PLAN

PO2 – Ambient Air Quality EMMP

Management System:	HSE	**File Name:**	CORP-HSE-PLA-009
Approver:	HSE&P Manager	**Version No:**	Issue 5.1
Reviewer:	Environmental Compliance Advisor, Environmental Planner, Well Test Manager	**Date of Issue:**	May' 18
Author:	HSE&P Manager	**Proposed date of Review:**	Nov' 18

Version	Section	Revision Information	Date	Reviser
0.1	All	Draft Publication	Jan 18	HSE&P Manager
0.2	All	ECA review	Feb 18	ECA
1.0	All	Submission to Environment Agency	Feb 18	HSE&P Manager
2.0	All	Response to Environment Agency	Feb 18	HSE&P Manager
3.0	All	Submission to Environment Agency	Apr 18	HSE&P Manager
4.0	All	Submission to Environment Agency	Apr 18	HSE&P Manager
5.0	All	Submission to Environment Agency	May 18	HSE&P Manager
5.1	All	Resubmission to Environment Agency	May 18	HSE&P Manage

Documents are reviewed as per proposed review date, or sooner if a significant change to the operation has taken place, to ensure relevance to the systems and process that they define.

Table of Contents

1.0 Purpose

The purpose of this report is to satisfy the requirements of pre-operational condition 2 and Schedule 3, Table S3.1 including the extended requirement for fugitive emissions monitoring.

2.0 Definitions

AQMA: *Air Quality Management Areas*

EPR*: Environmental Permitting Regulations 2016*

ES: *Environment Statement requirement of the Town and Country Planning (Environmental Impact Assessment) Regulations 2011.*

Fugitive Emission*: Emission to the atmosphere caused by loss of tightness of an item which is designed to be tight (BS EN15446:2008)*

PO*: Pre-operational condition*

S3*: Schedule 3 of EPR Permit EPR/AB3101MW*

3.0 Scope

The report covers Preston New Road site for all wells and operations conducted.

4.0 Introduction

The following literature review of EPR/AB3101MW permit and associated Waste Management Plan (HSE-Permit-INS-PNR-006) provides the relevant information as reference:

4.1 PO2

Pre-operational condition states:

At least 4 weeks prior to commencement of the gas flaring activity the operator shall submit to the Environment Agency for approval a written Environmental Management and Monitoring Plan (EMMP) which will include, but is not limited to;

Details of the baseline air quality study undertaken prior to activities commencing; details of the ambient air monitoring programme proposed for during and after the period of gas flaring; and shall obtain the Environment Agency's written approval to the EMMP.

The risk of emissions during the well testing phase has been assessed within the waste management plan concluding the following statement:

The Environmental Risk Assessment has concluded any quantities are expected to be very minor and consequently pose a low environmental risk.

5.0 Environmental Setting

The Site is located between Blackpool and Kirkham on the south-west of the Fylde coastal plain. The Site is approximately 400 metres west of the village of Little Plumpton and around one kilometre west of the village of Great Plumpton.

The site is currently accessed from Preston New Road (A583) and is approximately 150m north of the main entrance across single access track. The site was previously covered in short grass and used for livestock grazing. The site's previous ground level sloped gently from east to west, with the lowest part of the site being in the North West corner of the field. A pond is located approximately 60m to the south-east of the site.

The local environment air quality is influenced by sources including the A583, M55 motorway, farming and metrological conditions. Further from site, approximately 3km west of the site, is the Irish Sea, beaches and sand dunes. The prevailing wind is from the Western quadrant consistent with UK prevailing wind direction.

The site is surrounded by agricultural land on all sides generally comprising grassland for livestock grazing with the occasional pond.

The nearest properties are located approximately 300m south-west of the site (off Preston New Road), and 350m east of the site (also off Preston New Road). The properties are a mixture of residential and farm buildings.

Nearby properties that have been recorded on historical and current Ordnance Survey mapping of the area are indicated in Table 1 below.

Table 1 - Nearby properties

Distance from site (m)	Direction	Property Details & Dates Present From-To
300	SW	Staining Wood Cottages
350	SW	Staining Wood Farm
400	E	Buildings in Little Plumpton
800	NW	Moss House, (labelled as Moss Cottages from 1970)
800	NW	Moss House Farm
900	NE	Buildings in Great Plumpton

The surrounding land uses contain further agricultural land, as well as small areas of woodland, the closest of which is Humber Wood at approximately 100m south of the site boundary. There are several farms in the surrounding area, as well as the hamlet of Little Plumpton.

All available historical mapping, from 1847 to 2018 indicates that the site is undeveloped and lies within the boundary of an agricultural field; it has remained unchanged since the earliest available mapping.

Table 2 provides a summary of farming activities taking place in the surrounding fields immediately next to or within close proximity (less than 250m) of the monitoring stations. The activity can provide further information of why variations in air quality are occurring and will help contextualise data being presented during the baseline and during the operational period.

Table 2: Local farming activity within the immediate vicinity of the site monitoring stations

Farming Activity	Period	Potential Air Quality Impacts
Silage 3 or 4 crops per year	May to October	Methane, odour, hydrogen sulphide, oxides of nitrogen
Slurry/Manure Spreading	All year if ground conditions permit	Methane, odour, hydrogen sulphide, oxides of nitrogen
Milking	All year, 2x per day	Methane
Cows grazing	April to November	Methane
Sheep grazing	December to March	Methane
Spraying grazing weeds	April	VOCs
Planting rape seed	July	VOCs
Planting cereals	September	Dust, PM_{10}
Arable crop spraying	3 or 4 times per crop	VOCs
Harvest of arable crops	August to September	Dust, PM_{10}

5.1 Environmental Statement Review (Air Quality Chapter)

In 2014 Cuadrilla produced a comprehensive Environment Statement ("ES") to cover the lifecycle of the proposed development. Within the ES chapter 6 provided an Air Quality assessment. The summary of the chapter detailed the following points:

This chapter assesses the potential for the Project to emit pollutants into the air. It does this by predicting the likely changes in pollutant concentrations as a consequence of the Project. These are then compared to air quality objectives and limit values for these pollutants to determine whether the predicted changes are significant.

The area in which the Site is situated is rural and not densely populated. There are no existing significant sources of emissions to the atmosphere. Likewise, there are no areas within the vicinity of the Site where there is an existing problem with air quality or pollution.

The main source of atmospheric pollutants from the Project are the gases that are emitted when gas is burnt in the flare. The assessment quantifies the amount of nitrogen dioxide, benzene and radon that could be emitted from the flare and how it would be dispersed using weather data for the prevailing wind directions. This assessment concludes that for all of the above gases the concentrations that could be emitted from the flare are well below the level where a significant effect would be identified. *An additional assessment of the potential for the Project to generate dust has also been assessed. This concluded that there is a low risk of the Project creating dust and as a result is not a significant effect.*

The only mitigation measures required are standard dust control measures that are used during construction of the access track, well pad and the installation of the connection to the national transmission system. These will be sufficient to manage the risk of the Project generating dust that could adversely affect vegetation or nearby properties.

The Preston New Road and Roseacre Wood Sites are sufficiently distant from one another that their combined impacts on air quality will not result in a greater combined effect than individually.

The information from the ES concluded for air quality monitoring should concentrate on flaring activity which is conditioned under Schedule 3.1 point source emissions to air. Monitoring of the flare is detailed within section 10.0. Baseline desktop information was also conducted during the ES.

The study area for the assessment is a 10km radius from the centre of the Site. This is based on the screening distance for nature conservation sites required in the Environment Agency's H1 guidance.

The Site is located in a relatively undeveloped area with no large urban areas nearby (the nearest residential receptors being Blackpool and Wesham, which are approximately 2km and 2.5km from the Site respectively). Existing air quality at the Site would therefore be expected to be good, with concentrations of pollutants within air quality limits and objectives. Air quality in the nearby towns would be influenced by local traffic emissions and would experience comparatively higher concentrations of pollutants.

The Site is located within the Fylde Borough Council area, however is close to the border of Blackpool Borough Council. As required by the Environment Act 1995, each council has undertaken a regular review of air quality in their area to identify where air quality objectives may be exceeded. Both councils also carry out air quality monitoring to measure nitrogen dioxide concentrations using diffusion tubes. In the most recent report available on its website (Fylde Borough Council, Air Quality Progress Report, April 2013) it lists five monitoring locations for diffusion tubes throughout the borough. Monitoring is generally carried out in more urban locations and some distance from the site of the proposed development and therefore the results are not applicable for determining existing air quality from the proposed development. Fylde Borough Council has not declared any Air Quality Management Areas (AQMA) within their administrative area.

Blackpool Borough Council does undertake some monitoring that is closer to the proposed development. ***The closest monitoring site to the development is near Marton Mere to the north west of the Site where concentrations were well below the air quality objective for nitrogen dioxide during 2012 (the period reported in the 2013 Blackpool Borough Council Progress Report).***

The Defra website includes estimated background air pollution data based from 2010 with projections for future years for NOx, NO2 and PM10 for each 1km by 1km OS grid square. The average background concentrations have been calculated from the nine, 1km grid squares surrounding the Site. Estimated concentrations of NO2 (10.1µg/m3) and PM10 (12.9µg/m3) at the proposed development are well below the annual mean NO2 and PM10 objectives in 2013.

Background maps are also available for benzene. The maps created in 2001 have a projected year of 2010 for each 1km by 1km OS grid square. Defra have provided a methodology[1] and factors for predicting future year benzene concentrations up till 2025. The factors have been used in this case to predict benzene concentrations in 2013 at the grid square where the Site is located. The concentrations of benzene at the Site are well below the objective level in 2013.

Table 3 Estimated annual mean background concentrations in 2013.

Year	***NO_2 µg/m^3***	***PM_{10} µg/m^3***	***Benzene µg/m^3***
2013	***10.1***	***12.9***	***0.21***

[1] http://laqm.defra.gov.uk/documents/guidance_note_background_projections_1.pdf

5.2 Relevant Air Quality Objectives (AQOs)

A number of UK Air Quality Objectives exist which are relevant to the potential emission sources from the site. These are detailed in the following sections.

5.2.1 Particulate matter

A UK air quality objective (AQO) exists for particulate matter (PM_{10}). The long term AQO for PM_{10} is to achieve and maintain an annual mean value of 40 µg m^{-3} or below. A further AQO for PM_{10} is to prevent 24 hour means from exceeding 50 µg m^{-3} more than 35 times per year. These AQOs have been effective since 31st December 2004. Equivalent European obligations exist, which are also set at 40 µg m^{-3} and 50 µg m^{-3} respectively.

5.2.2 Nitrogen dioxide

A UK air quality objective (AQO) exists for nitrogen dioxide. The long term AQO for nitrogen dioxide is to achieve and maintain an annual mean value of 40 µg m^{-3} or below. A further AQO for nitrogen dioxide is to prevent 1 hour means from exceeding 200 µg m^{-3} more than 18 times per year. These AQOs have been effective since 31st December 2005. Equivalent European obligations exist, which are also set at 40 µg m^{-3} and 200 µg m^{-3} respectively.

