



Ambient Air Quality Monitoring Baseline Report, Kirby Misperton A Wellsite, KM8 Production Well.



Prepared for:

Third Energy UK Gas Ltd.



For: Third Energy UK Gas Ltd.

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GGs is the trading name of Ground-Gas Solutions Limited

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1 Outline of Baseline Monitoring

Third Energy has appointed GGS to conduct ambient air quality monitoring at the KMA wellsite before, during and after the hydraulic fracturing stimulation operations.

Ambient air quality monitoring undertaken before hydraulic fracturing stimulation operations commence will establish a baseline condition at the KMA wellsite. This will allow Third Energy to benchmark future results collected during the hydraulic fracturing stimulation operations, to determine whether Third Energy's operations have any significant effect on air quality.

Initial baseline sampling was undertaken in 2015 to inform the permit application and it is considered that this data is still suitable for use when establishing baseline conditions. In addition, significant baseline data has been undertaken at the KMA wellsite by the British Geological Survey from 13th January 2016.

GGS has undertaken a further two weeks of baseline air quality monitoring at the KMA wellsite, starting on 20th September 2017, to inform the overall baseline condition with data acquired prior to activities taking place at the KMA wellsite, namely the management of extractive waste as presented within Table S1.1 as activity A1 of the Environmental Permit. For clarity, the management of extractive waste does not commence until the extraction process of the mining waste begins. i.e. the bringing of waste streams to surface, which occurred on 16th October 2017.

During the baseline monitoring period from 20th September to 4th October the following site activity was undertaken:

- a. building of the soundwall - container positioning and scaffold building; and
- b. delivery of equipment (drill pipe).

The monitoring undertaken is designed to address both the Environment Agency's permit (reference: Decision Document EPR/DB3002HE) and North Yorkshire County Council planning permission conditions (reference: Decision Notice C3/15/00971/CPO). The baseline monitoring undertaken by GGS includes the parameters listed in Table 1, together with the proposed frequency and duration of monitoring.

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Table 1. Required Baseline Ambient Air Quality Parameters.

Parameters	Monitoring method	Required By
Methane (CH ₄)	Periodic monitoring on two occasions	Environment Agency / NYCC
Carbon Dioxide (CO ₂)	Periodic monitoring on two occasions	Environment Agency
Dust	2 week duration passive sampling	Environment Agency
BTEX	2 week duration passive sampling	Environment Agency
Top 10 VOC	2 week duration passive sampling	Environment Agency
Nitrogen dioxide (NO ₂)	2 week duration passive sampling	Environment Agency
Nitric Oxide (NO)	Active sampling on two occasions	Environment Agency
Hydrogen Sulphide (H ₂ S)	2 week duration passive sampling	NYCC – Planning Condition 25
Carbon Monoxide (CO)	Periodic monitoring on two occasions	NYCC – Planning Condition 25
Oxygen (O ₂)	Periodic monitoring on two occasions	NYCC – Planning Condition 25
Ozone (O ₃)	2 week duration passive sampling	GGs recommendation

2 Site Monitoring Locations

Prior to the erection of noise barriers, the periodic sampling and diffusion tubes were positioned at Location 1A on top of the existing soil mound. In addition, GGS established three other monitoring locations around the site in order to give a wide coverage to capture the baseline conditions for non-prevailing wind directions. Location 2 was established in the North West corner of the wellsite, a more remote 'upwind' monitoring location was established in the South West corner of the KMA wellsite, 20m south along the access track (Location 3) and Location 4 was established in the South East corner of the wellsite. Figure 1 below illustrates the monitoring locations.

