GAS RISK ASSESSMENT

CROFT QUARRY
MARION'S WAY
CROFT
LEICESTERSHIRE
LE9 3GP

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1.0 INTRODUCTION

1.1 Scope & Background

1.1.1 Sirius Environmental Limited (Sirius) has been commissioned by Aggregate Industries UK Limited ('AI'), to prepare an application to vary Environmental Permit: EPR/EB3708GW to add a waste recovery activity involving the permanent deposit of wastes to support the restoration of Croft Quarry, Marion's Way, Croft, Leicestershire, LE9 3GP. AI are seeking to commence restoration of the quarry which will bring the final restoration levels to below those of the surrounding natural ground levels. As part of this application, it is necessary to formulate a range of risk assessment documents, including the requirement to undertake a Gas Risk Assessment associated with the quarry restoration activity.

1.1.2 This assessment includes the development a conceptual site model for the proposed waste recovery operation and identifies the potential source-pathway-receptor linkages and direct and indirect pollution risks to the surrounding environmental setting.

1.1.3 This report should also be read in conjunction with the Environmental Setting and Site Design report (*Doc. Ref.: AI1009/07*) which accompanies the wider Environmental Permit application.

2.0 GAS CONCEPTUAL SITE MODEL SUMMARY

2.1 General

2.1.1 The details of the proposed design and the environmental setting of the site are set out in the Environmental Setting and Site Design (ESSD) Report (*Doc. Ref: AI1009/07*) and are summarised below:

- *infilling will take place in a void created by the extraction of the igneous diorite intrusion;*
- *the site will accept selected non-biodegradable, non-hazardous waste;*
- *an Artificially Established Geological Barrier will be constructed on the base and sidewalls of the quarry; and*
- *due to the nature of the waste streams, gas collection systems and sealing cap are not required.*

2.1.2 Comprehensive details on the setting of the site are provided within the ESSD report (*Doc Ref.: AI1009/07*).

2.1.3 The conceptual site model is based on the source-pathway-receptor linkages. The conceptual model for potential hazardous gases is presented in **Drawing No.: AI1009/14/15** and key elements of the conceptual site model are discussed in further detail below.

Source

2.1.4 The approved scheme of restoration will require the deposit of ~17.2 million cubic metres of suitable restoration materials, of which ~3.2 million tonnes will be source from site-won materials and the remaining ~14 million cubic metres (~25.2 million tonnes) being imported materials. For the import portion, the restoration of Croft Quarry will be carried out as a waste recovery operation involving the permeant deposit of non-biodegradable, non-hazardous materials.

2.1.5 The nature of these proposed wastes will offer limited potential to generate hazardous gas as they are non-biodegradable and non-hazardous. To minimise this potential and account for the scale of the restoration scheme, Waste Acceptance Procedures *(Doc. Ref.: AL1009/13)* have been developed that incorporate stringent verification testing above the testing requirements imposed on the waste producers. The greenhouse gas generation potential of the wastes will be controlled through limitation of the Total Organic Carbon or Loss by Ignition to 5% and 10% respectively.

Site Design and Construction

2.1.6 The site design is detailed within the ESSD (*Doc. Ref.: AI1009/07*). A summary is provided below.

Basal and Sidewall Engineering

2.1.7 The base and sidewalls of the quarry will be engineered with an Artificially Established Geological Barrier (AEGB) which will limit the lateral migration of pollutant gases to the surrounding strata. Whilst the characteristics of the waste proposed to be deposited will be non-hazardous, the presence of a AEGB will manage the risk associated with the potential deposit of a rogue load at the site.

Surface Capping

2.1.8 A low permeability cap will be installed across the surface of the waste deposits to provide physical separation between the wastes and surface waters within the final restored wetland habitats. This capping system will be constructed to at minimum thickness of 500mm and achieved a minimum hydraulic conductivity of $1x10^{-8}$m/s.

Gas Generation Potential of Wastes

2.1.9 Under the development proposals, the infilling of Croft Quarry will be achieved by means of the deposition of suitable non-biodegradable, non-hazardous material into quarry void that fit with the definition of Qualifying Materials under Section 4 of Excise Notice LFT1[1]. In particular, the wastes accepted will be those that would otherwise qualify under the schedule appended to The Landfill Tax (Qualifying Material) Order 2011[2]. On this basis infill materials shall consist of materials that have the following low potential for greenhouse gas emissions as defined by:

- Materials which are not biodegradable, have a low organic content or do not break down under the anaerobic conditions that prevail in landfill sites to produce methane. These include inert waste within the meaning given under the Landfill Directive (1999/31/EC); and material with little or no organic content, such as inorganic residues or completely combusted residues from the incineration of biodegradable/organic materials.

