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REVIEW OF LANDFILL GAS MONITORING AT THE BRYN PICA LANDFILL SITE DURING THE PERIOD JAN 15 – DEC 15

Amgen Cymru
Bryn Pica Landfill Site
Llwydcoed
Aberdare
CF44 0BX

Phone: 01685 870770
Fax: 01685 874684

Executive Summary

Amgen Cymru has carried out an annual review of the results of landfill gas monitoring activities carried out at the Bryn Pica landfill site during the period Jan 15 – Dec 15.

The submission to the Environment Agency (EA) of a periodic review of environmental monitoring results is required under Section 4.2 of the sites PPC Permit. It is outlined in this document that such a review should include:

a) A review of the results of the monitoring and assessment carried out in accordance with this permit against the relevant assumptions, parameters and results in the risk assessments submitted with the Application.

The purpose of this report is to fulfil the above requirement of Section 4.2 Reporting to the Environmental Permit for the Bryn Pica Landfill Site, Rhondda – Cynon – Taff.

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1. INTRODUCTION

This report presents a review of landfill gas monitoring carried out by Amgen Cymru and it's nominated contractor (Infinis) at the Bryn Pica Landfill Site during 2015.

Results of gas monitoring at the Bryn Pica site have been compared to Environmental Assessment Limits (EAL's) and comments made in relation to the performance of the gas management system at the site.

1.1 Aims of this Report.

The aim of this document is to satisfy the reporting requirements of Section 4.2 of the Bryn Pica Landfill Site Environmental Permit (DP3732SQ). With reference to landfill gas monitoring carried out at the site, this is considered to be as follows:

1. Provide a summary of landfill gas monitoring data collected at the site over the previous 12 months, including results for both Raw (in-waste) Landfill Gas and Sub-Surface (outside the margin of the waste) Landfill Gas.

2. Compare landfill gas monitoring data to relevant Environmental Assessment Limits (EAL's) justified in the report.

3. Make recommendation for any potential improvements in landfill gas monitoring at the site.

4. Make recommendation for any remedial work required, in the case that any potential negative trends are identified in the monitoring results.

1.2 Environmental Assessment Limits (EAL's)

Environmental Assessment Limits (EAL's) are used in this report to assess the effectiveness of environmental management systems in mitigating the risk associated with landfill gas production at the Bryn Pica Landfill Site.

EAL's for the assessment of landfill gas monitoring are provided in Table 1.1 below.

Table 1.1: Justification for EAL's used for Landfill Gas Monitoring at the Bryn Pica Landfill Site		
Monitoring	**EAL's (Thresholds) % by Vol in air**	**Justification**
Raw Landfill Gas Monitoring In waste monitoring carried out in gas well situated across the landfill site.	Methane CH_4 - Lower > 35% Upper > 60%	Lower - Approaching LEL Upper – Excessive gas Build Up
	Oxygen O_2 -Upper >5%	Upper - Approaching LEL
Sub-Surface Gas Monitoring Carried out on samples taken from ground monitoring boreholes located in ground strata adjacent to the landfill **(i.e. outside the landfill waste mass).**	Methane CH_4 – Upper > 1.0%	EA Guidance Doc LFTGN03 recommends a trigger level for CH_4 of 1 % above background levels. Background levels at Bryn Pica are assumed to be 0.0 %.
	Carbon Dioxide CO2 – Upper <2.8% v/v	EA Guidance Doc LFTGN03 recommends a trigger level for CO2 of 1.5 % above background levels. Background CO2 levels are calculated as being 1.3% /v – these are calculated for the opencast backfill material surrounding the Bryn Pica landfill using annual average values of the results of landfill gas monitoring in GMBH06-10 and GMBH06-11. These show no signs of landfill gas migration and are significantly removed from the existing area of landfilling.

2. SOURCE – PATHWAY – RECEPTOR ANALYSIS.

Analysis of the contamination linkage model (i.e. source, pathway and receptor) has been used as basis for the interpretation of landfill gas monitoring carried out at Bryn Pica.

The environmental setting of the site is laid out below to allow a Source – Pathway – Receptor analysis of the monitoring results.

2.1 Environmental Setting

Site Location and Surroundings

The Bryn Pica Landfill Site is located approximately 4 km North of Aberdare at National Grid Reference (NGR) SO 010 047, at an elevation of between 260 – 350 mAOD, on the Northern slope of the Cynon Valley. The sites location in relation to its environmental setting is illustrated in Drawing No. AC2016/ENV/01/01(Site Location Plan).