5.2.3 Benzene

A UK air quality objective (AQO) exists for benzene. The long term AQO for benzene is to achieve and maintain an annual average value of 5 µg m^{-3} or below. A further AQO for benzene in England and Wales exists which requires a running annual mean of 16.25 µg m^{-3} or below. These AQOs have been effective since 31st December 2010 and 31st December 2003 respectively. An equivalent European obligation exists, which is also set at 5 µg m^{-3}.

5.2.4 Methane

A UK air quality objective (AQO) does not exist for methane.

6.0 Baseline Air Quality Monitoring

A 12 month baseline survey was conducted by independent consultants utilising a combination of long-term static monitoring combined with short term grab sampling taking into account Environment Agency Technical Guidance Note M8, EA Evidence: Monitoring and control of fugitive methane from unconventional gas operations and EA Petroleum Activities Guidance Note & EA Guidance H1 Annex F- Air Emissions as well as UK National Air Quality Objectives. The baseline methodology was produced in February 2014. Table 4 provides a list of parameters and justification for the period of monitoring.

Cuadrilla's ambient air quality monitoring programme commenced in May 2014 and continued for 12 months until May 2015. The monitoring programme re-commenced in November 2016 and continues to date, with site construction starting in January 2017 and drilling commencing in June 2017. The offsite baseline monitoring objectives were set to:

1. Establish baseline local ambient air quality for future operations to benchmark;
2. Cross reference data against desktop information e.g. DEFRA sources within the Environment Statement;
3. Provide a source of information to reference against during operations;
4. Affirm that there are no potential hot spots of methane prior to the start of operations;
5. Provide data sets for reporting against; and
6. Inform future operational monitoring requirements

While not directly associated with Cuadrilla's operations, a further independent baseline monitoring exercise was undertaken by the British Geological Survey (BGS) in association with the University of York and University of Manchester and others. This programme of monitoring commenced in late January 2016 and continued up to and beyond the start of site construction in January 2017. The BGS baseline data was collected at 1-minute intervals from a location approximately 400m down prevailing wind of the eventual location of the site. While the BGS monitoring is independent of Cuadrilla's own monitoring efforts, and will not be relied upon for operational compliance purposes, it does provide useful data to understand baseline ambient air quality conditions at the site. For this reason, and in consultation with the Environment Agency, it will be used as the primary data source for the baseline period.

A summary of the baseline data gathered is provided below in Table 5 and Section 7.0. Data supporting the baseline is provided in Appendix A.

Table 4: List of offsite Air Quality Monitoring: source Waste Management Plan (HSE-Permit-INS-PNR-006)*

Determinant	Justification	Measurement Method	Short Term/ Long Term	Explanation
Methane (CH_4)	Potential greenhouse gas emission emanating from incomplete combustion or fugitive emissions.	GC-FID	Grab Sample short term on a monthly basis	Methane is a potent greenhouse gas. It is present in ambient air, typically at concentrations between 2-4ppmv. Localised detections of elevated methane concentration can be caused by a range of natural and anthropogenic sources including various geologies, agricultural and industrial activities. Potential sources of elevated ambient methane from the site include the wellheads and associated equipment, fluid storage tanks, separators and flares. Appropriate equipment selection, maintenance and strict process controls will be used to minimise any emissions from onsite sources. A comprehensive programme of environmental monitoring, incorporating both continuous and passive techniques will record ambient methane concentrations throughout onsite operations. Methane is not considered to cause human health effects except when encountered in very high concentrations, where oxygen displacement can become an issue (typically in confined settings only).

Determinant	Justification	Measurement Method	Short Term/ Long Term	Explanation
Nitrogen Dioxide (NO_2)	Potential for human health effects and environmental damage e.g. soil acidification, acid rain.	Diffusion Tube	Long term static sampling over a month	Nitrogen dioxide is a product of combustion and other processes. It is a common air quality pollutant. It is present in ambient air, typically at concentrations between 5-40 µg m^{-3}, however actual concentrations are strongly controlled by local setting and can be highly variable. Nitrogen dioxide can be caused by natural causes such as volcanic emissions and the further atmospheric oxidation of nitric oxides (and other nitrogen compounds) released by bacterial respiration, however it is more commonly associated with anthropogenic sources including most industrial and commercial combustion processes and emissions from vehicle traffic. Nitrogen dioxide can cause both chronic and acute health effects in humans, particularly amongst vulnerable groups. The nearby major roads are likely to be significant local offsite sources of nitrogen dioxide. Potential onsite sources include the engines of vehicles and non-mobile plant, however these sources are likely to be comparatively short lived in nature. A comprehensive programme of environmental monitoring, incorporating both continuous and passive techniques will record ambient nitrogen dioxide concentrations throughout onsite operations.

Determinant	Justification	Measurement Method	Short Term/ Long Term	Explanation
Hydrogen Sulphide (H_2S)	Potential odour nuisance and human health impacts	Diffusion Tube	Long term static sampling over a month	Hydrogen sulphide is a highly toxic and explosive gas. Hydrogen sulphide is generally not present in ambient air, however localised sources (both natural and anthropogenic) can cause elevated concentrations. Hydrogen sulphide can be caused by natural processes (such as anaerobic degradation of sulphide bearing organic materials) and can be present in hydrocarbon deposits. Hydrogen sulphide concentrations within hydrocarbon deposits is typically controlled by natural, reservoir-specific causes and hydrocarbon extraction practices. No hydrogen sulphide is anticipated within the target resource based on local analogues. Hydrogen sulphide can cause both chronic and acute health effects in humans. Hydrogen sulphide is also odourous at very low concentrations, and can cause a nuisance effect as a result. A comprehensive programme of lab analysis, gas detection alarms, targeted human detection and environmental monitoring, incorporating both continuous and passive techniques will detect and record any elevated hydrogen sulphide concentrations throughout onsite operations. Exploration wells drilled in the Bowland Shale across Lancashire within Cuadrilla's PEDL license areas have not encountered hydrogen sulphide. Core analysis of the wells at Preston New Road confirmed hydrogen sulphide is not present.

Determinant	Justification	Measurement Method	Short Term/ Long Term	Explanation
BTEX (includes Benzene)	Potential for environmental accumulation and persistence Potential greenhouse gas emissions Potential for odour nuisance Potential precursor to ground level ozone formation	Diffusion Tube	Long term static sampling over a month	BTEX is a group of organic compounds including benzene, toluene, ethylbenzene and xylene. BTEX compounds are naturally present in hydrocarbon deposits, and many fuels and other compounds derived from them. BTEX compounds are not naturally present in ambient air, however, elevated concentrations can be caused by a range of artificial processes, most notably the use of hydrocarbon fuels in vehicles and other combustion equipment. Potential onsite sources of benzene include the use of onsite combustion equipment (vehicles and plant), however these sources are likely to be comparatively short lived in nature. In particular, benzene is a known human carcinogen, and can cause a range of acute and chronic health effects in humans. A comprehensive programme of environmental monitoring, incorporating both continuous* and passive techniques will record ambient benzene concentrations throughout onsite operations. *GasSentinel will continuously monitor Total VOC concentrations (including benzene) as a surrogate for continuous benzene monitoring due to the practical difficulties of benzene-specific continuous monitoring.

Determinant	Justification	Measurement Method	Short Term/ Long Term	Explanation
PM_{10}	Environmental damage potential both natural and anthropogenic sources includes sea salt, soil dust and the products of combustion.	Combined Frisbee Depositional Gauge with Adhesive Strips Directional Gauge	Long term static sampling over a month	PM_{10} refers to a broad range of particulate matter types of various composition, which are grouped together for monitoring purposes into those particles smaller than 10 microns in size. PM_{10} particles are typically present in ambient air in highly varying concentrations, in locally specific and temporally variable patterns associated with a range of natural and anthropogenic sources both in a given locality, and indeed on a regional or continental basis. PM_{10} particles can cause both chronic and acute health effects in humans. Sources of PM_{10} particles can include agriculture and other land uses, commercial and industrial activities and vehicle and other combustion emissions. Potential onsite sources of PM_{10} particles include vehicle and other combustion emissions and materials handling, however these sources are likely to be comparatively short lived in nature. A comprehensive programme of environmental monitoring, incorporating both continuous and passive techniques will record ambient PM_{10} concentrations throughout onsite operations.
Dust (nuisance)	Environmental damage and potential for nuisance			Dust is a vaguely defined group of particulates found in ambient air. Dust can be sourced from a wide range of natural and anthropogenic sources. Typically, ambient dust concentrations in any given locale are highly specific to surrounding land uses and other factors, and can be temporally highly variable. A comprehensive programme of environmental monitoring, incorporating both continuous and passive techniques will record ambient dust concentrations throughout onsite operations.

*Table adapted from HSE-Permit-INS-PNR-006 with Environment Agency agreement to reflect monitoring requirements agreed subsequent to the approval of the waste management plan.

7.0 Baseline Data Gathering and Calculation

A range of ambient air quality monitoring has been undertaken in the vicinity of the site using a range of techniques. All baseline monitoring has been undertaken prior to the construction of the site. This monitoring has taken place over a number of years, and includes data from Cuadrilla's deployed monitoring, along with data from other third party data sources. Where passive or periodic monitoring techniques have been used, typically at monthly frequencies, the data has been analysed by undertaking basic statistical analysis of the collected results to provide representative minimum and maximum observed values, along with an average of all the results gathered over the course of a twelve month period. This data is supplemented by analysis of high frequency continuous monitoring data gathered by independent third parties. This second data source was combined with co-located meteorological monitoring which when combined with the data density allows much more detailed analysis of baseline air quality at the site. This data has been statistically analysed for a number of key parameters, under a range of meteorological conditions over the course of approximately a calendar year. A statistical summary for each parameter and each principle wind vector (where possible) is presented below.

For clarity, the data gathered during the baseline monitoring period was collected at different locations, using different techniques at different monitoring locations and in different years. As such, the data sources are not directly comparable with each other, however, combined, they provide a rich and detailed examination of baseline air quality at the site over a substantial period of time for a number of key parameters. As all of this data has been gathered prior to the commencement of any onsite activities (including site construction), it follows that all of the observed concentrations are derived from offsite sources. A further summary of the maximum observed baseline data is presented in Table 6 below. Table 6 is based on the results gathered using independent third party data.

