two weeks of identification.

The EA considers that given the prevalence of high hydrogen sulphide concentrations across the site, rather than use the default threshold for remediation of surface areas of >100ppm

methane, a remedial action level for methane gas emissions targeting areas of >50 ppm is to be applied. This criterion only applies to permanent and temporary capped areas and is subject to review following additional FID surveys and the results of Tier 3 modelling of H_2S surface emissions.

4.5 Landfill Gas - other monitoring requirements

4.5.1 Monitoring Requirements

Other monitoring requirements for landfill gas include the gas collection system and LFG Utilisation Compound as summarised in Tables 10a – 10c.

Table10a. Landfill gas – other monitoring requirements for gas collection system (EP Table S3.10 with updated monitoring frequency)

Monitoring Point Reference	Parameter	Monitoring frequency
Gas collection system at well control valve, manifolds (if applicable) and strategic points on gas system	CH_4, CO_2, O_2, CO Atmospheric pressure Gas flow rate or suction % Balance Gas (calculated as the difference between the sum of measured gases and 100%)	Monthly in the EP or at such other frequency as may be agreed in writing with the Environment Agency. Currently this is weekly for all gas wells, leachate wells and horizontal wells, and twice weekly for strategic monitoring points.
Gas collection system at well control valve	H_2S	Currently this is weekly while H_2S concentrations are elevated

Table 10b. Landfill gas – other monitoring requirements for LFG utilisation compound (EP Tables S3.2 and S3.10 with updated parameters and monitoring frequency)

Monitoring Point Reference	Parameter	Monitoring frequency
Gas quality at the gas compound	CH_4, CO_2, O_2 Gas flow rate Suction % Balance Gas (calculated as the difference between the sum of measured gases and 100%)	Weekly in the EP or at such other frequency as may be agreed in writing with the Environment Agency. Currently continuous monitoring to flares and gas engines, plus twice daily every weekday using hand-held instruments
Landfill gas engines A1, A2 and A4	NOx and CO	Quarterly
Input to flare or LFG Utilisation Compound	Trace gas testing carried out in accordance with LFTGN04 v3 (2010) in both “Utilisation Gas” and “Flare Gas” gas lines, to be sampled and analysed concomitantly.	Annually in the EP or at such other frequency as may be agreed in writing with the Environment Agency, if there is a

		significant increase in H_2S concentrations observed by hand-held instruments.
Fixed gas flare A3 and Mobile gas flare	Temperature Gas flow rate	None specified in the EP, this is at a frequency as may be agreed in writing with the Environment Agency. Currently this is continuous monitoring.

Table 10c. Landfill gas – other monitoring requirements not included in the EP

Monitoring Point Reference	Parameter	Monitoring frequency
Gas quality at the independent Flare	CH_4, CO_2, O_2 Gas flow rate Suction % Balance Gas (calculated as the difference between the sum of measured gases and 100%)	None specified in the EP, this is at a frequency as may be agreed in writing with the Environment Agency. Currently this is twice daily every weekday using hand-held instruments.

4.5.2 Methodology and Equipment

Gas Field

The gas collection system will be monitored regularly to assist the balancing of the gas extraction system. A real-time landfill gas analyser (GA5000 or similar, with H_2S and CO sensors with appropriate concentration span settings) will be used in monitoring of landfill gas concentrations in gas wells and at key points in the gas extraction system. The analysers are maintained in good working order and are calibrated in-line with the manufacturer's recommendations.

CEL operates a series of operational procedures for monitoring, logging, assessment and reporting landfill gas data. The monitoring procedures are in line with the recommendations of the EA's Guidance LFTGN03 Management of Landfill Gas (2004). Gas monitoring procedures are listed in Well Monitoring and Balancing Protocol, CO Monitoring Procedure, Gas Field Operating Parameters. Monitoring of hydrogen sulphide (H_2S) is carried out in accordance with the Safe System of Work for Working in the Presence of Hydrogen Sulphide and Methane. The relevant documents are enclosed in Appendix C.