Pathways

2.1.10 The CSM was developed with cognisance of the site-specific geology and hydrogeology, proposed final infill levels, and any required engineering systems.

2.1.11 In order to visually depict this, a CSM section line transecting the Croft Quarry void has been prepared and is presented in **Drawing No.: AI1009/14/15**.

2.1.12 The prepared CSM indicates that the proposed infill materials will be entirely located within the South Leicestershire Diorite Complex, which is deemed to consist of a limited fluid flow interconnectivity. As such it is considered that any gas flow from the landfill will be severely restricted.

2.1.13 Whilst some fracture networks have been observed on the working faces, these are discrete networks developed due to historic mining activities - particularly from blasting and the reduction in stress from the removal of overburden - and not a wider feature of the lithology. The AEGB constructed along the base and sidewalls of the quarry will further restrict flows of any potential landfill gases into these fracture networks.

2.1.14 Groundwater levels monitored within the diorite surrounding the void are currently suppressed below -40mOD by a cone of depression centred around the quarry void. As infilling progressed water levels within the diorite will rebound, largely keeping pace with infill levels within the quarry void. Groundwater will further impede the lateral migration of any potential hazardous gases.

[1] *Excise Notice LFT1: a general guide to Landfill Tax - GOV.UK (www.gov.uk)*
[2] *The Landfill Tax (Qualifying Material) Order 2011 (legislation.gov.uk)*

Receptor

2.1.15 The site is bordered by commercial and industrial premises on its eastern and southeastern sides. To the west lies agricultural, recreational and residential property. Within 500m south of the site lies the village of Croft, and the village of Huncote lies 330m – 1km northeast of the site. A map of the receptor classes is shown in **Drawing No.: AI1009/14/11.**

2.1.16 To the immediate south lies the Nuneaton to Wigston railway line. On either side of the site lies Croft Hill Road and Coventry Road - minor B roads. Approximately 1km northwest is the M69 motorway, running southwest-northeast.

2.1.17 The primary receptors to the discharge of pollutants from the landfill would be the residential, commercial and industrial properties located within 250m of the quarry void.

3.0 GAS RISK ASSESSMENT

3.1 Nature of the Gas Risk Assessment

3.1.1 Due to the nature of the wastes to be deposited to restore Croft Quarry this Gas Risk Assessment is restricted to a screening assessment only.

3.2 Risk Screening

3.2.1 It is important to highlight that hazardous waste is excluded from the list of permitted wastes and that infill materials shall consist of materials that have the following low polluting potential for greenhouse gas emissions:

- Materials which are not biodegradable, have a low organic content or do not break down under the anaerobic conditions that prevail in landfill sites to produce methane. These include inert waste within the meaning given under the Landfill Directive (1999/31/EC); and material with little or no organic content, such as inorganic residues or completely combusted residues from the incineration of biodegradable/organic materials.

3.2.2 The risk of the wastes generation significant quantities of hazardous gases is very low due to the nature of the non-degradable wastes that will be deposited. Therefore, the restoration of Croft Quarry using the qualifying waste materials therefore presents no significant risk to local receptors.

Accidents and their Consequences

3.2.3 Details of accidental occurrences at the site that could present a potential risk to receptors adjacent to the site are provided in **Table LGFRA2**.

Table GRA1: Qualitative Accident Risk Assessment

Hazard	Risk to Receptors	Likelihood	Mitigation and Corrective Measures
Deposition of biodegradable and non-degradable, non-hazardous and hazardous wastes	Generation of landfill gas, lateral migration and build up in enclosed spaces e.g. buildings.	**Low** – due to the essential and technical precautions	Appropriate characterisation of wastes prior to delivery to the site will be provided by the customer, with the appropriate verification checks/tests performed wastes by the operator. Any incorrectly accepted wastes will be immediately returned to the customer or moved to a suitable storage area prior to removal to a suitable site.