The landfill waste disposal facility at the Bryn Pica site has been established in a former opencast coal working, with some mined coal seams beneath. The site also contains Site Offices, Materials Recycling Facility (MRF), Landfill Gas Power Generation Scheme and Leachate Treatment Plant.

Environmental Setting

A detailed assessment of the Bryn Pica landfill site in relation to its environmental setting is provided in the Environmental Setting and Installation Design Report (ESID), produced as part of the PPC Permit Application Documents (Reference 1 – AM5458/ESID). The main details of which are summarised below:

Hydrogeology:

The Bryn Pica landfill site overlies the North limb of the South Wales Coalfield Syncline, comprising Carboniferous middle and lower coal measure strata. These comprise cyclic deposits with aquifer forming rocks (i.e. sandstones) separated by non-aquifer forming rocks (i.e. siltstone, mudstone, coals and associated argillaceous horizons). Typical for the area, coal seams are crossed with several faults, with a large fault system (Werfa Fault) running just North of the site.

The majority of coal seams underlying the Bryn Pica landfill site have under gone extensive deep mining, with the Nine Feet and Gellideg seams proving highly productive. Below the Gellideg, as well as interspersing higher seams extensive ironstone formations were identified and worked.

The Bryn Pica site was extensively opencast during the 1950's and 1960's. Following completion of the opencast mining at the site, backfilling of the open cast void was undertaken using the opencast waste arising. In place of the natural geology, a heterogeneous mix of sandstones, siltstones and mudstones now exists. In places this is known to be up 70m thick.

It is anticipated that groundwater infiltrating the opencast backfill material is intercepted by deep mine workings. Previous studies have shown that the most likely discharge point for this deep mine groundwater as being the Watercourse Level, located within the Pirelli Cable Works at national grid reference (NGR) SN 997040.

Groundwater issuing from the Watercourse Level is discharged to the Avon Cynon a short distance away at NGR 001035.

Hydrology:

During 2009, the Avon Cynon between NGR SN 968 053 and SO 004 027 was classified by the Environment Agency as being of very good quality (Class A).

The Nant-y-Derlwyn watercourse discharges to the Avon Cynon at NGR SO 994041 flowing in a south westerly direction along Mynydd Aberdar (originating at NGR SO 015058). This watercourse is located approximately 500m away from the Bryn Pica landfill site in a westerly direction.

Adjacent to the south of the landfill site an unnamed stream flows in a south westerly direction, joining the Avon Cynon at NGR SO 003 034.

<u>Environmental Management Systems</u>

At the time of writing tipping operations are ongoing within the Phase 4a landfill cell. Future landfill operations at Bryn Pica are currently under review and the development of subsequent landfill cells will depend on the analysis of future trends in waste disposal (i.e. the continuing diversion of waste from landfill).

Leachate and Landfill Gas management systems at the site are managed by Amgen staff and Infinis (Landfill Gas to Energy Contractor), respectively. These systems protect local environmental receptors from the potentially harmful effects of leachate and landfill gas generation at the site.

Phase 1 Landfill Gas Management

Phase 1 of the Bryn Pica Landfill consists of a 6 ha basal area of unlined waste cell, situated on a significant thickness of opencast backfill material. The cell contains approximately 1.5 million cubic metres of domestic, commercial and non-hazardous industrial waste.

A permanently engineered cap has been constructed over 5.3 ha of the western flank and top surface of the landform. A total of 20 landfill gas collection wells are currently operational within the waste mass of Phase 1, enabling continuous landfill gas extraction from this area of the site. These wells supply landfill gas to the onsite combustion engine to produce electricity. Any gas not being used for energy production is passed through an enclosed, high temperature flare.

Phase 2 and 3 Landfill Gas Management

Phases 2 and 3 of the Bryn Pica landfill are separated into 5 containment cells (cell 2a, 2b, 2c, 3a and 3b). These cells each consist of a composite basal liner (engineered barrier) and basal drainage system. Basal drainage is provided by a 300 - 500 mm thick, non-calcareous, clean stone blanket laid with slotted HDPE pipe acting as preferential drainage pathways. The basal drainage system in Phase 2b and 3a consist of recycled whole tyres constructed in a manner which provides an appropriate thickness of drainage blanket on compaction.

Phase 3b

Capping works undertaken in 2008 consisted of approximately 0.7 hectares of temporary (plastic) capping in the area of the cell 3b intermediate slope. This brings the total area of landfill now covered with a permanent cap to approximately 9.6 hectares and temporary cap to 3.7 hectares. An additional area of Engineered (Permanent) Capping was completed over an approximate area of 1.2 hectares, in Autumn 2012.