Table 5: Baseline summary data, elevations and detailed analysis

Location	Key Numerical Analysis	Summary of Baseline Data
Eastern (P1)	PM_{10} Max: 39.0 µg.m^{-3} (24hrs) PM_{10} Avg: 21.5 µg.m^{-3} (annual) PM_{10} Min: 5.0 µg.m^{-3} (24hrs) **Env Statement: 12.9 µg.m^{-3} (annual)** **BGS Mean: 14.6 µg.m^{-3} (East wind vector)**	**PM_{10} summary** PM_{10} is averaging above desktop assessment levels and also BGS data set. Annual average of PM_{10} is between 50% and 100% of UK Air Quality Objective. There was one increase in PM_{10} in September 2014 coinciding with harvest season. September 2014 concentrations were consistently above the applicable AQO threshold values for all four monitoring stations. For clarity, individual exceedances of AQO threshold values do not constitute a formal breach of the relevant AQO. Further note; during the baseline survey United Utilities undertook an installation of a large diameter trunk main across the field in close proximity to the proposed site. This coincided with the Q4 2014 and Q1 and Q2 2015 baseline data set. See appendix B for overhead view and scale of the development. The activity from the construction of the pipeline could result in the variation for data sets in comparison to a rural environment.
	NO_2 Max: 22.38 µg m^{-3} (monthly) NO_2 Avg: 12.93 µg m^{-3} (annual) NO_2 Min: 8.29 µg m^{-3} (monthly) **Env Statement: 10.1µg m^{-3} (annual)** **BGS Mean: 9.0 µg m^{-3} (East wind vector)**	**NO_2 summary** NO_2 data is elevated in comparison to the desktop predictions of a rural environment.

Location	Key Numerical Analysis	Summary of Baseline Data
	Benzene Max: 6.0 µg m^{-3} (24hrs) Benzene Avg: 1.55 µg m^{-3} (annual) Benzene Min: <0.4 µg m^{-3} (24hrs) **Env Statement: 0.21 µg.m^{-3}** **BGS Avg: 1.3 µg.m^{-3}* (annual)** ***conversion from ppb**	**Benzene summary** Benzene annual average at both BGS and Cuadrilla monitoring stations were above the ES desktop data set but were relatively consistent with each other. A single monthly sample exceeded the applicable AQO threshold value by 1 µg m^{-3} recording 6.0 µg m^{-3} in comparison to the limit 5 µg m^{-3} (calendar year).. The monitoring recorded an annual average for Benzene is 1.55 µg m^{-3} for the baseline below the annual objective of 5.0 µg m^{-3}. For clarity, individual exceedances of AQO threshold values do not constitute a formal breach of the relevant AQO.
	Methane Max: 667ppm (19ppm)* Methane Avg: 121ppm (11.4ppm*) Methane Min:<5ppm **BGS Data: 2-4ppm hourly averages** *see summary of baseline for explanation	**Methane summary** The grab sample data is significantly different to the other data collected and highlights the difference in sampling methodology. Subsequently a TDL 500 has been installed on the pad perimeter to improve methane detection. Reviewing the data set the maximum methane result is considered an outlier which is skewing the average figure. The Mode for the data is <5ppm for the monitoring location. Removing the suspected outlier in December 2014 the new sampled maximum data is 19ppm with an average 11.4ppm which is significantly different to results recorded.

<table>
<tr><th>Location</th><th>Key Numerical Analysis</th><th>Summary of Baseline</th></tr>
<tr><td>Northern

(P2)</td><td>PM_{10} Max: 36.0 µg m^{-3} (24hrs)

PM_{10} Avg: 17.8 µg m^{-3} (annual)

PM_{10} Min: 9.0 µg m^{-3} (24hrs)

Env Statement: 12.9 µg m^{-3}

BGS Mean: 7.9 µg m^{-3} (North wind vector)</td><td>PM_{10} summary

PM_{10} is averaging above desktop assessment levels and also BGS data set.

Annual average of PM_{10} is less than 50% of UK Air Quality Objective.

There was one increase in PM_{10} coinciding with harvest season.

Further analysis utilising SEM (Scanning Electron Microscopy), was conducted to breakdown the elevation of the exceedance at location P2 and P3 only. The breakdown of the composition is detailed below for P2.

<table><tr><td>Particle Category (%)</td><td></td><td></td></tr><tr><td>Unburnt Coal/Carbonaceous Matter</td><td>4</td><td></td></tr><tr><td>Carbonised Coal</td><td></td><td></td></tr><tr><td>Silicon Rich</td><td>48</td><td></td></tr><tr><td>Plant/Animal Fragments</td><td>8</td><td></td></tr><tr><td>Calcium Rich</td><td></td><td></td></tr><tr><td>Iron Rich</td><td>4</td><td></td></tr><tr><td>General Dirt</td><td>36</td><td></td></tr></table>
Further note; during the baseline survey United Utilities undertook an installation of a large diameter trunk main across the field in close proximity to the proposed site. This coincided with the Q4 2014 and Q1 and Q2 2015 baseline data set. See appendix B for overhead view and scale of the development. The activity from the construction of the pipeline could result in the variation for data sets in comparison to a rural environment.</td></tr>
</table>

	NO_2 Max: 16.62 µg m^{-3} (monthly) NO_2 Avg: 10.31 µg m^{-3} (annual) NO_2 Min: 6.24 µg m^{-3} (monthly) **Env Statement: 10.1µg m^{-3}** **BGS Mean: 4.9 µg m^{-3} (North wind vector)**	**NO_2 summary** NO_2 data is consistent with desktop predictions of a rural environment.
	Benzene Max: 1.7 µg m^{-3} (24hrs) Benzene Avg: 0.93 µg m^{-3} (annual) Benzene Min: <0.4 µg m^{-3} (24hrs) **Env Statement: 0.21 µg m^{-3}** **BGS Avg: 1.3 µg m^{-3}* (annual)** ***conversion from ppb**	**Benzene summary** Benzene levels are above the ES desktop information and below the BGS data set. The levels of Benzene at this location are below the Air Quality Objective of 5µg m^{-3} annual average.
	Methane Max: 20ppm Methane Avg: 8.75ppm Methane Min:<5ppm **BGS Data: 2-4ppm hourly averages**	**Methane summary** The data set identifies peak samples for January, February and March. The grab sample data is significantly different to the data collected and highlights the difference in sampling methodology. The grab sample data is significantly different to the BGS data and also P1 (Eastern) which identifies the potential for the P1 (Eastern) maximum sample being an outlier. Subsequently a TDL 500 has been installed on the pad perimeter to improve methane detection.

Location	Key Numerical Analysis	Summary of Baseline
Southern (P4)	PM_{10} Max: 41.0 µg m^{-3} (24hrs) PM_{10} Avg: 19.3 µg m^{-3} (annual) PM_{10} Min: 10.0 µg m^{-3} (24hrs) **Env Statement: 12.9 µg m^{-3}** **BGS Mean: 13.8 µg m^{-3} (South wind vector)**	**PM_{10} Summary** PM_{10} is averaging above desktop assessment levels and also BGS data set. Annual average of PM_{10} is less than 50% of UK Air Quality Objective. There was one elevation of PM_{10} in September 2014 coinciding with harvest season. September 2014's data was consistently above the applicable Air Quality Objectives threshold value for all four monitoring stations. For clarity, individual exceedances of AQO threshold values do not constitute a formal breach of the relevant AQO. Further analysis utilising SEM (Scanning Electron Microscopy), was conducted to breakdown the elevation of the exceedance at location P2 and P3 only which provide a breakdown of the elevated results. Further note; during the baseline survey United Utilities undertook an installation of a large diameter trunk main across the field in close proximity to the proposed site. This coincided with the Q4 2014 and Q1 and Q2 2015 baseline data set. See appendix B for overhead view and scale of the development. The activity from the construction of the pipeline could result in the variation for data sets in comparison to a rural environment.
	NO_2 Max: 25.39 µg m^{-3} (monthly) NO_2 Avg: 13.75 µg m^{-3} (annual) NO_2 Min: 7.24 µg m^{-3} (monthly) **Env Statement: 10.1µg m^{-3}** **BGS Mean: 15.7 µg m^{-3} (South wind vector)**	**NO_2 Summary** NO_2 is relatively elevated. However the levels of NO_2 in comparison to an urban environment or relatively high traffic urban road environments is low.

	Benzene Max: 1.0 µg m^{-3} (24hrs) Benzene Avg: 0.8 µg m^{-3} (annual) Benzene Min: <0.36 µg m^{-3} (24hrs) **Env Statement: 0.21 µg m^{-3}** **BGS Avg: 1.3 µg m^{-3}* (annual)** ***conversion from ppb**	**Benzene summary** Benzene levels are above the ES desktop information and BGS data set. The data identifies levels of benzene at this location are below the Air Quality Objective of 5 µg m^{-3} annual average and below the BGS data.
	Methane Max: <5ppm Methane Avg: <5ppm Methane Min:<5ppm **BGS Data: 2-4ppm hourly averages**	**Methane summary** Methane levels have remained consistently below the level of detection <5ppm. The grab sample data is in keeping with the potential for consistency with the BGS data of 2-4ppm. Subsequently a TDL 500 has been installed on the pad perimeter to improve methane detection.

<table>
<tr><th>Location</th><th>Key Numerical Analysis</th><th>Summary of Baseline</th></tr>
<tr><td>Western

(P3)</td><td>PM_{10} Max: 32.0 µg m^{-3} (24hrs)

PM_{10} Avg: 20.9 µg m^{-3} (annual)

PM_{10} Min: 12.0 µg m^{-3} (24hrs)

Env Statement: 12.9 µg m^{-3}

BGS Mean: 9.7 µg m^{-3} (West wind vector)</td><td>PM_{10} Summary

PM_{10} is averaging above desktop assessment levels and also BGS data set.

Annual average of PM_{10} is between 50% and 100% of UK Air Quality Objective.

There was one elevation of PM_{10} in September 2014 coinciding with harvest season. September 2014’s data was consistently above the applicable Air Quality Objectives threshold value for all four monitoring stations.

Further analysis utilising SEM (Scanning Electron Microscopy), was conducted to breakdown the elevation of the exceedance at location P2 and P3 only. The breakdown of the composition is detailed below for P3. PM10 is averaging above desktop assessment levels and also BGS data set.

<table>
<tr><td>Particle Category (%)</td><td></td></tr>
<tr><td>Unburnt Coal/Carbonaceous Matter</td><td>2</td></tr>
<tr><td>Carbonised Coal</td><td></td></tr>
<tr><td>Silicon Rich</td><td>36</td></tr>
<tr><td>Plant/Animal Fragments</td><td>20</td></tr>
<tr><td>Calcium Rich</td><td></td></tr>
<tr><td>Iron Rich</td><td>2</td></tr>
<tr><td>General Dirt</td><td>40</td></tr>
</table>

Further note; during the baseline survey United Utilities undertook an installation of a large diameter trunk main across the field in close proximity to the proposed site. This coincided with the Q4 2014 and Q1 and Q2 2015 baseline data set. See Appendix B for overhead view and scale of the development. The activity from the construction of the pipeline could result in the variation for data sets in comparison to a rural environment.</td></tr>
</table>

	NO_2 Max: 23.33 µg m^{-3} (monthly) NO_2 Avg: 12.82 µg m^{-3} (annual) NO_2 Min: 6.96 µg m^{-3} (monthly) **Env Statement: 10.1µg m^{-3}** **BGS Mean: 3.1 µg m^{-3} (West wind vector)**	**NO_2 Summary** NO_2 is relatively elevated due. However the levels of NO_2 in comparison to an urban environment or relatively high traffic urban roads environment is low.
	Benzene Max: 1.12 µg m^{-3} (24hrs) Benzene Avg: 0.90 µg m^{-3} (annual) Benzene Min: <0.36 µg m^{-3} (24hrs) **Env Statement: 0.21 µg m^{-3}** **BGS Avg: 1.3 µg.m^{-3}* (annual)** ***conversion from ppb**	**Benzene Summary** Benzene levels are consistent with the BGS data set with the average below levels recorded but above the ES desktop information. The levels of Benzene at this location are below the Air Quality Objective of 5 µg m^{-3} annual average.
	Methane Max: 20ppm Methane Avg: 12.00ppm Methane Min:<5ppm **BGS Data: 2-4ppm hourly averages**	**Methane Summary** The data set identifies peak samples for January, February and March. The grab sample data is significantly different to the data collected and highlights the difference in sampling methodology. The grab sample data is significantly different to the BGS data and also P1 (Eastern) which identifies the potential for P1 (Eastern) maximum sample being an outlier. Subsequently a TDL 500 has been installed on the pad perimeter to improve methane detection.