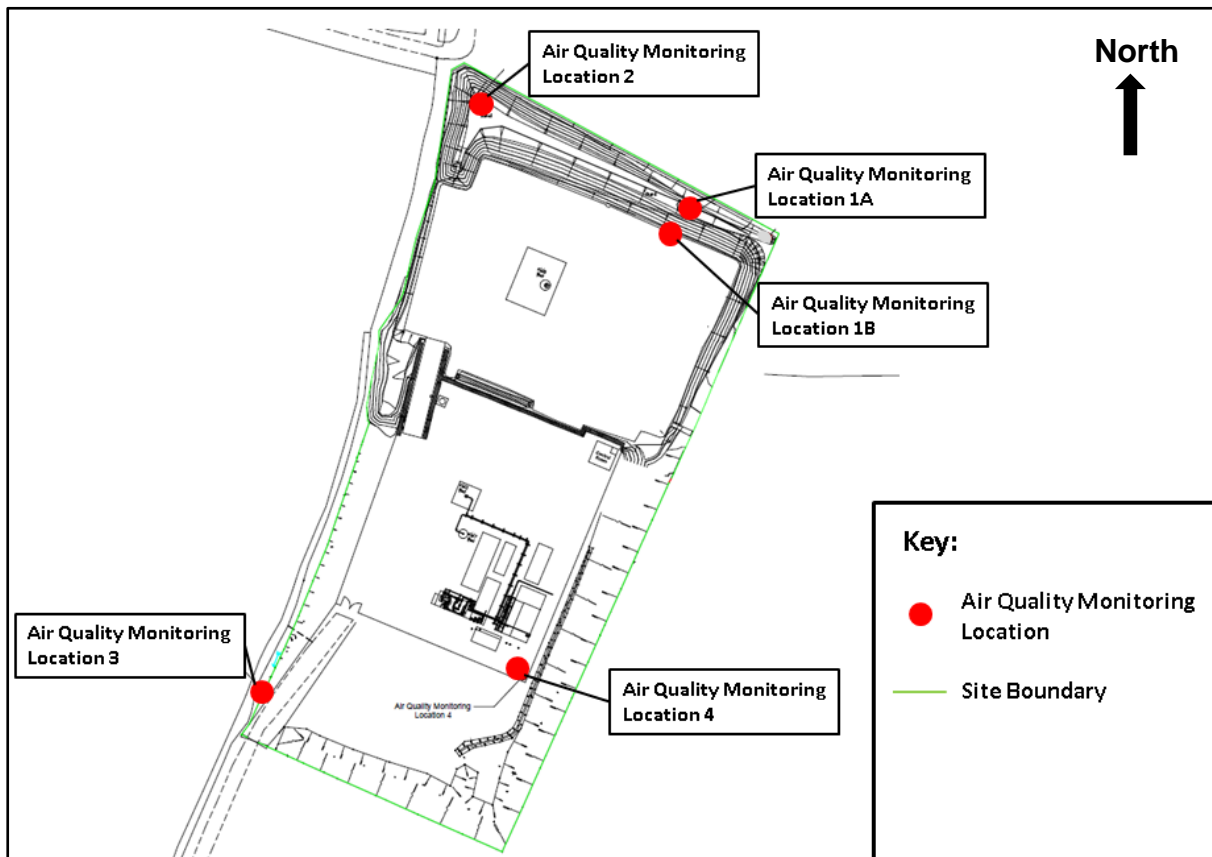


Figure 1. Location of Ambient Air Quality Monitoring Stations.

Note: Monitoring location 1B, seen on Figure 1, is a future location for monitoring location 1A, once the sound barrier has been erected.

3 Baseline Monitoring

3.1 Methane (CH₄)

Methane is naturally occurring in the environment and arises from organic rich soils and ruminant cattle. It is present in the atmosphere at approximately 2 ppm, but this can vary due to local influences. It is also the principle constituent of the target gas to be produced from the geological formations that are proposed to be hydraulically fractured. Monitoring of methane at the site is required by both the Environment Agency (EA) and North Yorkshire County Council (NYCC).

3.1.1 Methodology

Periodic monitoring of methane was undertaken over a 10-minute duration on 20th September 2017 and 4th October 2017 at the four monitoring locations at the site.

The methane detector used was a Gazomat Inspectra[®] Laser (TDL-500) which is a portable gas detector that uses the principle of infrared laser light absorption of methane molecules. A technical summary of the instrument is presented in Table 3.1 below and the calibration certificate for the instrument can be provided upon request.

Table 3.1 TDL-500 Specification

Feature	Sensor	Range	Accuracy
Methane	Infrared	0 – 10,000 ppm 0.1% - 100% v/v	1 ppm

3.1.2 Results

Table 3.2. Methane results from periodic monitoring.