Where the oxygen concentration exceeds 5%, or 20% of balance gas then an assessment of air ingress into the system will be undertaken. Where the concentration of carbon monoxide exceeds 100ppm then further investigation will be undertaken. Concentrations of hydrogen sulphide will be assessed in accordance with the gas and odour management plans.

Gas Plant

Where the oxygen concentration in the input to flare or LFG Utilisation Compound exceeds 5% or the % balance gas is greater than 20% an assessment of air ingress into the system shall be undertaken.

Monitoring of emissions of NOx and CO will be carried out in accordance with Appendix C of LFTGN08 v2 (2010) or such other subsequent guidance as may be agreed in writing with the Environment Agency. Where monitoring using hand-held, electrochemical equipment indicates an exceedance of the emissions standards specified in Table S3.2, these shall be used as action levels and the operator shall investigate the cause and take appropriate measures to reduce emissions.

Trace gas testing will be subcontracted to a specialist contractor to ensure the tests and analysis are carried out in accordance with LFTGN04 v3 (2010).

Trace gas sampling will be undertaken concomitantly on both the "Utilisation Gas" line to the gas compound and on the "Flare Gas" line to the sour gas flare. Once a complete set of trace gas samples has been undertaken to provide a baseline dataset for 2022, testing will take place concurrently on both gas lines annually or when a significant increase in hydrogen sulphide is detected in either gas line by hand held instruments.

Monitoring of the flare temperature is required to ensure that the minimum temperature of 1000^{o}C is maintained for operational control as per LFTGN05 v2 (2011). The monitoring will be carried out as per M2 or such other subsequent guidance as may be agreed in writing with the Environment Agency.

4.5.3 Redundant Monitoring Requirements in Table S3.10

Monitoring Point Reference / Monitoring Requirements	**Other Specifications**
In waste gas monitoring boreholes or sealed leachate wells or sacrificial gas extraction system in cells for non-hazardous waste. Monthly monitoring of bulk components of landfill gas (CH_4, CO_2), O_2, CO, Differential Pressure, Atmospheric pressure, and Quarterly monitoring of H_2S. For cells or phases which have no active gas extraction.	Gas extraction system shall be installed, and extraction commenced once monitoring shows onset of methane production in waste at a rate that can be sustainably extracted. Once gas extraction has commenced in a particular cell or phase, there is no longer a requirement to carry out this monitoring.
One in waste borehole per cell and / or leachate wells for separate cells for stable non-reactive hazardous waste, asbestos or gypsum on landfills for non-hazardous waste. Monthly monitoring of bulk components of landfill gas (CH_4, CO_2), O_2, CO, Differential Pressure, Atmospheric pressure and quarterly monitoring of H_2S and H_2. Annual monitoring of Trace Gases.	None. Stable non-reactive hazardous waste, although permitted to be deposited at Walleys Quarry LFS, is not accepted by the site operator.

5.0 DATA STORAGE AND REPORTING

Routine gas monitoring data uploaded from the gas analyser is submitted to Walleys Quarry monthly by email. Any exceedances / issues outside and the non-routine data is reported directly to the site manager by the CEL's Landfill Gas Manager.

All data will be reviewed by the site operator, as supplied and assessed for compliance with the Permit conditions.

Schedule 4 (Table S4.1) of the Site's environmental permit lists the reposting requirements for landfill gas monitoring data. The data will be reported to the Environment Agency as listed in Table 11 below.

Table 11. Reporting of Monitoring Data (Landfill Gas) (EP Table S4.1)

Parameter	Reporting Period	Period ends
Point source emissions to air (Table S3.2)	Annually	31st December
LFG in external monitoring boreholes (Table S3.5)	Quarterly	31st March 30th June 30th September 31st December
LFG emissions from capped surfaces (Table S3.8)	Annually	31st December
Other LFG monitoring (Table S3.10)	Quarterly	31st March 30th June 30th September 31st December
Other LFG monitoring - Trace Gas (Table S3.10)	Annually	31st December
Landfill Gas Production (Table S4.2): • Combustion in flare • Combustion in gas engines • Other methods of gas utilisation • Average methane concentration entering the gas plant • Methane generation rate (50%ile from a representative model)	Annually	31st December