7.1 Third party baseline monitoring data summary

A statistically formulated summary of the BGS' baseline environmental monitoring data for selected parameters is presented below. The high frequency nature of this data (collected at 1-minute sampling frequency) provides an additional line of evidence for comparison with the continuous monitoring data that will be gathered at the site during the operational periods. The data presented is a selected summary of the BGS' data as included in Environmental Baseline Monitoring Project. Phase II, final report (Ward et al, British Geological Survey, 2017).[2] A brief summary of the observed spatial variation of each pollutant is also presented below. For clarity, the BGS' baseline data was gathered using different methods and during a different period to Cuadrilla's own baseline monitoring. All values are shown in units of µg m^{-3} unless otherwise stated. The maximum values observed by the BGS' monitoring are presented in Table 6 below.

Note: Unlike most parameters, the BGS' monitoring of benzene during the baseline period used a number of weekly samples gathered between 29/10/2015 and 31/10/2016 rather than high-frequency continuous monitoring data. As a result, it is not possible to undertake the same level of spatial analysis on the available benzene data. A basic statistical summary of the available benzene data is presented below. The BGS VOC baseline monitoring did not include a measurement of Total VOCs, instead using speciated VOC monitoring for certain parameters.

[2] Ward et al, British Geological Survey, 2017 - Environmental Baseline Monitoring Project. Phase II, final report - http://nora.nerc.ac.uk/517889/ (Accessed, 19/03/2018)

North wind vector

	PM_{10}	Nitrogen dioxide (NO_2)	Methane (CH_4)*
5th percentile	1.9	0.9	1.9
Median	6.3	2.9	2.0
Mean	7.9	4.9	2.0
95th percentile	19.3	14.7	2.4

East wind vector

	PM_{10}	Nitrogen dioxide (NO_2)	Methane (CH_4)*
5th percentile	4.5	1.7	2.0
Median	12.2	5.1	2.4
Mean	14.6	9.0	2.7
95th percentile	30.2	29.6	4.7

North East wind vector

	PM_{10}	Nitrogen dioxide (NO_2)	Methane (CH_4)*
5th percentile	1.5	1.1	1.9
Median	6.4	3.6	2.1
Mean	8.1	6.5	2.1
95th percentile	20.6	22.2	2.7

South East wind vector

	PM_{10}	Nitrogen dioxide (NO_2)	Methane (CH_4)*
5th percentile	5.2	2.0	2.0
Median	15.2	13.7	2.3
Mean	18.0	18.1	2.5
95th percentile	39.6	50.7	3.8

South wind vector

	PM_{10}	Nitrogen dioxide (NO_2)	Methane (CH_4)*
5th percentile	4.0	1.9	2.0
Median	11.3	10.9	2.1
Mean	13.8	15.7	2.1
95th percentile	32.4	46.4	2.6

West wind vector

	PM_{10}	Nitrogen dioxide (NO_2)	Methane (CH_4)*
5th percentile	3.6	0.5	1.9
Median	8.7	2.3	1.9
Mean	9.7	3.1	1.9
95th percentile	19.1	7.8	2.0

South West wind vector

	PM_{10}	Nitrogen dioxide (NO_2)	Methane (CH_4)*
5th percentile	3.1	1.0	1.9
Median	8.2	4.8	2.0
Mean	9.6	8.0	2.0
95th percentile	20.5	27.1	2.3

North West wind vector

	PM_{10}	Nitrogen dioxide (NO_2)	Methane (CH_4)*
5th percentile	3.0	0.5	1.9
Median	7.4	2.2	1.9
Mean	8.6	3.1	2.0
95th percentile	17.7	8.1	2.1

* Results expressed in units of ppmv. Values converted from ppbv, and rounded to the nearest 0.1ppm.

Benzene (ppb)

5th percentile	0.126
Median	0.21
Mean	0.472
95th percentile	1.914

Methane

Baseline methane concentrations show a generally narrow range of values at the site under various assessed wind vectors. Mean and median methane concentrations for all wind vectors ranges between 1.9 – 2.7 ppmv. The highest mean and median concentrations were observed when the wind was blowing from the East wind vector, the South East wind vector also displayed relatively elevated mean and median values. The lowest mean and median concentrations were observed when the wind was blowing from the West wind vector. The difference between the lowest and highest observed 95th percentile concentrations ranged between 2.0 ppmv (W vector) and 4.7 ppmv (E vector).

Particulates

Baseline PM_{10} concentrations show a broad range of values at the site under various assessed wind vectors. Mean and median PM_{10} concentrations for all wind vectors ranges between 6.3 – 18.0 µg m^{-3}. The highest mean and median concentrations were observed when the wind was blowing from the South East wind vector, the East and South wind vectors also displayed relatively elevated mean and median values. The lowest mean and median concentrations were observed when the wind was blowing from the North wind vector. The difference between the lowest and highest observed 95th percentile concentrations ranged between 14.7 µg m^{-3} (NW vector) and 34.4 µg m^{-3} (SE vector).

Nitrogen dioxide

Baseline nitrogen dioxide concentrations show a broad range of values at the site under various assessed wind vectors. Mean and median nitrogen dioxide concentrations for all wind vectors ranges between 2.2 – 18.1 µg m^{-3}. The highest mean and median concentrations were observed when the wind was blowing from the South East wind vector, the East and South wind vectors also displayed relatively elevated mean and median values. The lowest mean and median concentrations were observed when the wind was blowing from the West and North West wind vectors. The difference between the lowest and highest observed 95th percentile concentrations ranged between 7.3 µg m^{-3} (W vector) and 48.7 µg m^{-3} (SE vector).

Benzene

As noted above, spatial analysis of benzene concentrations was not possible with the data available.

Maximum observed baseline concentrations

As would be expected with such a substantial dataset, the BGS data records a wide range of concentrations for each parameter. Generally speaking, the mean concentrations observed are in keeping with the site's relatively rural location, although the presence of significant vehicle emissions due to the adjacent trunk road is evident. The maximum concentrations due to offsite sources are significantly in excess of the mean (or typical) concentrations for each measured parameter. These maximum concentrations are associated with particular activities and conditions in the surrounding environment, such as agricultural activity, increased vehicle emissions and regional air quality conditions. The maximum observed concentration for each measured parameter is detailed in Table 6 below. The potential occurrence of these elevated concentrations will require consideration when interpreting future monitoring results during the site's operational activities.

Table 6. Maximum observed baseline concentrations of key parameters

Parameter	Concentration
Methane	70.5 ppmv
Nitrogen dioxide	313 µg $m^{-3*\#}$
PM_{10}	229.6 µg m^{-3}
Benzene	8.36 µg m^{-3*}

*Converted from ppbv. # Rounded to the nearest µg m^{-3}.

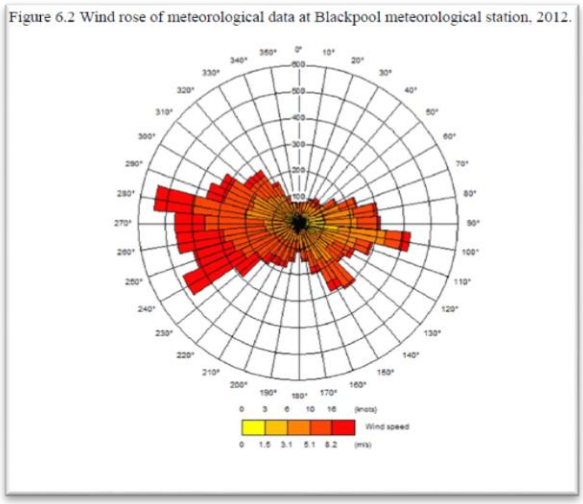
7.2 Meteorological Conditions

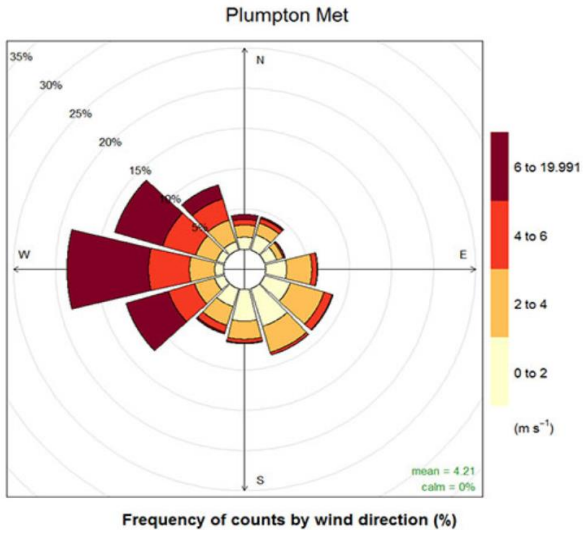
The below wind roses were provided from the Environment Statement, Arup 2014 and the weather station situated at Great Plumpton (as used in the collection of the BGS' baseline data).

Cuadrilla has a local off site weather monitoring station which records hourly weather at the same location as the L2 (Location 2) noise monitoring station. The weather station was installed in December 2016. As detailed in Section 8.7 below, Cuadrilla will also have a further weather station co-located with the continuous monitoring instruments. This equipment will be installed during May 2018.

The two available wind roses provide a consistent assessment of wind direction coming predominantly from the Western quadrant.

Figure 1: Baseline Wind Rose Maps





7.3 Location of Baseline Sampling Stations

Cuadrilla's own baseline sampling locations are located North, South, East and West of the site and were located subject to landowner consent. The locations were specifically chosen to account for changes in wind direction and the site perimeter. Therefore up and down wind conditions can be accounted for to assess contributions from sources depending on the wind direction. The distance of the monitoring locations were selected to collate data on local emissions and also provide surveillance of any ambient air quality changes.

The locations of the monitoring stations will remain in situ for the lifecycle of the site up to site restoration. This is consistent with figure 4 section 9.6.1 of the Waste Management Plan.

The location points for the ambient monitoring stations are shown in figure 2.

The location of the BGS' ambient monitoring station is adjacent to Plumpton Hall Farm, approximately 400m East of the site.