To date a total of 22 wells have been installed over the completed area of Phase 3 (Landfill Cells 3a and 3b), these are connected to the gas processing plant by a series of surface laid pipes and associated controls.

Phase 4a/4b

Tipping operations commenced within Phase 4b Landfill Cell in Jan-14. At the time of writing Phase 4 has a total of 12 operational landfill gas wells. Tipping operations are currently ongoing within Phase 4b and thus the scale of gas management within this cell is restricted to that of interim arrangements.

2.2 Landfill Gas

Source:

Landfill Gas is created by the degradation of biodegradable material contained within the landfill.

If uncontrolled, significant gas pressure can accumulate within the landfill – thus increasing the potential for landfill gas to migrate (move) into the ground surrounding the landfill and/or into the atmosphere (surface emissions).

Note: Example of control measures: impermeable barriers (i.e. basal liners, landfill caps), gas extraction systems and flaring.

Pathway:

If allowed to persist, landfill gas under positive pressure within the landfill has the potential to migrate (move) away from the base of the landfill into the surrounding strata (soil or rock). The rate, direction and distance in which landfill gas can migrate, depends on the nature (particularly permeability) of the ground conditions.

Note: Colliery Spoil present beneath the Bryn Pica site consists of backfilled waste material from opencast mining operations. This material has been described as a heterogeneous mix of sandstone, siltstone and mudstone of a general free draining nature. Therefore the opencast backfill present at Bryn Pica has the potential to act as a pathway for horizontal and vertical landfill gas migration.

Receptor:

List of receptors typically associated with landfill gas migration:

1. Human Health – exposure to landfill gas compounds.
2. Property – explosion / asphyxiating conditions.
3. Vegetation Stress – exposure to toxic components of landfill gas.

Note: Generic list, not specifically identified in relation to the Bryn Pica Landfill Site.

3. REVIEW OF LANDFILL GAS MONITORING RESULTS.

The following sections provide an overview of landfill gas monitoring results as collected and provided by Infinis (on behalf of Amgen Cymru) during the period Jan 15 – Dec 15.

3.1 Raw 'In-Waste' Landfill Gas Monitoring

Throughout 2015 the landfill gas extraction system at the Bryn Pica Landfill has consisted of 80 operational landfill gas extraction wells. In addition to this, a series of perforated pipes, laid horizontally in the waste ('Horizontals') are currently being utilised to extract gas from the operational area of Cell 4a. These are provided as an interim measure whilst waste filling is ongoing.

Gas extraction infrastructure is connected to 1 of 4 manifold units situated at various locations around the landfill installation. The quantity and quality of landfill gas directed to the landfill gas flare / engine is controlled at each individual manifold.

The landfill gas power generation compound consists of a High Temperature Landfill Gas Flare and 2 Landfill Gas Power Generation Units. A number of pneumatic powered dewatering facilities (KO Pots) are employed to ensure that pipe-work across the site is free from gas condensate (water).

Operational management of the gas extraction and processing system at the site is sub-contracted to Infinis as part of the power generation scheme in place at the site. Infinis staff have carried out monitoring of individual gas collection wells as requested by the Environmental Permit for the landfill installation. Annual average values for: methane (CH_4), carbon dioxide (CO_2), oxygen (O_2) and relative pressure are provided in Tables 3.1 to 3.5. The full raw data set is provided in Appendix C (PDF version only).