Location	Range of Methane Concentrations (ppm) 20 th September 2017	Range of Methane Concentrations (ppm) 4 th October 2017
1A	0.9 – 1.9	2.1 – 2.3
2	2.1 – 2.4	1.9 – 2.1
3	1.9 – 2.5	2.0 – 2.2
4	1.4 – 2.3	1.9 – 2.3

3.2 Carbon Dioxide (CO₂)

Carbon dioxide is a natural constituent of the atmosphere and is produced from both volcanic activity and animal respiration. It is currently present in the atmosphere at approximately 400ppm, however this varies seasonally and can be influenced by the local setting. It is also produced by the combustion of petroleum based fuels. Monitoring of carbon dioxide at the site is required by the EA.

3.2.1 Methodology

Periodic monitoring of carbon dioxide was undertaken over a 10-minute duration on 20th September 2017 and 4th October 2017 at the four monitoring locations at the site.

The carbon dioxide detector used was a GFM 100 series instrument fitted with a high-resolution carbon dioxide sensor. A technical summary of the instrument is presented in Table 3.3 below and the calibration certificate for the instrument can be provided upon request.

Table 3.3 GFM100 Specification

Feature	Method / Type	Range	Accuracy
Carbon Dioxide	Infrared	0 – 10,000 ppm	100 ppm

3.2.2 Results

Table 3.4 Carbon dioxide results from periodic monitoring.

Location	Range of Carbon Dioxide Concentrations (ppm)	Range of Carbon Dioxide Concentrations (ppm)
	20 th September 2017	4 th October 2017
1A	395 – 417	290 – 295
2	405 – 415	289 – 293
3	369 – 381	293 – 299
4	388 – 412	285 - 296

3.3 Dust

Dust can be defined as all airborne particulate matter. It is present naturally in the atmosphere wherever there are particles present that may become suspended in the atmosphere due to air movement (i.e. wind). It is likely that dust will be generated on the site during operations and therefore monitoring of dust at the site is required by the EA.

3.3.1 Methodology

Passive sampling of dust was undertaken between 20th September 2017 and 4th October 2017 at the four monitoring locations at the site.

The dust samplers used were the DustScan DS100-D, which is a combined directional and deposited dust sampler. The directional and deposited dust sampler collects dust in horizontal flux from 360° around the sampling head as well as dust depositing out of the air. The collected dust is measured to determine dust coverage (AAC) and dust soiling (EAC); these measurements are expressed as percentages and are noted in the Institute of Air Quality Management (IAQM) guidance.

- AAC% is a measure of the dust coverage on a surface, irrespective of colour;
- EAC% is a measure of dust soiling, or obscuration, on a surface.

AAC and EAC can be combined to indicate possible annoyance caused by dust deposition.

3.3.2 Results

The laboratory results, including a dust impact risk assessment, can be provided to the EA upon request. A summary of the results is presented in Tables 3.5 and 3.6, and Figure 2 below.

Table 3.5 Depositional Dust sampling and analysis results

Location	Exposure Interval	AAC% / interval	EAC% / interval	AAC% / day	EAC% / day	Dust Impact Risk
1A	14 days	55.9	1.8	4.0	0.1	Very Low
2	14 days	61.3	1.7	4.4	0.1	Very Low
3	14 days	84.2	3.9	6.0	0.3	Very Low
4	14 days	96.2	6.3	6.9	0.5	Low

Table 3.6 Directional Dust Flux sampling and analysis results

Location	Exposure Interval	AAC% / interval	EAC% / interval	AAC% / day	EAC% / day	Maximum Dust Impact Risk
1A	14 days	25.1	2.3	3.9	0.2	Very Low
2	14 days	62.3	3.1	4.5	0.2	Medium
3	14 days	63.3	2.6	4.5	0.2	Very Low
4	14 days	54.3	2.0	3.9	0.1	Very Low