3.2.4 With respect to the deposition of potentially contaminated wastes, it is considered that the risks and potential consequences of such accidents are extremely low for the following reasons:

- all waste deliveries will be pre-arranged and come from known sources to ensure no contaminated material is delivered;

- if deemed necessary, characterisation testing will be undertaken to demonstrate that the waste will not give rise to polluting leachate, prior to the acceptance of waste at the site;
- if deemed necessary compliance testing will be undertaken to ensure the continued acceptability of the waste stream;
- visual inspection will be undertaken of every waste load deposited at the site; and
- in the event of suspicion regarding the acceptability of the waste, quarantine procedures will be enforced.

4.0 GAS MANAGEMENT PLAN

4.1 Control Measures

4.1.1 Due to the non-degradable and non-hazardous nature of the deposited wastes, the primary control measure will be the implementation of strict waste acceptance procedures. There is no requirement for a gas collection system or associated infrastructure.

4.2 Gas Monitoring

Background monitoring

4.2.1 Background gas monitoring was undertaken in six monitoring boreholes; BH01, BH02A, BH02B, BH03A, BH03B, BH03C, BH04A and BH04B, and recorded methane, carbon dioxide and oxygen concentrations, barometric and relative pressures and internal flow rates. The location of each borehole is presented in **Drawing No.: AI1009/14/10**.

4.2.2 Full datasets and time-series charts for each determinand are provided in **Appendix ESSD6** of the accompanying ESSD. In addition to this, **Table GRA2** has been prepared and displays the statistically analysed background concentrations for each determinand across both individual monitoring boreholes and within specific lithologies.

4.2.3 Background gas monitoring demonstrates that methane is not regularly detected around the periphery of the site, with a limited number of detections of 0.1% v/v in each borehole throughout the monitoring period.

4.2.4 Carbon dioxide was continuously detected across the majority of the monitoring boreholes around the edge of Croft Quarry with recorded concentrations decreasing between February 2019 and June 2019. The highest concentration of 1.8%v/v was recorded in BH02/A, which is located approximately 65m to the southwestern edge of the quarry void and monitors the underlying Mercia Mudstone Group. The mean concentration at BH02/A during the monitoring period was 0.4%v/v. Whilst some variation in mean carbon dioxide concentrations is observed between the monitoring boreholes these concentrations fall within a narrow range (between 0.1%v/v and 0.7%v/v). The consistent mean concentrations around the periphery of Croft Quarry suggest that the concentrations recorded are representative of the baseline ground gas conditions.

4.2.5 Similarly, oxygen was continuously monitored around the periphery of Croft Quarry. However, it was identified that unlike the previously discussed carbon dioxide concentrations, no decreasing trend was observed with concentrations remaining largely stable throughout the monitoring period. This stability in concentrations is reflected in the similarity between recorded maximum and mean concentrations with all boreholes recording a maximum oxygen concentration of 22.2%v/v.

4.2.6 It was also noted that both recorded relative pressures and internal flow rates show broad consistency across all monitoring points, with monitoring boreholes indicating average relative pressure values of between -1mBar to 1.5mBar and average internal flow rates of between -2.3l/h and 0.4l/h.

4.2.7 As previously indicated complete datasets and time-series plots for each of the monitoring parameters are presented in **Appendix ESSD6** of the accompanying ESSD. Furthermore, in order to identify whether there were any diagnostic gas

characteristics between the Diorite and Mercia Mudstone lithologies, boreholes monitoring was collated depending on which lithology they were monitoring. The collated datasets were then statistically analysed, and each parameter was compared. The results of this collation and statistical analysis are presented in **Table GRA2** and indicate that all parameters are consistent across all lithologies and that there are no lithology specific trends.

Table GRA2: Baseline Ground Gas Quality Summary (statistical outliers removed) between November 2018 and July 2021