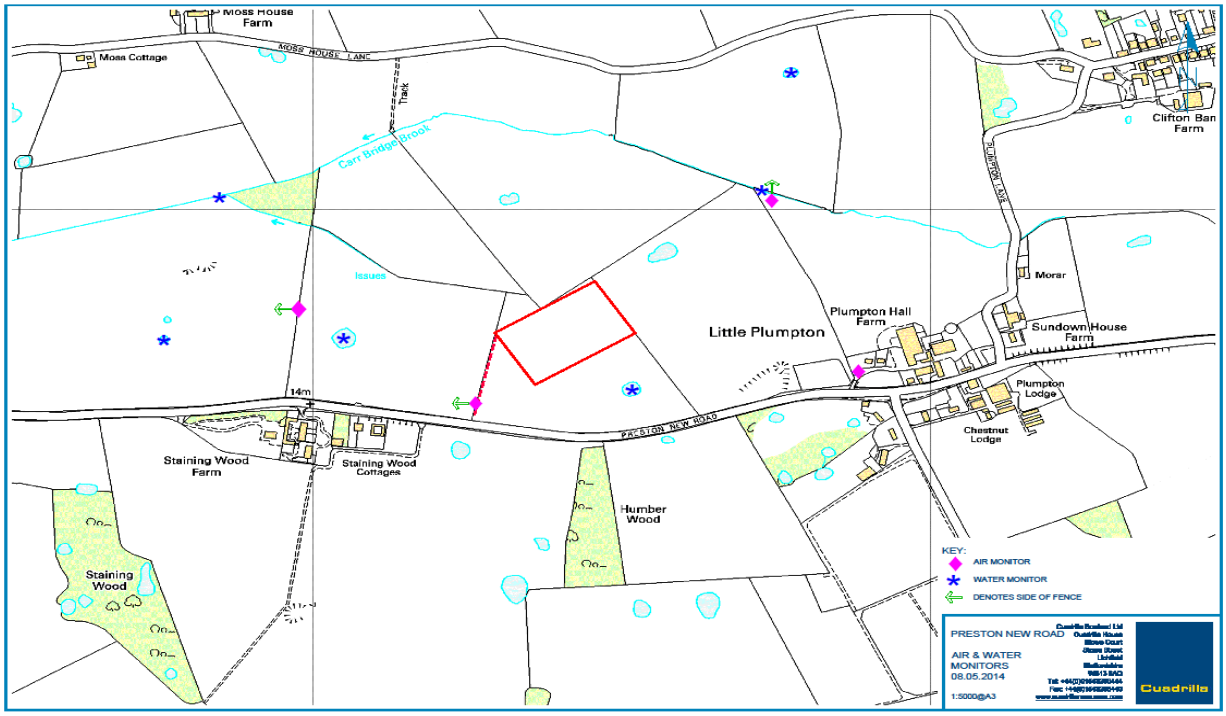


Figure 2: Offsite Air Quality Monitoring Stations

Figure 3. Locations for P1 (Eastern), P2 (Northern), P3 (Western) and P4 (Southern)

7.4 Third Party Data

Independent monitoring of atmospheric conditions have been conducted by research and university institutions. Further information can be found at the following link:

http://www.bgs.ac.uk/research/groundwater/shaleGas/monitoring/atmosphericComposition.html

This data collection is an independent operation which provides a further source of information. The reference is made in this plan to state that Cuadrilla is aware of the monitoring and has made comparison to the data for baseline setting purposes. However it is wholly independent of the operation and the data is not controlled by Cuadrilla or relied upon for operational permit compliance.

7.5 Initial Operational Air Quality

Since the start of site construction operations in January 2017 passive sampling data has been collected in accordance with Cuadrilla's own baseline data set. Table 8 provides a summary of the data collection so far.

Table 8: Operational Ambient Air Quality Review

Location	Initial Operational Data Collection
Eastern (P1)	PM_{10} was below the Air Quality Objectives (AQO) threshold values at the time of taking the samples. Benzene remained below the applicable AQO threshold value in all samples. NO_2 remained below the applicable AQO threshold value in all samples.
Northern (P2)	PM_{10} was below the Air Quality Objectives (AQO) threshold values at the time of taking the samples. Benzene remained below the applicable AQO threshold value in all samples. NO_2 remained below the applicable AQO threshold value in all samples.
Western (P3)	PM_{10} was below the Air Quality Objectives (AQO) threshold values at the time of taking the samples. Benzene remained below the applicable AQO threshold value in all samples. NO_2 remained below the applicable AQO threshold value in all samples.
Southern (P4)	One exceedance of the applicable AQO threshold value for PM_{10} was recorded in May 2017. The exceedance was 16 μgm^{-3} above the AQO threshold value, recording 67 μgm^{-3}. The exceedance was an isolated occurrence and has not been repeated during any subsequent month. For clarity, such an isolated exceedance does not constitute a formal breach of the relevant AQO. Benzene remained below the applicable AQO threshold value in all samples. NO_2 remained below the applicable AQO threshold value in all samples.

8.0 Ambient Air Quality Monitoring Programme Operational Phase

During the operational life of the site, up to and including site restoration, the parameters detailed above will be maintained as outlined within this plan. To supplement the monitoring undertaken during the baseline period, an additional programme of continuous ambient air quality monitoring will also be undertaken throughout the operational period.

To maintain consistency of the baseline and to improve monitoring a range of continuous monitoring instruments will form part of the air quality monitoring programme before the start of flaring. All continuous monitoring equipment will remain in place and operational throughout the site's operations, with the exception of short periods of occasional maintenance (monthly), instrument failures and when instruments are removed for calibration or repair. Where it is necessary to remove an instrument, a replacement will be deployed and activated as soon as reasonably achievable.

Condition 3.5.4 of the site's permit requires that all monitoring equipment, techniques, personnel and organisations to be either MCERTS certified or accredited, where possible. While MCERTS certified/accredited methods are available for certain lab-based analytical techniques and CEMS systems, there are generally no suitable continuous monitoring instruments available for field-deployable continuous monitoring which are MCERTS certified/accredited (with the exception of the Turnkey Osiris, which is MCERTS certified). The continuous monitoring instruments selected for use at the site are the best available while still being proportionate and appropriate to the monitoring needs and operational risks associated with the site.

8.1 Objectives of the Ambient Air Quality Monitoring Programme

The following objectives outline the plan to monitor and manage air quality at Preston New Road site during the operational period:

1. Consistent and auditable process monitoring air quality and greenhouse gas emissions from Preston New Road Site.
2. Reference baseline air quality conditions and any changes associated with operations and activities.
3. Regular surveillance of air quality during the well testing phase before during and after operations at Preston New Road Site.
4. Comply with Cuadrilla's Waste Management Plan (HSE-Permit-INS-PNR-006) and associated permit (EPR/AB3101MW)
5. Provide regular data sets and reporting to stakeholders and regulators.

8.1.1 Objective 1

The independent consultant who conducted the Cuadrilla baseline operation will continue to provide consistent air quality ambient monitoring of the site during operations (hydraulic fracturing and well testing). The data sets will provide consistency and reference information to review ongoing performance. A separate independent consultant will conduct the continuous monitoring programme throughout our operational period. Passive monitoring methodologies will be reviewed during the operational period (hydraulic fracturing and well test) to refine and focus monitoring towards the existing continuous monitoring programme. This will be agreed in writing with the Environment Agency.

The records of the ambient monitoring will be kept within Cuadrilla's HSE management system and be available at all times for inspection and review.

The continuous monitoring instruments will be set up before the start of flaring, with a minimum of 4 weeks monitoring data available. The instruments will report via telemetry data to an online portal which is available for review and interpretation. The records will be kept within the dedicated software package for review and inspection at all times.

8.1.2 Objective 2

As outlined above previous air quality data and baseline data will be reviewed either daily or monthly subject to the availability of the results.

The continuous monitoring instruments provide near real time monitoring. Subsequently the data will be reviewed on a daily basis by site based personnel.

The passive ambient air quality monitoring will be reported on a monthly basis for review and interpretation consistent with the baseline and current operational monitoring.

8.1.3 Objective 3

Surveillance monitoring will be performed at the ambient air quality monitoring stations surrounding the site (North, South, East and West) as well as the continuous monitoring instruments. Process emissions from the flares will be monitored in accordance with the information outlined in Section 10.0. In addition, fugitive emission monitoring will be executed in accordance with Section 9.0.

8.1.4 Objective 4

Compliance with the Waste Management Plan (HSE-Permit-INS-PNR-006) and EPR/AB3101MW as it pertains to environmental emissions will be executed through this Environmental Management and Monitoring Plan (EMMP).

8.1.5 Objective 5

Data sets will be recorded and be available for inspection at all times. Data will be reported in alignment with the following permit conditions:

- Schedule 3, table S3.1,
- Schedule 3, table S3.7, and
- Schedule 4, table S4.1

8.2 Operational ambient air monitoring programme

The programme of agreed monitoring to satisfy objectives 1 -5 above are detailed in Table 9 below.

Table 9: Air Quality Determinants and Sampling Summary

Measured Parameter	Sampling Method	Sampling Period	Analysis Method	Detection Limit
Methane	Grab Sample	Seconds	ENV/GAS03	5ppm
	Continuous monitoring	10 minute average	TDL500	0.1ppm
	Continuous monitoring (Targeted)	10 minute average	TDL500	0.1ppm
Volatile Organic Compounds	Diffusion Tube	1 Month	ATD GC-MS	5ng/tube
			10 most abundant	10-20ng/tube
	Continuous monitoring*	Every 10 minutes	GasSentinel	1ppm
BTEX	Diffusion Tube*	1 Month	ATD GC-MS	5ng/tube
Nitrogen Dioxide	Diffusion Tube	1 Month	Colorimetric	
	Continuous monitoring	Every 10 minutes	AQMesh	<10ppb
Hydrogen Sulphide	Diffusion Tube	1 Month		ppb
	Continuous monitoring	Every 10 minutes	GasSentinel	1ppm
Nuisance Dust	Combined Frisbee Dust Deposition & Adhesive Strip Directional Gauge	1 Month	Gravimetric & reflectance	1mg
			ENV/FD01 & ENV/FD05	
PM_{10}	Diffusion Tube	1 Month	Gravimetric	5µg
	Continuous monitoring	Every 10 minutes	Osiris	<5µg

* Continuous monitoring of Total VOCs is being undertaken as a surrogate measure of continuous benzene concentrations. Bezene-specific passive sampling will continue throughout.

*Note not all measured parameters have Air Quality Limits

Laboratory analysis of results is undertaken by a UKAS accredited laboratory and details of the UKAS accreditation is available within Appendix C.