The Reporting will follow the requirements of the Site's environmental permit Section 4.2 (Reporting), as follows:

4.2.3 Within 28 days of the end of the reporting period the operator shall, unless otherwise agreed in writing by the Environment Agency, submit reports of the monitoring and assessment carried out in accordance with the conditions of this permit, as follows:

(a) in respect of the parameters and emission points specified in schedule 4 table S4.1;

(b) using the forms specified in Schedule 4 Sable S4.4 or other reporting format as agreed in writing with the Environment Agency; and

(c) giving the information from such results and assessments as may be required by the forms specified in those tables.

4.2.4 Within one month of the end of each quarter, the operator shall submit to the Environment Agency using the form made available for the purpose, the information specified on the form relating to the site and the waste accepted and removed from it during the previous quarter.

4.2.5 The operator shall, unless notice under this condition has been served within the preceding four years, submit to the Environment Agency, within six months of receipt of a written notice, a report assessing whether there are other appropriate measures that could be taken to prevent, or where that is not practicable, to minimise pollution.

Note: regarding Reporting Form for landfill gas, Form LFG1 is not used by the Environment Agency at this Site however all data is submitted by the operator in the format that allows the Regulator to fully assess the reported parameters.

- The quarterly reports will present the data in the tabulated format.
- An annual review of the monitoring data will be collated into an Annual Monitoring Report detailing the following:
- The monitoring work undertaken during the reference period;
- Monitoring results (factual reports and distribution graphs);

A review of the results of the monitoring and assessment carried out in accordance with the Site's environmental permit against the relevant assumptions, parameters and results in the risk assessments submitted in relation to this installation and any agreed amendments thereto. The review will include written descriptions of the improvements made to operational performance during the year, action plans developed and planned improvements for the coming year;

- Implementation of Monitoring Action Plan and actions agreed with the Environment Agency;
- Monitoring issues /constraints during the review period.
- Drawings showing the Monitoring and Extraction Point Plan (MEPP).

6.0 GAS ACTION PLAN

This action plan establishes the steps required to be taken in the event of four key events relating to the control and monitoring of landfill gas at Walleys Landfill Site. These are:

- Failure of the gas extraction system;
- Breach of the Action Levels for methane or carbon dioxide in external monitoring boreholes;
- Hydrogen sulphide in landfill gas;
- Exceedances of carbon monoxide in landfill gas / suspected in-waste fire.

6.1 Failure of Gas Extraction System

Landfill gas is currently managed by placing suction to the completed landfill and burning in in two engines and a flare. Gas extracted has condensate removed by via knock-out pots, gravity drain legs and a pumped sump. Condensate is returned to the waste mass.

The gas extraction system will be inspected during each monitoring visit to ensure the ongoing operation of various components. CEL undertakes continuous checks of the gas collection system for any of the following:

- Failed sampling ports and valves;
- Cracks in any over-ground pipework;
- Leaks at flange connection points on the gas infrastructure;
- Liquid build up in the over-ground pipework;
- Signs of deep-seated fire.

Any identified minor faults will be repaired immediately. In the event of any major defects identified in the system when repair could not be carried out immediately then a temporary fix will be carried out immediately with where possible permanent repair/remediation being undertaken as soon as possible.

A failure of the extraction system to exert suction to the field will trigger the implementation of section A of this Action Plan.

6.2 Breach of Action Levels in Perimeter Boreholes

Landfill gas will be monitored at all boreholes located around the perimeter of the Site. All monitoring data relating to routine and periodic landfill gas monitoring will be entered directly onto an electronic database system and checked against Action Levels.

The Action Levels are outlined in Table 12 below.

Table 12. Landfill Gas Action Levels

Parameter	Monitoring point	Level
CH_4	BH17D	**4.4% v/v**
CO_2	BHs 03D, 04S, 05S, 05M, 05D, 16S, 17S, 17D, 18S, 19S, 20S, 22D, 23S	**based on BH specific Action Levels, as shown in Table 8**

In the events when methane and/or carbon dioxide concentrations in perimeter boreholes exceed the Action Levels, these events will trigger the implementation of **section B1** of this Action Plan.