Asset ID	Location	Count	Methane (CH4)			Carbon Dioxide (CO2)			Oxygen (O2)			Relative Pressure		
			Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
BYPWM101	Phase 1	17	77.8	32.5	54.7	26.8	21.7	23.5	0.2	0.0	0.1	-0.3	-2.2	-1.1
BYPWM102	Phase 1	16	54.8	39.4	47.9	29.4	25.1	26.6	0.8	0.0	0.2	-0.1	-3.4	-1.0
BYPWM103	Phase 1	13	47.3	25.7	34.6	21.1	17.8	19.6	0.2	0.0	0.1	0.3	-2.3	-0.8
BYPWM104	Phase 1	22	72.9	23.5	51.4	28.3	21.2	25.0	0.2	0.0	0.1	1.5	-18.7	-2.4
BYPWM105	Phase 1	19	71.4	25.0	55.3	34.9	23.6	31.4	0.5	0.0	0.1	0.6	-32.2	-3.4
BYPWM107	Phase 1	22	74.8	17.5	54.3	25.4	20.7	23.6	0.3	0.0	0.1	0.7	-2.6	-0.9
BYPWM108	Phase 1	16	47.1	4.1	30.9	28.3	3.3	23.5	18.6	0.0	1.2	0.0	-4.3	-1.8
BYPWM109	Phase 1	15	59.4	36.4	49.5	29.9	25.5	27.0	0.1	0.0	0.1	-0.5	-35.3	-8.0
BYPWM111	Phase 1	15	60.1	22.0	38.7	28.2	21.0	24.5	0.1	0.0	0.1	0.2	-4.4	-1.4
BYPWM201	Phase 1	24	68.9	21.4	48.5	29.6	21.8	26.4	1.0	0.0	0.2	-0.1	-2.1	-0.8
BYPWM202	Phase 1	25	70.1	0.0	37.4	22.7	0.9	19.7	20.9	0.0	1.9	0.1	-2.3	-0.7
BYPWM203	Phase 1	19	67.7	31.9	50.9	31.8	24.6	28.9	0.3	0.0	0.1	0.3	-4.4	-1.4
BYPWM204	Phase 1	13	58.8	1.4	34.6	32.8	1.4	23.0	20.4	0.0	3.4	0.3	-7.6	-2.1
BYPWM206	Phase 1	19	47.6	0.6	19.7	21.3	2.1	14.9	19.5	1.1	5.3	0.9	-1.7	-0.4
BYPWM207	Phase 1	25	67.3	28.5	48.5	22.9	19.9	21.3	1.3	0.0	0.3	0.1	-3.2	-1.7
BYPWM208	Phase 1	23	58.1	24.3	44.4	28.2	11.3	23.8	10.8	0.0	1.1	-18.4	-107.9	-52.4
BYPWM210	Phase 1	21	73.2	24.0	52.6	20.1	17.6	18.7	0.2	0.0	0.1	0.1	-5.9	-1.6
BYPWM211	Phase 1	12	35.6	2.9	19.5	19.5	3.6	14.4	19.7	0.9	6.4	0.2	-3.1	-1.2
BYPWM212	Phase 1	16	69.0	33.1	51.4	32.2	25.9	28.9	0.2	0.0	0.0	-1.0	-4.0	-2.4
BYPW0002	Phase 1	20	72.6	28.7	54.7	28.8	24.0	26.7	0.3	0.0	0.1	-0.5	-15.7	-3.9

Table 3.1: Annual average values for: methane (%CH_4 by Vol), carbon dioxide (%CO_2 by Vol), oxygen (%O_2 by Vol) and relative pressure (mbar) for in-waste monitoring carried out on Phase 1 of the Bryn Pica Landfill Site, during Jan 15 – Dec 15.