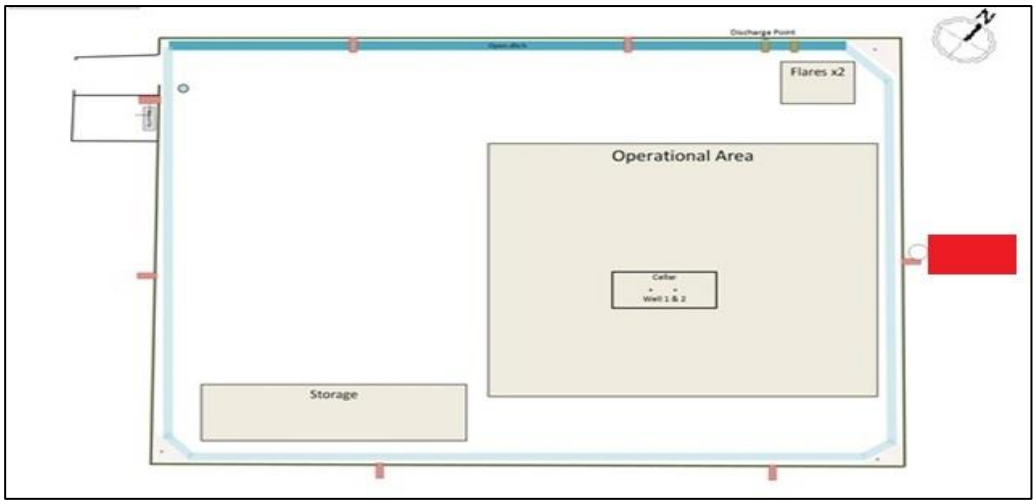
8.3 Location of Monitoring Stations

An array of continuous monitoring instruments will be deployed to supplement the baseline and ongoing passive sampling locations. The continuous monitoring instruments will be co-located with a real time weather station to provide additional context to the monitoring results.

The intended location and configuration of the continuous monitoring equipment and weather station will provide boundary fence continuous monitoring, down prevailing wind of the onsite operations as indicated in Figure 4.

This location provides high-frequency continuous monitoring of key parameters down prevailing wind of several of the key potential sources of emissions. This location will be downwind of the permitted activities approximately 70 - 80% of the time. This location is judged to provide the optimal location for a fixed monitoring array bearing in mind the permitted activities and the local wind climate. At various key stages in the permitted activities, this fixed monitoring location will be supplemented by the use of targeted methane monitoring (as detailed below) to enable the targeting of all onsite equipment, and to provide clear upwind/downwind comparisons of key equipment/activities.

Figure 4 Location of fixed continuous monitoring instruments



Location of fixed continuous monitoring instruments, indicated by the red rectangle.

An additional programme of continuous methane monitoring will be deployed during onsite operations. This programme will comprise of targeted short term continuous monitoring of methane using a number of pre-agreed monitoring locations. The monitoring will utilise a second TDL 500 instrument in addition to the fixed instrument located on the site's down prevailing wind boundary. The sampling inlet of the targeted monitoring instrument inside the site perimeter will be located at a height of between 1m and 3m above ground level, according to the particular equipment of interest during any particular monitoring period.

As with the fixed TDL500 instrument, the second instrument will record 10 minute average values (1 data point per second then averaged into a 10 minute value) throughout the monitoring period, unless otherwise agreed. The monitoring will be carried out in a number of 24 hour periods scheduled to coincide with key operational activities taking place on site (for example, hydraulic fracturing, well flowback and during extended well testing). On occasion, these periods may be extended to 48 or 72 hours to account for any onsite delays or other operational issues. The scheduling of this monitoring will be determined between 10 working days and 24 hours in advance, and will be communicated to the Environment Agency. The precise monitoring location will be selected (from the pre-agreed list) on the day of deployment to allow the wind conditions prevailing on the day to be taken account of. It is proposed to undertake approximately 6 such monitoring episodes per well, broadly split between hydraulic fracturing, initial flowback and commissioning and during the extended well test.

The use of monitoring location F will be subject to a health and safety risk assessment to consider the risks of deployment in a constrained location in close proximity to high pressure equipment.

Deployment protocol for targeted methane monitoring

Each well will be subjected to six rounds of targeted methane monitoring between the initial hydraulic fracturing of the well and the conclusion of the extended well test for that well. The precise scheduling of each round of targeted monitoring will determined by the programme of onsite activity, however, all rounds will be confirmed with between 10 working days and 24 hours notice. The following protocol will be adopted.

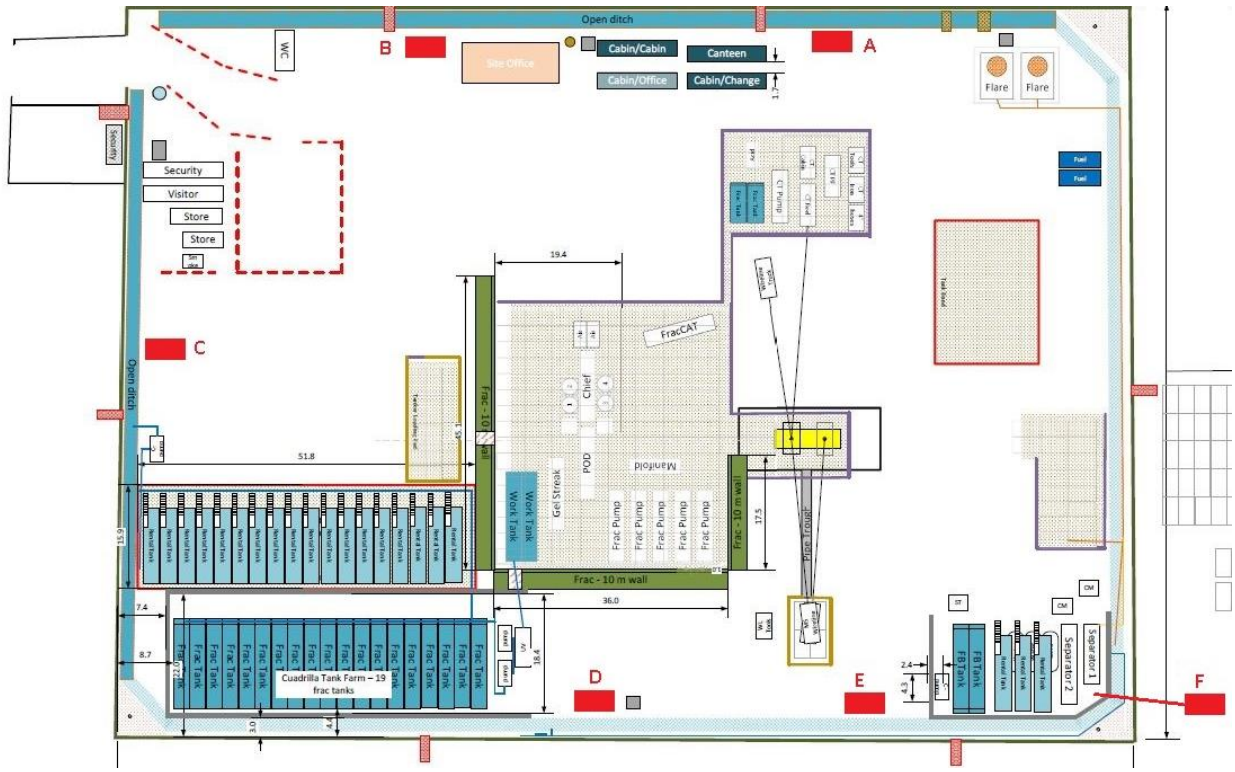
1. Cuadrilla to inform EA of planned monitoring round approximately 10 days in advance. The 'Target' (equipment/area etc.) of the round of additional monitoring to be clearly agreed as part of notification process. For example, the target may be the wellhead area, the frack spread, the tank farm etc.

2. Proposed monitoring location to be selected by Cuadrilla from available list of options based on prevailing wind conditions at the time of notification but subject to change due to weather conditions on the day of deployment.
3. On the day of deployment, the actual wind conditions in conjunction with the agreed monitoring target will be used to select the most appropriate monitoring location from the available options.
4. The actual monitoring location used will be communicated by Cuadrilla to the EA by way of the following morning's daily update call.
5. The daily update call will be used to communicate initial data results and progress with monitoring.
6. At the end of the deployment, the data gathered will be reviewed for any elevations against agreed thresholds. N.B. It is not possible to create telemetry-based alarms/alerts for such short term monitoring episodes.
7. Any abnormal monitoring results (that is, those above agreed baseline levels) from this monitoring approach will be notified to the EA within 48 hours of the end of the monitoring period. This period is required due to the non-telemetered nature of this particular dataset.

A plan of the proposed supplementary monitoring locations is shown below.

Figure 5. Proposed locations of targeted short-term continuous methane monitoring (Locations A – F)

Monitoring installations not shown to scale. Drawing adapted from site 'as-built' plan.



8.4 TDL 500

Cuadrilla's own baseline monitoring collected a monthly single spot sample of methane with a limit of detection ("LOD") of 5ppm. A review of the ambient monitoring for methane has taken place to challenge the suitability of the baseline monitoring carried out. Subsequently to improve methane detection a TDL 500 has been installed at site on the downwind boundary to provide a lower LOD on a continual basis rather than relying solely upon grab sampling. The TDL 500 has been installed at site as of February 2018 to begin collecting data before hydraulic fracturing and flaring takes place.

The TDL 500 instruments is maintained and calibrated in line with the manufacturer's instructions, including running maintenance and checks, and annual (or more frequent) calibration, as required by condition 3.5.4. Personnel using the monitoring instrumentation will be trained and briefed in the manufacturer's instructions.

Figure 6: TDL 500 ambient monitoring equipment at Preston New Road site

The specification of the TDL 500 will meet the following:

- Response time of a range between 2 to 6 seconds;
- Range of 0-10,000ppm and 0ppm to 100% gas volume; and
- Detection limit of 1ppm

The instrument is attached to a datalogger which records 10-minute averages (1 data point per second then averaged into a 10 minute value). For one week at the start of hydraulic fracturing and well testing periods, the data averaging period will be increased to 1-minute. Where well testing immediately follows hydraulic fracturing, this period of more intensive monitoring will last one week. If for any reason, there is a delay between hydraulic fracturing and well testing, a one week period of more intensive data recording will also be carried at the start of the well testing period, providing a total of up to two week's more intensive methane monitoring per well.

The TDL 500 is located outside of the site noise/acoustic boundary at the top of the soil mound accounting for the prevailing wind direction and potential shadow impact from the noise wall. The monitoring station will be accessible at all times. The location is alongside the eastern boundary.

Further details regarding the TDL 500:

- Does not require battery changes
- No maintenance or daily checks are required of the instrument
- The TDL will be setup and operated by trained competent personnel in accordance with the manufacturer instructions and procedures
- Calibration is 12 monthly, during calibration period the instrument will be swapped out and replaced during this period.
- Alerts will be configured to provide an early alarm based on the baseline data. This configuration will be available for inspection by the Environment Agency.
- Data is communicated in 15 minute updates via the telemetry system.

A second TDL instrument will be used for a programme of targeted short-term continuous methane monitoring during key stages of onsite operations (for example, during hydraulic fracturing). This supplemental programme of monitoring will allow targeted continuous monitoring of various elements of the onsite equipment under a broader range of meteorological conditions than a single fixed monitoring installation alone.