6.3 Breach of Compliance Limits in Perimeter Boreholes

The revised Compliance Limits are outlined in Table 13 below.

Table 13: Landfill Gas Compliance Limits

Parameter	Monitoring point	Limit
CH_4	All boreholes with no previous history of methane presence	**1.0%v/v**
	BH17D	**6.2% v/v**
CO_2	Landfill gas monitoring points other than those listed in Table 12.	**7%v/v**

In the events when methane and/or carbon dioxide concentrations in perimeter boreholes exceed the Compliance Limits, these events will trigger the implementation of **section B2** of this Action Plan.

6.4 Exceedances of Carbon Monoxide / Suspected In-Waste Fire

Presence of Carbon Monoxide (CO) in landfill gas is a precursor of potential in-waste fire. The CEL limit for CO in gas wells is 100 ppm.

Unfortunately, the CO sensor in the GA5000 (and its precursors) can be positively skewed by elevated H_2S concentrations in the landfill gas, and so when testing for CO there has to be an inline H_2S scrubber that is not saturated with H_2S in order to get a clean CO reading. Any CO readings that exceed 100 ppm need to be confirmed by bag samples or Draeger tubes.

Once a fire or hotspot has been identified CEL will follow a process to contain and control this occurrence; either the CEL's procedure will be adopted, or a set of recommended actions will be discussed and agreed with the site operator.

The Control measures for prevention of subsurface fires are listed in **section C** of this Action Plan.

6.5 Hydrogen Sulphide in Landfill Gas

Hydrogen Sulphide (H_2S) is an extremely hazardous and toxic compound. At concentrations of above 100 parts per million (ppm), a person's ability to detect H_2S is affected. This loss of the sense of smell means the gas can be present in high concentrations with no perceivable odour so a person will continue to breathe in the gas without realising causing possible respiratory failure and death.

Hydrogen Sulphide can settle in low areas, and employees working on landfill sites are issued with personal gas detectors to detect concentration levels of this gas set at current HSE short term and long-term exposure levels.

CEL operates a safe system of work necessary to protect safe operations of the site personnel in relation to working in the presence of hydrogen sulphide on landfill sites. This has been reviewed and several specific RAMS reviewed and updated in light of recent elevated gas levels. The Safe System of Working in the Presence of Hydrogen Sulphide (and Methane) is enclosed in Appendix C. The specific RAMS are held on site and on CEL's intranet CLPNET so staff can access them.

The control of H_2S emissions is also required for prevention of odour events at the site. Control measures for prevention of H_2S emissions are listed in **section D** of this Action Plan.

Draft control measures for managing gas engines and flares following exceedances of H_2S loading rates to the landfill gas engines are listed in **section E** of this Action Plan. These are based on five complete cycles of silo operation and may be subject to future revision.

The Site has experienced a number of short-term power outages recently, and because of the need to maintain hydrogen sulphide emissions at low levels, there will be a standby generator installed at the gas utilisation plant to maintain gas utilisation and flaring in the event of a power outage.

A FAILURE OF GAS EXTRACTION SYSTEM

A.1 Identify cause of failure – CEL on Site within 3 hours. Resolve as soon as possible.

A.2 If electric supply has failed, contact emergency electrician or if mains electricity supply has failed contact the electricity board - instigate CEL's Accident Management Plan (Section 1.4.7) (Appendix C).

A.3 If flare unit has broken down - CEL on Site within 3 hours. Resolve as soon as possible

A.4 If gas engine unit has broken down, CEL on Site within 3 hours. Resolve as soon as possible.

A.5 If gas blower unit has broken down, CEL on Site within 3 hours. Resolve as soon as possible. Spare blower is available at CEL's head office (Bolton) and will be brought to Site within 24 hours if required.

A.6 If the condensate pumping system has failed, CEL on Site within 3 hours. Resolve as soon as possible.