Asset ID	Location	Count	Methane (CH4)			Carbon Dioxide (CO2)			Oxygen (O2)			Relative Pressure		
			Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
BYPW0003	Phase 2	22	64.3	34.5	47.3	29.0	24.5	26.5	0.8	0.0	0.1	2.8	-15.5	-3.2
BYPW0004	Phase 2	20	63.3	25.8	49.5	38.9	23.5	33.0	0.2	0.0	0.1	0.4	-47.8	-15.4
BYPW0005	Phase 2	18	57.1	37.9	49.0	42.0	32.0	38.2	0.6	0.0	0.2	3.5	-15.6	-5.4
BYPW0006	Phase 2	15	59.9	37.1	47.4	40.1	31.2	34.9	0.2	0.0	0.1	1.1	-7.3	-3.9
BYPW0007	Phase 2	14	56.6	41.1	46.7	39.3	34.7	36.6	0.7	0.0	0.2	-3.5	-20.8	-12.9
BYPW0008	Phase 2	17	57.1	36.6	45.8	41.7	31.0	35.7	0.1	0.0	0.1	-0.2	-7.5	-3.8
BYPW0009	Phase 2	15	58.8	39.3	48.9	40.5	33.0	36.5	0.2	0.0	0.1	0.6	-9.0	-5.2
BYPW0011	Phase 2	14	49.7	41.1	46.2	37.8	33.8	36.3	0.9	0.0	0.2	-3.7	-12.9	-9.3
BYPW0501	Phase 2	19	68.2	0.1	52.9	31.2	1.0	26.8	20.9	0.0	1.2	-0.1	-2.8	-1.1
BYPW0502	Phase 2	20	68.0	25.0	48.8	31.0	19.0	26.1	3.0	0.0	0.3	1.3	-20.8	-4.0
BYPW0503	Phase 2	17	58.7	22.6	49.3	30.1	18.3	27.1	3.7	0.0	0.3	-0.5	-33.3	-7.4
BYPW0504	Phase 2	21	64.0	28.9	45.7	33.1	22.9	28.2	0.1	0.0	0.0	0.3	-7.0	-2.8
BYPW0505	Phase 2	21	68.4	27.2	50.4	32.8	23.9	29.5	0.3	0.0	0.1	-0.4	-5.8	-2.4
BYPW0515	Phase 2	15	58.6	15.9	41.7	44.0	21.3	34.8	0.6	0.0	0.2	3.1	-1.2	0.2
BYPW0516	Phase 2	15	56.7	31.3	49.6	40.8	26.1	37.6	5.8	0.0	0.5	-4.1	-18.2	-8.4
BYPW0601	Phase 2	15	58.3	37.0	49.4	40.2	33.3	37.4	0.1	0.0	0.1	-1.0	-11.1	-5.6
BYPW0602	Phase 2	21	66.9	27.8	50.6	37.7	27.5	34.0	0.2	0.0	0.1	0.1	-46.2	-18.8
BYPW0605	Phase 2	18	58.5	0.4	27.3	40.8	0.8	24.1	20.6	0.0	3.4	1.6	-10.6	-1.0
BYPW0606	Phase 2	22	58.5	18.7	47.0	42.7	24.5	37.1	0.6	0.0	0.2	0.5	-2.6	-0.7
BYPW0607	Phase 2	16	58.9	33.7	47.7	41.5	31.0	35.6	0.2	0.0	0.1	1.9	-2.6	-1.1
BYPW0608	Phase 2	19	58.1	0.1	37.0	42.6	1.2	31.6	20.9	0.0	1.9	0.2	-2.7	-1.0
BYPW1203	Phase 2	15	63.2	18.4	38.9	32.5	21.7	25.2	0.2	0.0	0.1	0.0	-4.7	-1.6
BYPW1204	Phase 2	15	69.9	30.6	50.0	31.5	24.7	27.8	0.8	0.0	0.2	-0.3	-6.9	-2.8
BYPW1307	Phase 2	15	57.2	37.7	46.5	43.0	33.8	37.0	0.2	0.0	0.1	-4.5	-26.9	-14.0
BYPW1308	Phase 2	16	58.3	43.4	50.9	40.9	35.8	38.1	0.4	0.0	0.1	6.7	-17.2	-9.9

Table 3.2: Annual average values for: methane (%CH_4 by Vol), carbon dioxide (%CO_2 by Vol), oxygen (%O_2 by Vol) and relative pressure (mbar) for in-waste monitoring carried out on Phase 2 of the Bryn Pica Landfill Site, during Jan 15 – Dec 15.

Asset ID	Location	Count	Methane (CH4)			Carbon Dioxide (CO2)			Oxygen (O2)			Relative Pressure		
			Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
BYPW0702	Phase 3	19	62.3	35.9	51.4	37.2	28.6	34.2	0.4	0.0	0.1	0.0	-14.1	-5.6
BYPW0703	Phase 3	14	60.2	54.2	57.7	43.3	40.2	42.1	0.3	0.0	0.1	-35.4	-68.5	-52.4
BYPW0704	Phase 3	18	61.3	34.4	51.7	41.4	30.5	37.9	0.1	0.0	0.1	0.3	-21.7	-5.7
BYPW0705	Phase 3	21	67.1	31.1	56.4	36.7	26.1	34.4	0.4	0.0	0.1	9.0	-69.7	-32.5
BYPW0706	Phase 3	15	61.5	38.9	52.6	40.3	32.5	37.3	0.3	0.0	0.1	-33.8	-69.5	-48.7
BYPW0707	Phase 3	12	4.2	0.0	0.9	11.5	1.1	4.8	20.9	12.4	18.6	0.8	-2.9	-1.1
BYPW0904	Phase 3	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BYPW1001	Phase 3	17	58.0	31.2	46.1	41.0	30.0	35.7	0.5	0.0	0.1	0.2	-5.1	-1.6
BYPW1002	Phase 3	16	55.5	38.5	48.0	37.9	31.2	34.3	0.3	0.0	0.1	-2.3	-16.9	-7.8
BYPW1003	Phase 3	15	54.0	39.6	47.8	38.3	31.2	35.0	0.2	0.0	0.1	-6.1	-21.1	-12.4
BYPW1004	Phase 3	13	63.7	54.1	58.4	44.4	40.9	42.1	0.2	0.0	0.1	-34.2	-73.6	-49.4
BYPW1005	Phase 3	14	62.6	40.7	49.1	38.3	33.2	35.0	0.2	0.0	0.1	-34.4	-72.5	-47.0
BYPW1006	Phase 3	16	76.1	33.7	54.6	37.8	16.8	29.8	8.2	0.0	1.7	0.5	-6.9	-1.4
BYPW1101	Phase 3	13	60.3	46.1	55.0	40.8	35.8	38.7	0.2	0.0	0.1	-34.2	-71.7	-48.4
BYPW1102	Phase 3	18	60.3	0.5	39.2	40.1	0.4	27.5	19.3	0.0	6.4	1.4	-37.9	-6.9
BYPW1103	Phase 3	15	34.5	0.0	7.0	27.4	0.9	6.4	20.9	8.1	18.5	-4.1	-68.2	-30.4
BYPWM101	Phase 3	17	77.8	32.5	54.7	26.8	21.7	23.5	0.2	0.0	0.1	-0.3	-2.2	-1.1
BYPZ0001	Phase 3	13	61.0	53.7	57.2	45.2	40.6	42.8	0.3	0.0	0.1	-34.9	-67.1	-51.6
BYPW1201	Phase 3	15	52.7	41.5	47.7	40.6	34.5	37.0	0.2	0.0	0.1	-9.0	-25.1	-15.8
BYPW1202	Phase 3	16	62.8	41.9	50.6	41.0	32.4	36.0	0.2	0.0	0.1	-3.8	-25.8	-16.4
BYPW1301	Phase 3	16	59.9	45.0	56.2	44.9	33.8	39.6	0.8	0.0	0.2	-0.7	-8.5	-2.9
BYPW1302	Phase 3	17	64.0	34.1	50.9	42.7	26.8	35.4	6.0	0.0	0.5	0.9	-5.1	-1.3