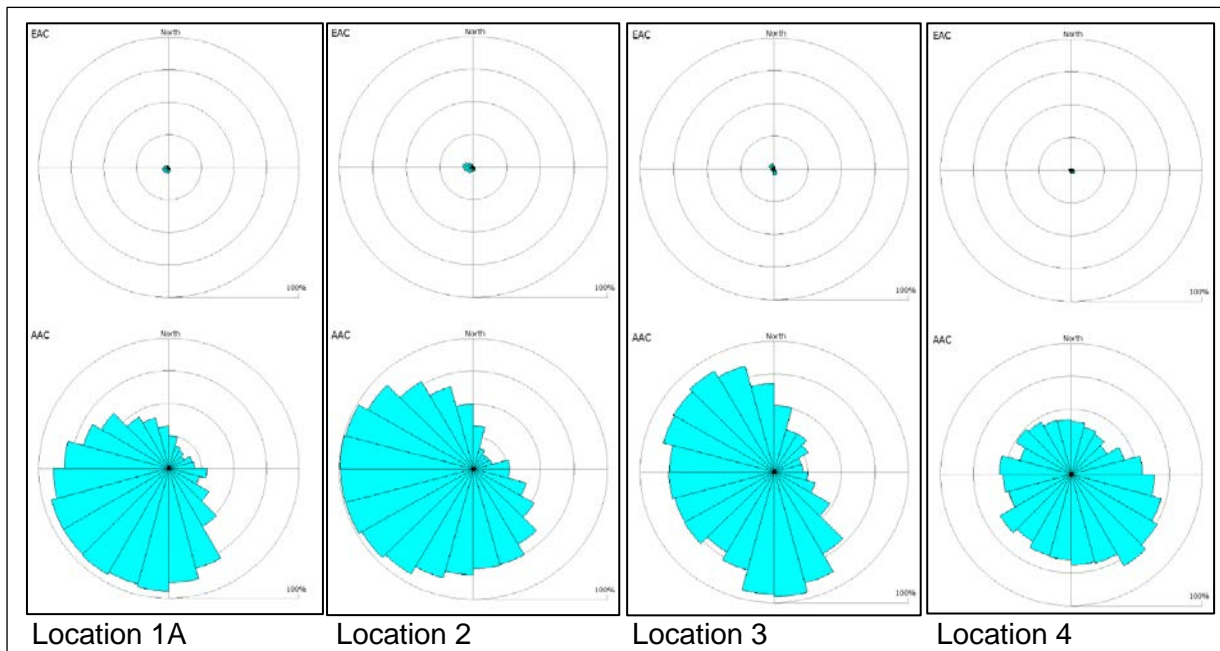


Figure 2 Directional Dust rose diagrams

3.4 BTEX

BTEX refers to the chemicals benzene, toluene, ethylbenzene and xylene. These compounds occur naturally in petroleum deposits and are also present in vehicle exhaust fumes and cigarette smoke. BTEX monitoring at the site is required by the EA.

3.4.1 Methodology

Passive sampling of BTEX was undertaken between 20th September 2017 and 4th October 2017 at the four monitoring locations at the site.

GGs passively sampled for BTEX using Tenax sorbent tubes located at the four monitoring locations. The tubes were exposed for a two-week period and dispatched to an appropriately accredited laboratory for BTEX analysis. Field blanks were also deployed in line with best practice guidelines.

3.4.2 Results

The laboratory results can be provided to the EA upon request. A summary of the results is presented in Table 3.7 below.

Table 3.7 BTEX monitoring results

Location	Unit	Benzene	Toluene	Ethylbenzene	m/p-Xylene	o-Xylene
1a	µg/m ³	<0.8*	<0.7*	<0.7*	<0.7*	<0.7*
2	µg/m ³	1.8	<0.7*	<0.7*	<0.7*	<0.7*
3	µg/m ³	1.5	0.8	2.5	8.2	2.8
4	µg/m ³	1.3	0.8	<0.7*	0.7	<0.7*

*Results with < (less than) indicate that concentrations are below the reporting limit.

3.5 Top 10 VOCs

Volatile organic compounds (VOCs) are substances with low boiling points that evaporate from solids or liquids. They occur both naturally and as products used in industrial processes. There are many different VOC's but one of the most common is formaldehyde which is found in building products and furniture. VOCs are also produced by diesel combustion. Monitoring of the top 10 VOC compounds is required by the EA.

3.5.1 Methodology

Passive sampling of VOCs was undertaken between 20th September 2017 and 4th October 2017 at the four monitoring locations at the site.

GGs passively sampled VOCs using Tenax sorbent tubes located at the four monitoring locations in line with the Emissions Monitoring Plan. The tubes were exposed for a two-week period and dispatched to an appropriately accredited laboratory for Top 10 VOC analysis. A field blank was also deployed as a quality check in line with best practice guidelines to ensure that the samples were not contaminated in transit.. This was left sealed in its container at Location 4 for the two weeks.