A.7 If there is a suspected fire on Site - instigate CEL's Accident Management Plan (Section 1.2.7) (Appendix C).

A.8 Operator to notify the Environment Agency in accordance with Schedule 5 of the Environmental Permit.

A.9 If elevated levels of methane are identified in the perimeter boreholes, then Section B of this Action Plan should be instigated.

A.10 If the failure results in increased odour release – Operator to follow the Odour Management Plan.

B1 ACTION LEVEL BREACH IN PERIMETER MONITORING BOREHOLES

B.1 The purpose of action levels is for the site manager to take action, and the compliance limit is to assess compliance with the permit. For an action level breach, inform site manager/supervisor immediately and monitor relative gas pressure in the affected borehole(s).

B.2 Immediately start investigating the reason and nature of the breach. Review whether the borehole recorded methane or carbon dioxide in excess of the action level during background monitoring and if so if the concentrations are within normal ranges for the borehole. Review the risk associated with the breach e.g., proximity of properties. Carry out review of gas control system in discussion with CEL and instigate immediate measures to remediate any problems identified. If gas control system has failed instigate Section A of this Action Plan. Review if any sudden changes in leachate levels have occurred. Instigate increased leachate pumping if required.

B.3 Whilst investigation is underway and if the concentrations of methane or carbon dioxide are outside normal ranges for boreholes that record concentrations in excess of action levels during background monitoring, the following measures will be implemented to reduce the methane and carbon dioxide to within the action levels.

- The borehole shall then be monitored weekly, until the gas is below the agreed action level. All results will be forwarded to the Environment Agency.
- Wells associated with the active gas extraction system will be monitored for gas quality.
- If monitoring of the gas extraction system shows that excessive amounts of oxygen are being drawn into the system through the Site, oxygen ingress will be reduced through adjustment of valves on individual wells and extraction points.
- Increased suction will be applied where possible to wells in the vicinity of the affected boreholes.

B2 COMPLIANCE LIMIT BREACH IN PERIMETER MONITORING BOREHOLES

B.4 Follow steps B.1-B.3.

B.5 Notify the Environment Agency in accordance with Schedule 5 of the Environmental Permit.

B.6 The gas monitoring data collected from the affected monitoring point(s) during the investigation will be forwarded to the EA. If after 14 days of non-compliance, methane levels are not reducing (or 4 weeks in the case of carbon dioxide), or a reason for gas migration is not evident, inform the EA.

B.7 Take gas samples as soon as practicable for confirmatory landfill gas chromatography analysis for methane, or trace analysis for carbon dioxide. A review of off-site monitoring measures should also be undertaken.

C SUBSURFACE FIRES

C.1 If a subsurface fire is suspected by the Operator, inform CEL and agree the control and contain process;

C.2 If a subsurface fire is suspected by CEL, inform the Operator and agree the control and contain process;

C.3 CEL to instigate procedures in the Hot Spot Containment Plan (Appendix C).

C.4 The Operator to notify the Environment Agency in accordance with Schedule 5 of the environmental permit.

D H2S IN LANDFILL GAS

D.1 A personal Gas Detector is issued to all CEL and operator personnel. This safety device warns when H_2S exceeds factory set alarm set-points - 5 ppm (low) to 10 ppm (high).

D.2 On discovering the presence of hydrogen sulphide above safe levels CEL's Landfill Site Manager is to be informed as soon as possible.

D.3 H_2S data is logged and added to the H_2S Site Plan drawing indicating elevated H_2S areas. This is a 'live' drawing which is updated as required; each 'elevated' well has signage attached and that level dictates the method of operation around it. Once the H_2S concentrations dropped below safe levels the 'elevated' wells are removed from the H_2S drawing.

D.4 With elevated H_2S readings in the landfill gas, H_2S is being scrubbed prior to testing for CO. If H_2S readings are to be used for gas field management purposes, the GA5000 analyser should be used without an H_2S filter on the inlet to the analyser. The H_2S filter should not be fitted to the outlet port of the analyser to reduce the risks to monitoring staff. Instead, a longer exhaust tube should be used to vent the analyser away from the operator.