Statistic	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Barometric Pressure (mBar)	Relative Pressure (mBar)	Internal Flow (l/h)
BH01						
Min	<0.1	<0.1	12.3	980	-1.83	-1.6
Mean	<0.1	0.3	18.7	1003	0.15	-0.4
Max	0.1	1.2	21.9	1021	2.01	0.2
Stdev	0.04	0.4	2.9	10	1.22	0.5
Count	22	22	22	22	22	21
BH02/A						
Min	<0.1	<0.1	13	982	-2.54	-2.6
Mean	<0.1	0.4	19.1	1005	0.21	-1.0
Max	0.1	1.8	21.9	1024	2.47	2
Stdev	0.04	0.5	2.8	11	1.42	1.2
Count	22	22	21	22	22	21
BH02/B						
Min	<0.1	<0.1	8.3	982	-1.2	-1.4
Mean	<0.1	0.25	15.9	1005	0.20	-0.2
Max	0.1	0.7	21.9	1024	1.74	0.5
Stdev	0.04	0.3	5.2	11	0.89	0.6
Count	22	22	21	22	21	21
BH03/A						
Min	<0.1	<0.1	19.9	981	-1.59	-6.1
Mean	<0.1	0.1	21.1	1005	0.34	-2.3
Max	0.1	0.4	22	1024	3.56	0.1
Stdev	0.04	0.1	0.5	11	1.34	2.0
Count	22	22	21	22	22	21
BH03/B						
Min	<0.1	<0.1	13.4	981	-2.25	-1.8
Mean	<0.1	0.2	18.9	1005	0.70	-0.4
Max	0.1	0.5	21.8	1024	3.17	1.3
Stdev	0.04	0.2	2.7	11	1.44	1
Count	22	22	21	22	22	21
BH03/C						
Min	<0.1	<0.1	6.5	981	-1.17	-1.8
Mean	<0.1	0.2	16.2	1005	0.26	-0.3
Max	0.1	0.5	21.8	1024	3.73	0.4
Stdev	0.05	0.2	5.3	11	1.22	0.7
Count	22	22	22	22	22	21
BH04/A						
Min	<0.1	0.6	1	985	-1.54	-1.9
Mean	<0.1	0.7	2.1	1006	1.44	0.4
Max	0.1	0.9	5.8	1023	5.65	5

Statistic	Methane (%v/v)	Carbon Dioxide (%v/v)	Oxygen (%v/v)	Barometric Pressure (mBar)	Relative Pressure (mBar)	Internal Flow (l/h)
Stdev	0.04	0.1	11	10	2.16	1.8
Count	22	22	22	22	18	18
BH04/B						
Min	<0.1	<0.1	8.3	985	-1.76	-2.4
Mean	<0.1	0.2	20	1006	-0.16	-0.4
Max	0.1	0.7	22.2	1023	1.61	0.6
Stdev	0.04	0.2	2.9	10	1.02	0.7
Count	22	22	22	22	22	21
Diorite (BH01, BH02/B, BH03/c and BH04/B)						
Min	<0.1	<0.1	6.5	980	-1.83	-2.4
Mean	<0.1	0.2	17.6	1005	0.11	-0.3
Max	0.1	1.2	22.2	1024	3.73	0.6
Stdev	0.04	0.3	4.5	11	1.09	0.6
Count	88	88	87	88	87	84
Mercia Mudstone (BH02/A, BH03/B and BH04/A)						
Min	<0.1	<0.1	1	981	-2.54	-2.4
Mean	<0.1	0.5	13.2	1005	0.74	-0.3
Max	0.1	1.8	21.9	1024	5.65	5
Stdev	0.04	0.4	8.4	11	1.72	1.4
Count	66	62	64	66	62	59

4.2.8 Statistical analysis of the background peripheral gas concentrations was completed utilising the statistical assessment/outlier screening methodology presented in Environment Agency Research and Development document "Techniques for the Interpretation of Landfill Monitoring Data Guidance Notes, Report No. P1-471".

Monitoring Plan

4.2.9 It is important to note that only non-biodegradable, non-hazardous wastes will be deposited at the site, therefore the potential for deposited wastes to produce hazardous gases will be negligible.

Operational Phase

4.2.10 Due to the scale of the quarry restoration scheme, it is proposed to undertake gas monitoring around the perimeter of the site in boreholes screening the diorite. The position of existing and proposed perimeter monitoring borehole installations are presented in **Drawing Nos.: AI1009/14/05**. Borehole positions target the sensitive receptors located within 250m of the edge of the waste deposits, with a increased borehole spacing along the perimeters where no sensitive receptors are located within 250m of the wastes deposits.

4.2.11 Taking into consideration the current and future groundwater levels within the Diorite, and the increased distance between waste and the sensitive receptors at depth, the monitoring boreholes will be installed to a maximum elevation of -40mOD.