8.5 GGS Ambient GasSentinel®

A GGS Ambient GasSentinel® will be deployed for the continuous monitoring of total volatile organic compounds and hydrogen sulphide.

Monitoring has been collected via monthly single spot sample of benzene and hydrogen sulphide at each monitoring location. A review of the ambient monitoring has taken place to challenge the suitability of monitoring carried out. Subsequently to improve VOC and hydrogen sulphide detection during site operations a GGS Ambient GasSentinel® will be installed at site at the downwind boundary to provide total VOC and hydrogen sulphide concentrations on a continual basis rather than relying solely upon diffusion tube sampling.

The GGS Ambient GasSentinel will be installed onsite during May 2018 to begin collecting data before hydraulic fracturing and flaring takes place.

The GGS Ambient GasSentinel instruments are maintained and calibrated in line with their manufacturer's instructions, including running maintenance and checks, and annual (or more frequent) calibration, as required by condition 3.5.4. Personnel using the monitoring instrumentation will be trained and briefed in the manufacturer's instructions.

The GasSentinel®'s limit of detection for Total VOCs is 1ppmv. The limit of detection for hydrogen sulphide is 1ppmv

The GasSentinel® uses a photoionisation detector (PID) based sensor for the detection of total VOCs. The PID used features a standard 10.6 eV lamp. A PID lamp can reliably detect any compound with an ionisation energy lower than the lamp in question. The ionisation energy of benzene is 9.25 eV, therefore the PID sensor used within the GasSentinel® can be used to reliably detect the presence of benzene. It must be noted the continuous monitoring of Total VOCs (TVOC) is being undertaken as a surrogate measure for the continuous monitoring of benzene. In the event of a fugitive emissions occurring it is unlikely that benzene (or any single VOC compound) being emitted in isolation. As such, the continuous monitoring of TVOC should be used as an indicator of change, and the elevated presence of multiple VOCs of which benzene is likely to be just one.

Continuous TVOC monitoring should therefore be used as an early warning indication of elevated TVOC concentrations. Benzene specific passive monitoring which is simultaneously being carried out will subsequently confirm or refute the emission of benzene associated with any individual instance of elevated TVOC concentrations.

The specification of the GGS Ambient GasSentinel is included as Appendix D.

Figure 7. An example of a GGS Ambient GasSentinel® at an onshore petroleum site.

Figure 8. An example of an AQMesh instrument at an onshore petroleum site.

8.6 AQMesh

An AQMesh instrument will be deployed for the continuous monitoring of nitrogen dioxide.

Monitoring has been collected via monthly grab and diffusion tube samples for this parameter at each monitoring location. A review of the ambient monitoring has taken place to challenge the suitability of monitoring carried out. Subsequently to improve air quality pollutant detection during site operations an AQMesh instrument will be installed at site on the downwind boundary to provide air quality monitoring on a continual basis rather than relying solely upon diffusion tube or grab sampling.

The AQMesh instrument will be installed onsite during May 2018 to begin collecting data before hydraulic fracturing and flaring takes place.

The AQMesh instrument is maintained and calibrated in line with the manufacturer's instructions, including running maintenance and checks, and annual (or more frequent) calibration, as required by condition 3.5.4. Personnel using the monitoring instrumentation will be trained and briefed in the manufacturer's instructions.

The AQMesh's limit of detection for nitrogen dioxide is less than 10ppbv.

The specification of the AQMesh instrument is included as Appendix E.

8.7 Gill MetPak onsite weather station

A real time weather station will be deployed alongside the other continuous monitoring instruments. The weather station will continuously measure and record atmospheric temperature, atmospheric pressure, wind speed and wind direction at all times during site operations.

The provision of the co-located weather station will provide real time comparative weather data to supplement the other continuous monitoring data streams. This data will add additional context to the other continuous monitoring data streams, and allow discrimination between pollutants sources arising onsite and those arriving from offsite (notably from the South East quadrant). Additionally, this data will allow for enhanced comparison of recorded pollutant concentrations during the operational period and those equivalent concentrations gathered during the baseline monitoring period.

The specification of the Gill MetPak weather station is included as Appendix F.

Figure 9. An example of a real time weather station at an onshore petroleum site (centre unit)

8.8 Turnkey Osiris

A Turnkey Osiris instrument will be deployed for the continuous monitoring of particulate matter, specifically PM10.

Previous monitoring has utilised long term static sampling for this parameter at each monitoring location. A review of the ambient monitoring has taken place to challenge the suitability of monitoring carried out. Subsequently to improve air quality pollutant detection during site operations a Turnkey Osiris instrument will be installed at site on the downwind boundary to provide continuous particulates monitoring on a continual basis rather than relying solely upon static sampling.

The Osiris instrument will be installed onsite during May 2018 to begin collecting data before hydraulic fracturing and flaring takes place.

The Osiris instrument is maintained and calibrated in line with the manufacturer's instructions, including running maintenance and checks, and annual (or more frequent) calibration, as required by condition 3.5.4. Personnel using the monitoring instrumentation will be trained and briefed in the manufacturer's instructions.

As the principal likely sources of particulates emissions from our proposed operations are from onsite materials handling and power generation activities, when these potential sources no longer exist (for example, following the completion of hydraulic fracturing activities on all wells) we will discontinue our continuous monitoring of PM10.

The Osiris' limit of detection is 0.01µg m^{-3}.

The MCERTS certification of the Turnkey Osiris is included as Appendix G.

8.9 Management of Monitoring Data

The instruments and telemetry system have been configured to be virtually autonomous once deployed. Pre-deployment checks are carried out, but once installed and operating, no additional operator intervention is required, except for periodic maintenance checks during prolonged deployments.

The monitoring data is sent to a Cuadrilla feed which will be monitored via a site-based screen. Site based operatives will review the data on a daily basis in the site control room where data can be accessed remotely via online log in. The screen will also be checked formally on a daily basis and records of the check logged.

Automatic alerts for any data in excess of agreed threshold values will be provided to allow rapid response to any elevated results. The alerts will prompt a series of non-sequential actions which includes:

1) Checking flare operating parameters including flare temperature
2) Checking onsite operational log at the time of the alarm for onsite issues
3) Checking of instrumentation for faults or damage
4) Checking equipment and control systems for process upsets
5) Checking local conditions (meteorological) and activities at the time of the alarm for offsite influences.

If any of the above responses do not provide clarity as to why the agreed notification threshold values are elevated then site operatives will conduct a check of equipment in accordance with inventory using the fugitive emissions monitoring kit to check for leaks. Furthermore if the elevation is not repeated more than two times above the notification in a single day then it is not deemed necessary to conduct a pad sweep due to highly unlikely nature of the emission not associated with a process leak.

Actions will be generated on a case by case basis however, the main principles of the actions will be to fix the source(s) where possible or, subject to the parameters in Schedule 3.1 EPR/AB3101MW not being complied with, identify and prevent reoccurrence of incomplete combustion of the flares or other fugitive emission sources.

Actions and close out of the response will be recorded. The Environment Agency will be notified in accordance with condition 4.3, EPR/AB3101MW.

Ambient air quality will continue to be documented and consistently checked against the baseline data. Variations against the baseline will be reviewed and investigated to ascertain whether further assessment or investigation is required including potential contributions from the local environment or operations.

If data indicates a potential source, pathway receptor linkage from site, more frequent or targeted sampling may be introduced to ascertain if patterns of variation in the data collection is consistent with site operations or alternative sources. Sources or process contributions will be investigated and mitigated to prevent or reduce the likelihood of repeated events or air quality levels deteriorating.

All monitoring data will be retained for the life of the permit, or as agreed in writing with the Environment Agency. All monitoring data will be available for inspection and review upon request.

8.10 Reporting of Monitoring Data

During the on-site operations, the results of the specific continuous monitoring, periodic monitoring and available laboratory analyses will be made available via a public access web portal. The monitoring results will be published within 28 days from date of the last samples being collected. All collected monitoring data will remain available for the lifetime of the permit, or as otherwise agreed in writing, and will be available for inspection and review on request. Cuadrilla will also provide a fortnightly summary report of the monitoring data observed during key activities, unless otherwise agreed in writing with the Environment Agency.

In addition, if threshold concentrations, as determined from baseline monitoring carried out prior to well stimulation operations and as agreed with the Environment Agency, are exceeded then the likely source (onsite or offsite) of the exceedance will be identified, and the Environment Agency will be notified in accordance with condition 4.3, EPR/AB3101MW. The applicable threshold concentrations will be agreed with the Environment Agency prior to the commencement of hydraulic fracturing and flaring activities commencing.

The proposed threshold concentrations have been derived using statistical analysis of the data observed (by independent continuous monitoring) during baseline conditions. The selected thresholds have been derived using 3σ analysis for all parameters with the exception of benzene, which is detailed separately below. The use of 3σ values means the thresholds are set at levels below which 99.73% of the baseline monitoring results fall. For the internal action thresholds, these results have been rounded to provide clear, memorable values against which to operationally assess all continuous monitoring results within 24 hours.

The thresholds are representative of ambient air quality at the site over the vast majority of the baseline monitoring period. It is important to recognise that significantly higher values are occasionally seen due to offsite sources. It is also important to acknowledge that the onsite activities can occasionally give rise to elevated results for short periods, however, the risk of such elevated concentrations have been determined as acceptable in the granting of the site's environmental permit. Cuadrilla will at all times employ operational measures to eliminate or reduce emissions from the site to the lowest level practical.

The baseline dataset available for benzene is more limited than for other parameters. As such, Cuadrilla have adopted a more conservative approach to the setting of thresholds for ambient benzene concentrations. For an internal action threshold, the 90th percentile value has been used. For an external notification threshold, the 95th percentile value has been used, and subsequently rounded down to provide a clear and memorable

threshold. Due to the practical difficulties of undertaking continuous benzene monitoring, a complementary approach will be taken to assessing future benzene monitoring results. Continuous monitoring of Total VOC concentrations will provide early warning of any adverse trends or occurrences of all VOCs, including benzene. A sustained elevation of TVOCs will be used to prompt an internal review of operations.

It is expected that benzene concentrations will be less than 0.1% v/v of any gas encountered, however this can only be confirmed once well testing has commenced using reference data from Preese Hall (Arup Environment Statement, Appendix B, 2014). As detailed below, the formal assessment of ambient benzene concentrations will be provided by the network of passive samples around the site. Additionally, in real time, continuous monitoring of Total VOC concentrations will indicate any changes to VOC concentrations in ambient air around the site. In the event that an emission of benzene was to occur, it would be contained within a mixture of other VOCs in which benzene would be a minor constituent.