D.5 CEL notifies the Operator of any elevated H_2S observations and when noticed by olfactory monitoring.

D.6 The Operator to instigate Odour Action Plan.

E EXCEEDING H2S ENGINE LIMITS IN ENGINE SUPPLY

E.1 The gas cleaning system for the supply to the landfill gas engines has been installed and has undergone at least five full operational cycles. This is a system of two 30m^3 Silos in series. One is filled with activated carbon and one containing impregnated carbon.

E.2 The recommended engine limit is 200ppm of H_2S in the gas supply. The practical limit to avoid serious engine damage is 800 ppm. Above 800 ppm it is likely that serious liner and pistons ring damage could take place, along with build-up of sulphur trioxide ash in the combustion spaces. These effects can cause engine failures to happen very quickly, potentially within 200 – 300 hours. In this period, emission control may be less effective due to ash build up in the combustion space and concomitant damage to spark plugs. Oil life can be shortened to days rather than weeks and corrosion may become evident within the engine. CEL has further confirmed that they can manage the short-term impact on gas engine damage at the maximum engine input levels observed in Figure 1 of 1,720 ppm. These peak concentrations have been reached due to time delays between request and installation of exchange silos.

E.3 The H_2S levels are recorded each working day at Silo 1 input, Silo 1 output, and Silo 2 output. This is shown from initial installation to end of September 2021 in Figure 1 below. and the monitoring process is intended to result in new silos being ordered in time to change before the gas exceeds the limits set.

E.4 Initial experience with one engine from 30 June to 30 July showed that the silos lasted 4 weeks. Under two engine operation this reduced to 14-18 days or less. Breakthrough in silo 1 is almost linear with time, after a short lag period, whereas breakthrough in silo 2 is almost exponential, particularly in the cycle with two gas engines in operation, meaning that when 800 ppm concentration is observed in the inlet gas H_2S concentrations begin to increase more rapidly.

E.5 The inlet gas to the engines over the operational period in Figure 1 has ranged from 0 – 1,720 ppm H_2S with an average of 424 ppm H_2S. This average is below the proposed interim 500 ppm action level but more experience is needed in determining the best point to order replacement silos in order to avoid engine shut-downs or engine operation in excess of the interim action level of 500 ppm.

E.6 **Interim "Action Levels" and "Compliance Limits" for H_2S in the gas engine supply**

Ahead of completion and acceptance of Tier 3 modelling of SO_2 emissions from the gas utilisation compound (gas engines and flares), interim "action levels" and "compliance limits" have been determined which should help to ensure SO_2 air quality thresholds are not exceeded at permanent dwellings offsite.

Action Level to order replacement silo	500 ppm H_2S in the engine inlet line
Compliance Limit	1,800 ppm H_2S in the engine inlet line

These values are interim values based on the initial experience of operating the silos, our understanding of engine operational maintenance requirements, and modelling of the offsite impacts. They will be updated following acceptance by the Environment Agency of Tier 3 modelling.