Table 3.3: Annual average values for: methane (%CH_4 by Vol), carbon dioxide (%CO_2 by Vol), oxygen (%O_2 by Vol) and relative pressure (mbar) for in-waste monitoring carried out on Phase 3 of the Bryn Pica Landfill Site, during Jan 15 – Dec 15.

Asset ID	Location	Count	Methane (CH4)			Carbon Dioxide (CO2)			Oxygen (O2)			Relative Pressure		
			Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
BYPW1205	Phase 4	15	61.7	15.6	49.6	43.6	12.5	36.8	14.1	0.0	2.7	8.0	-78.3	-46.8
BYPW1206	Phase 4	19	63.0	51.1	57.7	42.8	37.9	40.8	2.7	0.0	0.4	15.1	-77.8	-49.9
BYPW1207	Phase 4	12	61.5	56.0	59.0	43.3	38.5	41.5	0.3	0.0	0.1	-35.7	-77.9	-55.1
BYPW1303	Phase 4	13	60.4	52.2	56.2	43.5	37.6	40.3	0.6	0.0	0.2	-34.7	-71.0	-50.0
BYPW1305	Phase 4	8	54.4	42.8	49.1	37.9	33.9	36.4	0.2	0.0	0.1	-16.8	-27.1	-21.6
BYPW1306	Phase 4	13	53.6	42.3	48.0	38.2	34.6	36.5	0.4	0.0	0.1	-33.2	-65.7	-48.6
BYPW1310	Phase 4	12	61.0	53.8	57.6	43.9	40.1	42.2	0.9	0.0	0.2	-34.5	-73.1	-53.6
BYPW1501	Phase 4	20	67.2	0.5	45.8	44.4	1.4	23.1	20.9	0.0	5.8	11.3	-74.1	-23.1
BYPW1502	Phase 4	15	59.6	54.7	56.5	43.5	40.9	42.5	0.6	0.0	0.1	-35.6	-73.4	-52.4
BYPW1503	Phase 4	20	59.2	52.8	55.6	42.6	39.2	41.0	0.8	0.0	0.1	0.0	-48.6	-21.0
BYPW1504	Phase 4	17	60.6	44.1	56.6	43.5	27.0	40.8	0.4	0.0	0.1	11.9	-65.7	-31.8
BYPW1505	Phase 4	8	48.7	0.0	17.7	32.8	0.0	12.0	20.9	0.0	14.1	0.4	-54.0	-7.1

Table 3.4: Annual average values for: methane (%CH_4 by Vol), carbon dioxide (%CO_2 by Vol), oxygen (%O_2 by Vol) and relative pressure (mbar) for in-waste monitoring carried out on Phase 4 of the Bryn Pica Landfill Site, during Jan 15 – Dec 15.

Discussion

Raw landfill gas monitoring results, taken from within the landfill waste, during the period Jan 15 – Dec 15, illustrate a good level of extraction and gas control. This is supported by the absence of any prolonged build up of landfill gas (i.e. positive landfill gas pressures) and low concentrations of Oxygen in the majority of gas wells sampled at the site.