The Top 10 VOC's were identified and their estimated concentrations were carried out in accordance with ISO16000-6

3.5.2 Results

The Top 10 VOC laboratory results for the four locations are provided in Tables 3.8.1, 3.8.2, 3.8.3 & 3.8.4 below.

Table 3.8.1 Top 10 VOC laboratory results – Location 1

Top 10 VOC		Estimated ng on tube	ppb in air*	$\mu\text{g}\text{m}^{-3}$ *
Cyclohexadecane	N	1423	35	316
Hexadecanal	N	76	1.9	18.0
Diphenyl sulfone	N	41	1.0	8.9
Benzaldehyde**	U	21	0.5	2.2
Diethyl phthalate	U	16	0.4	3.6
Nonanal**	N	15	0.4	2.1
2-Ethylhexyl salicylate	N	12	0.3	3.0
Acetophenone**	U	11	0.3	1.3
1,3,5-Trifluorobenzene	N	5	0.1	0.7
Benzoic acid	N	<5	<0.1	<0.6

Table 3.8.2 Top 10 VOC laboratory results – Location 2

Top 10 VOC		Estimated ng on tube	ppb in air*	$\mu\text{g}\text{m}^{-3}$ *
Cyclohexadecane	N	80	2.0	17.8
Benzaldehyde**	U	33	0.8	3.5
Hexadecanal	N	27	0.7	6.4
Nonanal**	N	15	0.4	2.2
2-Ethyl-1-hexanol	U	14	0.4	1.8
Acetophenone**	U	12	0.3	1.5
Diethyl phthalate	U	10	0.3	2.3
Acetic acid	U	8	0.2	0.5
Decanal**	N	8	0.2	1.2
1,3-Dichlorobenzene	N	7	0.2	1.0

Table 3.8.3 Top 10 VOC laboratory results – Location 3

Top 10 VOC		Estimated ng on tube	ppb in air*	$\mu\text{g}\text{m}^{-3}$ *
Diethyl phthalate	U	43	1.1	9.4
Benzaldehyde**	U	35	0.9	3.6
Nonanal**	N	33	0.8	4.6
Hexadecanal	N	23	0.6	5.6
Diphenyl sulfone	N	18	0.5	4.0
2-Ethylhexyl salicylate	N	12	0.3	2.9
Acetophenone**	U	12	0.3	1.4
Pentadecane	U	11	0.3	2.3
Octanal**	U	8	0.2	1.0
Decane, 2,2,9-trimethyl-	N	7	0.2	1.3

Table 3.8.4 Top 10 VOC laboratory results – Location 4

Top 10 VOC		Estimated ng on tube	ppb in air*	$\mu\text{g}\text{m}^{-3}$ *
Cyclohexadecane	N	205	5.1	45.6
Hexadecanal	N	74	1.8	17.5
Nonanal**	N	49	1.2	6.8
Benzaldehyde**	U	24	0.6	2.5
Pentadecane	U	17	0.4	3.6
Diethyl phthalate	U	14	0.3	3.0
2-Ethylhexyl salicylate	N	12	0.3	2.9
Decanal**	N	11	0.3	1.7
2-Ethyl-1-hexanol	U	8	0.2	1.0
Phenol	U	7	0.2	0.6

* Laboratory results obtained using exposure data.

** Compounds may be an artefact due to reaction of ozone with the Tenax sorbent.

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3.6 Nitrogen Dioxide (NO₂)

Trace concentrations of nitrogen dioxide occur naturally in the atmosphere from volcanic sources and lightening strikes. It is also a product of combustion and is present in vehicle exhaust fumes and cigarette smoke. Nitrogen dioxide monitoring is required by the EA.

3.6.1 Methodology

Passive sampling of nitrogen dioxide was undertaken between 20th September 2017 and 4th October 2017 at the four monitoring locations at the site.

GGs passively sampled nitrogen dioxide using diffusion tubes at all four locations. The tubes were exposed for a two-week period and dispatched to an appropriately accredited laboratory for nitrogen dioxide analyses. Field blanks were also deployed in line with best practice guidelines.

3.6.2 Results

The laboratory results can be provided to the EA upon request. A summary of the results is presented in Table 3.9 below.