4.2.12 The proposed operational phase gas monitoring schedule is presented in **Table GRA3.**

Table GRA3: Perimeter Gas Monitoring Schedule

Monitoring Point Ref.	Frequency	Parameter
BH01, BH02/B, BH03/C, BH04/B, BH05, BH06, BH07, BH08, BH09, BH10, BH11, BH12, BH13, BH14, & BH15.	Quarterly	Methane (%v/v) Carbon Dioxide (%v/v) Oxygen (%v/v) Differential Pressure (mbar) Atmospheric Pressure (mbar) <u>Meteorological Data</u> Cloud Cover (%) Wind Direction (Compass Direction or Degrees from North) Wind Speed (mph) Precipitation (general description) Ground Conditions (general description) Temperature (ºC)

4.2.13 Compliance Limits and Action Levels associated with the perimeter borehole are presented in **Table GRA4.**

Table GRA4: Action Levels and Compliance Limits for perimeter gas monitoring boreholes

Borehole ID	Methane		Carbon Dioxide
	Action Level (%v/v)	Compliance Limit (%v/v)	Action Level (%v/v)
BH01	0.5	1.0	2.2
BH02/B			1.7
BH03/C			1.5
BH04/B			1.7
BH05-BH15	To be determined		

4.2.14 The Action Levels and Compliance Limits for methane are set at 0.5% and 1% above TMax concentrations derived from statistical analysis on the datasets presented in Appendix ESSD6 to the ESSD Report (Doc. Ref.: AI1008/07). Similarly, the Action Levels for carbon dioxide are set at 1%v/v above the statistical TMax concentrations. Appropriate Action Levels and Compliance Limits for all additional boreholes will be derived upon the establishment of baseline conditions after installation.

<u>Aftercare Phase</u>

4.2.15 Once final levels are achieved across the quarry a series of in-waste monitoring boreholes will be installed within the wastes mass at a density of 1 per hectare where waste deposits exceed depths of 4m. These will be monitored monthly for a period of 2 years post-closure to support the subsequent surrender of the permit. The proposed positions and design of these boreholes are presented in **Drawing Nos.: AI1009/14/05** and **AI1009/14/12** respectively.

<u>Action Plan</u>

4.2.16 The following action swill be implemented in the event of an exceedance of any of the Action Levels or Compliance Limits specified for perimeter gas monitoring borehole installations.

<u>Action Level Exceedance</u>

4.2.17 The following actions will be implemented in the event of an exceedance of any of the above Action Levels:-

- The Site Manager will be informed before the Monitoring Technician leaves the facility;

- The details of the Action Level exceedances will be forwarded to the AI compliance team for review and the below escalation procedure will be followed
  - *The results from the affected perimeter borehole(s) will be reviewed against historic data to verify if the results demonstrate an anomalous trend.*
  - *Flag the boreholes for further review ahead of the next round of monitoring.*
  - *If further exceedances are recorded, undertake a condition survey of the boreholes;*
  - *If it is established through a review of the data, that there is a potential risk of off-site migration, then the frequency of monitoring in the affected borehole, will be increased to a frequency agreed with the Environment Agency*

Compliance Limit Exceedance

4.2.18 The following actions will be implemented in the event of an exceedance of any of the above Compliance Limits:-

- The Site Manager will be informed before the Monitoring Technician leaves the facility;
- The details of the Compliance Limit exceedances will be forwarded to the AI compliance team for review and the below escalation procedure will be followed:-
  - *The results from the affected perimeter borehole(s) will be reviewed against historic data to verify if the results demonstrate an anomalous trend.*
  - *Complete a schedule notice and inform the Environment Agency where required*
  - *Re-monitor borehole within 1 week and measure flow rate*
  - *If further exceedances are recorded, undertake a condition survey of the boreholes;*
  - *If it hazardous gas flow rates exceed 0.7l/hr, then the frequency of monitoring in the affected borehole will be increased to a frequency agreed with the Environment Agency*
  - *Agree investigation strategy with the EA to identify the source of the gas.*

5.0 CONCLUSIONS

5.1.1 The restoration of Croft Quarry will be carried out using waste with a low greenhouse gas generation potential. The importation of the waste will be subject to the Waste Acceptance Procedures which will ensure that only qualifying wastes will be accepted.

5.1.2 Monitoring around the perimeter of the site will also be implemented to manage the limited risk posed by the waste activity and support permit surrender criterion. In-waste gas monitoring infrastructure will also be installation once the final levels have been achieved to further support surrender of the permit.

6.0 REFERENCES

Environment Agency (2004). *Guidance on the Monitoring of Landfill Gas* Doc. Ref.: LFTGN03.