Phase 1

Waste disposal within the Phase 1 area of the landfill was undertaken during the period 1992 – 2001 and therefore waste contained within will be between 14 and 23 years old. Gas yields over the Phase 1 area are shown to be generally lower than subsequent phases of the landfill. This is illustrated by the lower concentration of methane (CH^4) recorded over the previous 12 months. Of a total of 20 wells located within Phase 1, three of them (15%) illustrated average CH_4 values of less than 32.0% by Vol.

Phase 2

Waste disposal within the Phase 2 area of the landfill was undertaken during the period 2001 – 2006 and therefore waste contained within will be between 9 and 14 years old. The majority of extraction wells located over the Phase 2 landfill area illustrate CH_4 concentrations in the range 40 – 50% by vol. Monitoring results indicate that a single gas well (out of a total of 25 located within the Phase 2 landfill area) illustrated average CH_4 concentration of less than 32.0% by Vol. The number of wells displaying average CH_4 concentration in the range 45% - 55% by Vol, throughout 2015 is recorded as being 21 (i.e. 84%).

Phase 3

Waste disposal within the Phase 3 area of the landfill was undertaken during the period 2007 – 2011 and therefore waste contained within will be between 4 and 8 years old. The majority of extraction wells located within Phase 3 illustrates CH_4 concentration greater than 45% CH_4 by vol. Of the 22 gas wells currently operational in the Phase 3 landfill cell, three installation (BYPW0707, BYPW1102 and BPPW1103) have consistently illustrated methane (CH_4) concentrations lower than 45% by Vol.

Monitoring results would tend to indicate that gas wells located in the Phase 3 area continue to have a high level of gas production with high average methane concentrations (i.e. in the range 50 – 60 % CH_4 by vol). The number of wells displaying average concentrations of methane in the range 45% - 60 % by Vol is recorded as being 19 (out of 22). A consistent level of negative pressure (extraction) has been maintained across this area over the previous 12 months. This ensures that the potential for surface emissions remains low.

Phase 4a

Landfill disposal operation within Phase 4 of the Bryn Pica facility are split into 2 cells, Phase 4a (completed) and the currently operational Phase 4b. Gas extraction infrastructure is continually extending in this area of the landfill, however at the time of writing, Phase 4 has 12 active landfill gas extraction wells. Monitoring of these installation over the previous 12 months have indicated a good degree of operational control. This is supported by the observation that Oxygen percentages on the whole are very low (with the exception of gas well BYPW1505) averaging less than 1%. In addition to this, Methane (CH_4)

percentages are within the range 45% - 60% (by Vol).

3.2 Landfill Gas Compound - Bulk Gas Monitoring

Landfill Gas extracted from the Bryn Pica site is piped to the Landfill Gas Compound for safe processing and disposal. The resulting combination of gas (bulk gas) is monitored continuously by the gas analysers present on the flare and engine. In addition to this gas quality is checked weekly using a hand held analyser. Table 3.5 (below) presents a comparison of monitoring results recorded at the landfill gas compound in 2013, 2014 and 2015.

Table 3.5: Comparison of gas monitoring results recorded at the Bryn Pica landfill gas compound in 2013, 2014 and 2015.

		Flare 2013	Flare 2014	Flare 2015
Methane (%CH4)	Ave	50.5	50.4	48.1
	Max	56.2	55.5	55.0
	Min	35.0	43.5	33.9
Carbon Dioxide (%CO2)	Ave	36.6	36.6	35.7
	Max	41.1	41.5	39.1
	Min	27.1	33.2	24.7
Oxygen (%O2)	Ave	0.4	0.4	0.4
	Max	5.4	1.5	4.3
	Min	0.0	0.0	0.0
Pressure (mbar)	Ave	-59.1	-43.2	-54.2
	Max	-92.6	-80.0	-80.6
	Min	-22.6	-20.7	-15.5
Gas Flow (m3/hr)	Ave	811	877	828
	Max	1080	1250	960
	Mix	500	575	600

Discussion

Monitoring of gas flow rates indicate that the total volume of landfill gas processed at Bryn Pica throughout 2015 decreased when compared with 2014. The average volume of gas extracted from the whole site in 2015 was calculated as being 828 cubic meters per second. This is a circa 5.6% decrease when compared to the 12 month period in 2014.

Monitoring records show the average methane (CH_4) concentration in 2015 was 48.1% by Vol, with low average Oxygen concentrations of 0.4% by Vol. These results provide an indication that the level of gas extraction at the site has been well controlled and that the gas management system has been operated in a proficient manner throughout the reporting period.