Table 3.9 Nitrogen Dioxide Passive Sampling results

Location	Unit	Nitrogen Dioxide
1a	µg/m ³	10.41
2	µg/m ³	9.14
3	µg/m ³	8.05
4	µg/m ³	7.02

3.7 Nitric Oxide (NO)

Trace concentrations of nitric oxide occur naturally from lightening strikes. It is also a product of combustion and is present in vehicle exhaust fumes. Nitric oxide monitoring is required by the EA.

3.7.1 Methodology

GGs carried out active sampling of nitric oxide over a 30-minute period on 20th September 2017 and on 4th October 2017. Nitric oxide was sampled using molecular sieve tubes which were actively sampled using a low-flow sampling pump. The tubes were then dispatched to an appropriately accredited laboratory for nitric oxide analysis. Field blanks were also deployed in line with best practice guidelines.

3.7.2 Results

The laboratory results can be provided to the EA upon request. A summary of the results is presented in Table 3.10 below.

Table 3.10 Nitric Oxide Active Sampling results

Location	Unit	Nitric Oxide 20 th September 2017	Nitric Oxide 4 th October 2017
1a	mg/m ³	<0.08	<0.08
2	mg/m ³	<0.08	<0.08
3	mg/m ³	<0.08	<0.08
4	mg/m ³	<0.08	<0.08

3.8 Hydrogen Sulphide (H₂S)

Hydrogen sulphide is a naturally occurring compound found in peaty deposits, volcanic areas and petroleum deposits. At the Kirby Misperton A Wellsite, hydrogen sulphide is not expected to be present in the target formation. However, North Yorkshire County Council requires it to be monitored under Planning Condition 25.

3.8.1 Methodology

Passive sampling of hydrogen sulphide was undertaken between 20th September 2017 and 4th October 2017 at the four monitoring locations at the site.

GGs passively sampled hydrogen sulphide using diffusion tubes at all four locations. The tubes were exposed for a two-week period and dispatched to an appropriately accredited laboratory for hydrogen sulphide analyses. Field blanks were also deployed in line with best practice guidelines.

3.8.2 Results

The laboratory results are can be provided to NYCC upon request. A summary of the results is presented in Table 3.11 below.

Table 3.11 Hydrogen Sulphide Passive Sampling results

Location	Unit	Hydrogen Sulphide
1a	µg/m ³	0.73
2	µg/m ³	1.05
3	µg/m ³	1.04
4	µg/m ³	1.11

3.9 Carbon Monoxide (CO)

Carbon Monoxide is a constituent of the exhaust gases from diesel engines and North Yorkshire County Council require it to be monitored under Planning Condition 25.

3.9.1 Methodology

Periodic monitoring of carbon monoxide was undertaken over a 10-minute duration on 20th September 2017 and 4th October 2017 at the four monitoring locations at the site

The carbon monoxide detector used was a GFM 400 series instrument fitted with a high-resolution carbon monoxide sensor. A technical summary of the instrument is presented in Table 3.12 below and the calibration certificate for the instrument can be provided upon request.

Table 3.12 GFM400 Specification

Feature	Method / Type	Range	Resolution
Carbon Monoxide	Electrochemical	0 - 2000ppm	1ppm

3.9.2 Results

Table 3.13 Carbon monoxide results from periodic monitoring.

Location	Range of Carbon Monoxide Concentrations (ppm)	Range of Carbon Monoxide Concentrations (ppm)
	20 th September 2017	4 th October 2017
1A	>1*	>1*
2	>1*	>1*
3	>1*	>1*
4	>1*	>1*

*Indicates that concentrations remained below the limit of detection of the instrument

3.10 Oxygen (O₂)

Oxygen, at a concentration of 21% in ambient air (at sea level), is the second most common gas in the atmosphere and is essential for respiration in animals. It is also used in the combustion of diesel fuels and is required by North Yorkshire County Council to be monitored at the site under Planning Condition 25.

3.10.1 Methodology

Periodic monitoring of oxygen was undertaken over a 10-minute duration on 20th September 2017 and 4th October 2017 at the four monitoring locations at the site

The oxygen detector used was a GFM 400 series instrument fitted with an oxygen sensor. A technical summary of the instrument is presented in Table 3.14 below and the calibration certificate for the instrument can be provided upon request.