In order for a threshold to prove useful, it must be set at a level which indicates genuine change in the parameter being measured. In the case of Total VOCs at the site, a judgement has been taken to set this threshold at 5 ppmv for Total VOCs. It is expected that Total VOC concentrations, as measured at the site and in keeping with ambient levels, will appear to move between 1 – 3 ppmv. The choice of the 5 ppmv threshold has been taken to minimize numerous ‘false positives’ triggered by natural variation in ambient levels whilst still providing clear and early indications of changes in air quality. In the event of a site-derived source, benzene would be expected to be a very small proportion of any TVOC detection in excess of 5 ppmv. Furthermore natural gas content is dominated by methane which is being detected on a continual basis. Subsequently any leaks or emissions from site will be detected and action taken based on the methane data set. Confirmation from the passive monitoring stations will confirm benzene levels.

The formal assessment of benzene will be based on the network of four passive monitoring stations located around the site. In the event that any results from any of the four locations are in excess of the notification threshold below, a formal notification will be issued to the Environment Agency will be issued within 24 hours of receipt of the monitoring result. It is again worth noting that the baseline dataset indicates that, on occasion, monitoring results in excess of the notification threshold will be observed due to offsite sources.

The proposed thresholds feature two levels for each parameter. An exceedance of the lower threshold, which can be thought of as an internal ‘action level’ will prompt a review of onsite activities to determine the likely source and cause of the observed elevations (whether onsite or offsite) and may trigger additional monitoring, more frequent LDAR surveys etc. An exceedance of the upper threshold will additionally trigger a formal notification to the Environment Agency within 24 hours. A summary of these notifications will be provided to the Environment Agency as part of a daily operational update. Automatic data alerts will be established for all fixed continuous monitoring instruments to provide immediate alerts to onsite staff of any elevated concentrations.

Table 10 Ambient air monitoring threshold values and maximum observed values

Parameter	Internal threshold value	External notification threshold	Maximum observed baseline
Methane	5.0 ppmv* (rounded from 4.8)	7.1 ppmv	70.5 ppmv
Nitrogen dioxide	100 µg m^{-3} (rounded from 97.35)	140 µg m^{-3} (equivalent to 73.1 ppbv)	313 µg m^{-3}

PM_{10}	40 µg m^{-3}(rounded from 37.81)	50.0 µg m^{-3}	229.6 µg m^{-3}
Benzene	4.51 µg m^{-3} / TVOC 5 ppmv	5.00 µg m^{-3}	8.36 µg m^{-3}

9.0 Managing fugitive emissions

9.1 Leak detection and repair

Cuadrilla will deploy a methane leak detection unit (sniffer) to monitor fugitive emissions on a regular basis. The purpose of the sniffer is to provide the onsite surveillance of site pipelines and equipment for gas leak detection. The data collected will form the basis of the leak detection and repair programme (LDAR). Our leak detection and repair programme will be fully detailed and documented separately. The programme will fully detail all aspects of our leak detection activities including the specification, operation, maintenance and calibration of all equipment used along with the training of all staff involved in the planning and executing of our leak detection and repair programme.

Reviewing the environmental risk assessments for the installation permit and Environment Agency Risk Assessment; An Environmental Risk Assessment for shale gas exploratory operations in England Version 1, August 2013, the residual risk is low for fugitive emissions.

Cuadrilla will share the LDAR procedure with the Environment Agency for review before the start of Hydraulic Fracturing operations. The LDAR will be standalone document as part of Cuadrilla HSE management system.

9.2 Managing odour from hydrogen sulphide

As odour is typically a transient issue, we will use multiple approaches to manage the potential for odours to arise from our onsite operations. In the case of hydrogen sulphide which is detectable as an odour at very low concentrations, we will target a range of measures at the potential for hydrogen sulphide odours from our onsite operations.

It must first be noted that we do not anticipate any gas arising from the site to contain measurable concentrations of hydrogen sulphide. However, we will nonetheless have measures in place to detect its presence should it occur.

Our system for managing this potential issue comprises five main elements. Firstly, we will be undertaking routine source gas analysis of any gas arising from the wells, part of this analysis will be the presence and concentration of any hydrogen sulphide. While it is not expected, should such analysis indicate the presence of hydrogen sulphide we will review our approach accordingly. Secondly, in line with general best practice, we will have in place an alarm system which will sound should hydrogen sulphide be detected around the well pad area. Thirdly, our onsite staff will be briefed and trained in the detection of hydrogen sulphide. In addition to general observations, staff will be required to periodically undertake dedicated checks for any hydrogen sulphide odours. Additionally, our site's continuous monitoring equipment will also include a sensor dedicated to hydrogen sulphide detection. This instrument will be located at the site's prevailing downwind direction, so any hydrogen sulphide present on site would be detected by this equipment should it be emitted from the site. Finally, as during our baseline monitoring period, our network of passive hydrogen sulphide sampling locations will remain consistent with the baseline. Any persistent or significant increase in the presence of hydrogen sulphide in or around our site would be detectable as a change in the results observed through this line of monitoring. Passive monitoring methodologies will be reviewed during the operational period (hydraulic fracturing and well test) to refine and focus monitoring towards the existing continuous monitoring programme. This will be agreed in writing with the Environment Agency.

It should also be noted that should hydrogen sulphide prove to be present within the gas produced at the site, then the natural gas itself would act as the carrier gas for any hydrogen sulphide emission. As we will be undertaking an intensive leak detection programme (detailed separately) during our onsite operations, the

absence of any natural gas leaks will also substantially mitigate any concerns surrounding hydrogen sulphide emissions. Should any unexplained hydrogen sulphide (or other operational odours) be detected, additional leak detection surveys may be triggered.

As part of our ongoing surveillance of environmental issues at the site, any increases or unexpected changes in hydrogen sulphide detection (through any means) will prompt us to reconsider the effectiveness of our odour management and environmental monitoring measures without delay.

In the event of our source gas analysis indicating the presence of hydrogen sulphide within the gas stream, we will undertake a further review of our onsite monitoring activities to provide additional surveillance of hydrogen sulphide to manage the risk of offsite odours occurring. We will agree the detail of any additional measures in consultation with the Environment Agency.

In the unlikely event that hydrogen sulphide is encountered, and all previous steps have failed to control hydrogen sulphide odour, which is causing verifiable odourisation complaints, then Cuadrilla will temporarily shut in the well/s and reassess the mitigation and monitoring techniques. The results of this assessment will be documented in an odour management plan and submitted to the Environment Agency for approval as per condition 3.3.2 of the site's permit.

10.0 Flare Monitoring

Sampling is to be conducted from the flare stacks using a contractor's proprietary mast system which is operated from ground level. The contractor will be fully MCERTS accredited and UKAS accredited using dedicated stack gas analysers.

The contractor selected has a track record of testing flare emissions from a range of industries for permit compliance within the UK, approximately testing 40 to 50 flares per annum. See Appendix C for UKAS accreditation.

The specific source testing equipment for flare monitoring work will incorporate a Horiba PG250 or 350 and Signal 3010HM analysers. These units are accredited under MCERTS for portable stack testing equipment. Extractive sampling would use PTFE heated lines and gas conditioners.

10.1 Volatile Organic Matter Monitoring

Volatile organic matter (excluding Particulates) will be determined to the requirements of BS EN12619 for instrumental determination. Detection will be by the use of a flame ionisation detector (FID, Signal 3010HM). A data logger would provide a real-time measure of concentration and a graphic display of the VOC variation with the operating cycle of the plant will be obtained. This sensitive device is capable of measuring a concentration as low as 0.1 ppm as carbon equivalent. The device will be calibrated *in situ* with zero air and approximately 7ppm propane against which its response will be measured. Calibration gas is traceable and certified to ±2%. Results will be reported as a time averaged standard concentration of carbon excluding particulate. The unit holds MCERTs certification for portable source testing equipment.

10.2 Carbon Monoxide, Oxygen and Oxides of Nitrogen

Carbon Monoxide (CO), Oxygen (O_2) and Oxides of Nitrogen (NO_x) would be analysed using a multi-analyte gas analyser - a Horiba PG250 or PG350. These units hold MCERTs certification for portable source testing equipment. Extraction would be by a heated transfer line, through a titanium probe. The gas would be conditioned to below the dew point to remove moisture prior to analysis.

CO would be monitored by extractive instrumental method by NDIR-Luft detection within the Horiba analyser (to the requirements of BSEN 15058). Calibration would be performed on-site prior to measurement with approximately 150 ppm CO (Calibration gas is traceable and certified at ±2%) and zero (CO free) air.

NO_x would be monitored by the chemiluminescent detector (to the requirements of BSEN 14792) - located within the analyser and calibrated against approximately 90 ppm NO (certified at ±2%). NO_x results would be expressed as NO_2. Calibration gas is traceable and certified to ±2%.

O_2 would be determined by extractive instrumental method by a zirconia detector to the requirements of BSEN 14789.

Calibration would be performed on-site prior to measurement with calibrated air and zero gas (with 99.998% N2). The instrument had a resolution of 0.01% and a lower detection limit of 0.01%.

10.3 Ancillary Equipment

The moisture (water vapour) present in the stack gas will be determined by gravimetric impingement tests to the requirements of BSEN 14790. Temperature will be measured to the requirements of BS EN 16911 using a calibrated thermocouple and reader.

10.4 Schedule

Flaring will be monitored in accordance with schedule 3 as a minimum on an annual basis, combustion temperature will be monitored continuously.

For instances of inclement weather for a scheduled test there is a possibility that the work may be cancelled or postponed. This would include wind speeds above 25mph (27 Knots), gusting wind, heavy rain, snow/ice, etc.

11.0 References

- BSEN 14790:2017 Stationary source emissions. Determination of the water vapour in ducts. Standard reference method
- BS EN 16911:2013 Stationary source emissions. Manual and automatic determination of velocity and volume flow rate in ducts. Manual reference method
- BS EN 12619: 2013 Stationary source emissions. Determination of the mass concentration of total gaseous organic carbon. Continuous flame ionisation detector method
- BS EN 15058: 2017 Stationary source emissions. Determination of the mass concentration of carbon monoxide. Standard reference method: non-dispersive infrared spectrometry
- BS EN 15446:2008 Fugitive and diffuse emissions of common concern to industry sectors – Measurement of fugitive emissions of vapours generating from equipment and piping leaks
- Cuadrilla Waste Management Plan (HSE-Permit-INS-PNR-006)
- Arup, Environment Statement 2014
- Arup, Environment Statement 2014 Appendix B Scheme Parameters
- Environment Agency Installation Permit EPR/AB3101MW
- Environment Agency M8 Technical Guidance, Version 2, May 2011
- Environment Agency Monitoring and control of fugitive methane from unconventional gas operations, August 2012
- Environment Agency Considerations for Quantifying Fugitive Methane Releases from Shale Gas Operations, July 2014
- Inficon website accessed February 2018: **https://products.inficon.com/getattachment.axd/?attaName=8aacece8-c1d7-499d-b698-8521c987ad60**

12.0 Appendix A Baseline Data

13.0 Appendix B UU Activity during Baseline

Photo sourced April 2014

14.0 Appendix C UKAS Accreditation

15.0 Appendix D GGS Ambient GasSentinel® technical specification

16.0 Appendix E AQMesh technical specification

17.0 Appendix F Gill MetPak technical specification

18.0 Turnkey Osiris MCERTS certification report