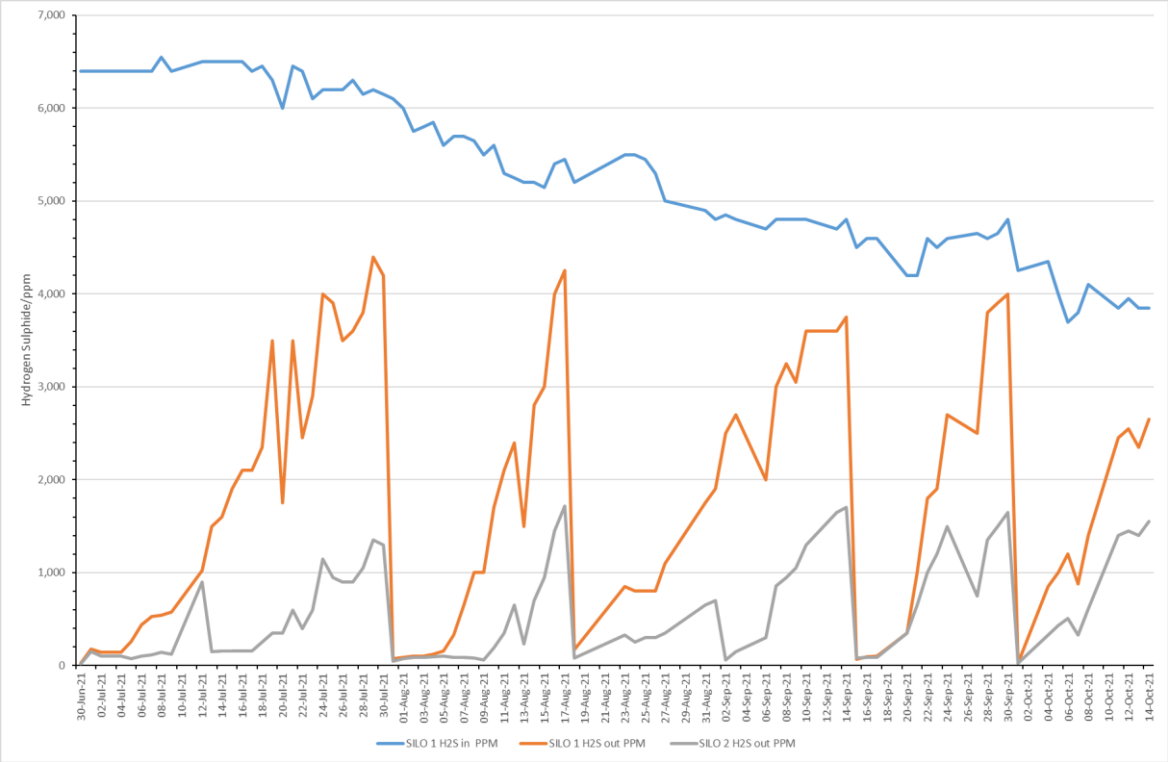

Figure 1. Hydrogen sulphide scrubbing effects through first five cycles.

E.7 The choice of the action level depends in part on what subsequent management activity then takes place. If the action level is used to trigger an order for replacement silos, then this has to be based on the appropriate lag time between the Action Level and the Compliance Limit. If it becomes practicable to keep replacement silos on site and pre-installed, so that a simple switchover between silos is all that is needed, then the Action Level can be relaxed a little.

E.8 Current practice is that the contractor supplying the carbon should be contacted as soon as H_2S concentrations meet the action level of 500 ppm.

E.9 The choice of compliance limit is based on CEL's operations and the results of Tier 3 modelling. CEL's stated management practice is that if the gas to engines after filtration exceeds the of 800 ppm H_2S, the engines will be taken off line and the gas flow will be wholly directed to the Site flares. In practice, CEL operates for short periods above this level. Furthermore, Tier 3 modelling has shown the H_2S concentration at the inlet to the gas engines has less impact on offsite SO_2 dispersion than the volumetric flow of unscrubbed H_2S in the inlet to the flares, so brief periods of engine operation up to 1,720 ppm H_2S are acceptable.

E.10 At concentrations above 9,000 ppm H_2S into the compound, however, the change-over of silos on a 7-day routine is not sustainable as silo life drops below 7 days. Under such conditions, the gas engines would be taken out of service to avoid engine damage. Gas control would then be maintained wholly by gas flares.

E.11 How gas is managed during the changeover of the treatment silos is documented in the relevant RAMS document that can be supplied if required.

Drawings

Appendices

Appendix A

Schedule for Implementation of Gas Field Works

Appendix B

Gas Utilisation Plant Specifications

Appendix C

Landfill Gas Management, Monitoring Procedures, Safe Working Protocols and Action Plans

- Gas Well Monitoring and Balancing Protocol
- Carbon Monoxide Monitoring Procedure
- Safe System of Work for Working in the Presence of Hydrogen Sulphide and Methane
- Gas Field Operating Parameters
- Landfill Accident Management Plan
- Hot Spot Containment Plan

Appendix D

Construction Quality Assurance Plan
The Installation of 28 Gas Wells