Table 3.14 GFM400 Specification

Feature	Method / Type	Range	Resolution
Oxygen	Electrochemical	0 - 25%v/v	0.1%

3.10.2 Results

Table 3.15 Oxygen results from periodic monitoring.

Location	Range of Oxygen Concentrations (%)	
	20 th September 2017	4 th October 2017
1A	20.8 – 21.0	20.8 – 20.9
2	20.8 – 20.9	20.8 – 20.8
3	20.8 – 20.9	20.8 – 20.9
4	20.8 – 21.0	20.8 – 20.9

3.11 Ozone (O₃)

Ozone occurs naturally in the upper atmosphere and is formed by the action of ultraviolet light and lightning discharges on oxygen. Near ground level it is formed by chemical reactions between the oxides of nitrogen and VOCs in the presence of sunlight. Ozone is a powerful oxidising agent and is an indicator of poor air quality. Monitoring of Ozone is not a requirement by either the EA or NYCC, but GGS has advised that this parameter be included in the monitoring regime at the site.

3.11.1 Methodology

Passive sampling of Ozone was undertaken between 20th September 2017 and 4th October 2017 at the four monitoring locations at the site.

GGS passively sampled Ozone using diffusion tubes at all four locations. The tubes were exposed for a two-week period and dispatched to an appropriately accredited laboratory for Ozone analyses. Field blanks were also deployed in line with best practice guidelines.

3.11.2 Results

The laboratory results can be provided upon request. A summary of the results is presented in Table 3.16 below.

Table 3.16 Ozone Passive Sampling results

Location	Unit	Ozone
1a	µg/m ³	52.56
2	µg/m ³	56.22
3	µg/m ³	36.90
4	µg/m ³	31.94

4 Quality Control & Assurance

All monitoring equipment operated by GGS is maintained in accordance with the manufacturer's guidelines. Annual services and calibrations are undertaken when required and routine visual inspections of the equipment are undertaken prior to and during site visits by GGS staff.

GGS operates an Integrated Management System (IMS) that is accredited by QMS International plc as complying with the following international standards:

- BS EN ISO 9001:2008 (Quality Management System);
- ISO 14001:2004 (Environmental Management System), and;
- OHSAS 18001:2007 (Occupational Health and Safety Management System).

All of GGS' monitoring and sampling are carried out to procedures that are subject to independent annual audit.

5 Ongoing Monitoring Regime

Ambient air monitoring will continue to be undertaken throughout the duration of site operations with particular attention given to monitoring during key site operations including cementing and hydraulic fracturing of the five designated intervals.

Continuous monitoring of the following parameters is also being phased from 9th October 2017 by GGS between the baseline monitoring period and prior to extraction process of the mining waste beginning:

- Methane;
- Carbon dioxide;
- Carbon monoxide;
- Oxygen;
- Particulate matter;
- Nitrogen dioxide;
- Nitric oxide;
- Ozone;
- Atmospheric temperature;
- Atmospheric pressure;
- Wind speed; and
- Wind direction.

Ambient air monitoring will also continue for four weeks after the site operations have ceased and the hydraulic fracturing plant and machinery has been removed from the site.

GGS will attend the site at two-weekly intervals for the duration of the ambient air monitoring to collect samples for laboratory analysis, undertake periodic monitoring and to maintain the continuous monitoring equipment.

During the on-site operations, regular weekly reports, containing the results of the continuous monitoring, periodic monitoring and available laboratory analyses will be

submitted to the Environment Agency and North Yorkshire County Planning Authority.

In addition, with specific reference to methane concentrations, if significant concentrations¹, as determined from baseline monitoring carried out prior to well stimulation operations and as agreed with the Environment Agency, are observed then the source of the exceedance will be identified and the Environment Agency will be informed within 24 hours of the occurrence.

Following the erection of the noise barriers the monitoring equipment at Location 1A will be relocated to Location 1B on a safe working platform adjacent to the noise barriers.

¹ In the context of the ambient air quality monitoring, a significant concentration is taken to be two consecutive readings of methane recorded at twice the previous highest baseline concentration of 5.34ppm recorded at BGS Monitoring Station on site on 4th March 2017 i.e. two consecutive readings of greater than 10.68 ppm.