3.3 Sub-Surface Landfill Gas Monitoring

Amgen Cymru currently has 18 ground monitoring installations for the purpose of detecting potential migration of landfill gas from the base of the landfill into the surrounding ground strata. The location of these installations is shown on Drawing No. AC2016/ENV/02/02.

Table 4.1 (Appendix B) provides a summary of the results of monthly landfill gas monitoring carried out at the Bryn Pica site by Amgen staff using a GA5000 Landfill Gas Analyser (Geotechnical Instruments, UK).

It has previously been noted that the Bryn Pica Landfill has two areas of subsurface landfill gas migration. A small degree of migration is noted on the south western margin of the phase 1 landfill, near to the location of gas wells BYPP1203 and 1204. This is reasonably limited in nature and due to the lack of any potential receptors near to this locality it is not considered to be of concern.

Ground monitoring boreholes located around the northern margin of the 'unlined' Phase 1 landfill continue to illustrate sub surface landfill gas migration of a notable extent. Elevated levels of methane (i.e. above the site specific trigger level of 1.0 % by Vol) were recorded on several occasions throughout 2015. These were typically accompanied by reduced levels of oxygen in ground gas (i.e. < 18% by Vol).

Area to the North of Phase 1

GMBH06-02

During the period Jan 15 to Dec 15, monitoring undertaken at GMBH06-02 illustrated an average of Methane (CH_4) concentration of 7.9 % CH_4 by Vol. This is a slight increase when compared to the average value calculated for the period Jan 14 to Dec 14 (recorded as being 5.5 % CH_4 by Vol). These observations suggest that the remediation measures targeting this migration have, to a degree, reduce in effectiveness over the previous 12 months. Further action is required in order to reduce the presence of landfill gas within this installation.

GMBH07-02

This installation was de-commissioned in 2014 as part of development works in this area of the waste management site.

GMBH 08-01

Ground monitoring installation GMBH 08-01 and GMBH 08-02 were installed in 2008 as part of works to further investigate the extent of sub-surface gas migration around the area immediately North of the Phase 1 Landfill at Bryn Pica.

GMBH 08-01 was adopted as an external gas extraction well in Mar-09. Prior to this time monitoring results had shown consistently high levels of Methane, typically in the range 40% - 60% CH_4 by Vol. The exertion of negative pressure on this well (from the site's landfill gas management system) was expected to intercept gas thought to be migrating in a northly direction from the unlined phase 1 landfill.

Throughout 2015 monitoring results from GMBH 08-01 constantly exhibited negative pressure, with an average of -7.4 mbar. Methane concentrations were recorded in the range 0.0% to 46.5% CH_4 by Vol.

GMBH 09-01

Ground monitoring borehole GMBH 09-01 is located at NGR 300920 205218, a few meters (less than 5) from the edge of the Phase 1 landfill in the direction of the Recycling Facility.

Monitoring of gas levels within this installation throughout 2014 recorded methane concentrations in the range 0% - 37.5 % CH_4 by Vol, with an average concentration of 7.0 % CH_4 by Vol. During the 12 month period now under consideration (i.e. Jan-15 to Dec-15), the level of landfill as observed within this installation has reduced significantly. Monitoring results from 2015 indicate a much lower range in Methane concentrations (0.0 – 2.7% CH_4 by Vol), with an annual average 0.4% % CH_4 by Vol.

GMBH 12-01

Ground monitoring borehole GMBH12-01 is located approximately 10 m away from the North boundary of the Phase 1 Landfill in the direction of the Recycling Centre.

The average CH_4 concentration calculated for GMBH12-01 during the period Jan-15 to Dec-15 is shown to be 1.4% CH_4 by Vol. This demonstrates a slight reduction in gas migration away from Phase 1 in this direction when compared to the average value reported in 2013 and 2014 (4.9 and 1.7 % CH_4 by Vol, respectively).

Area to the South West of Phase 1

GMBH06-06

Monthly analysis of Soil Gas sampled in GMBH06-06 has illustrated elevated levels of methane and carbon dioxide as well reduced oxygen concentrations. During the period Jan-15 to Dec-15, the average methane concentration recorded was 24.3% CH4 by Vol. With average values of carbon dioxide over the same period of 17.7% CO2 by Vol and average oxygen value of 4.8% O2 by Vol.

This is a likely indication of landfill gas migration from the unlined Phase 1 area in a south westerly direction towards the location of GMBH06-06. This monitoring installation is located less than 10 m west of the Phase 1 landfill area and is shown from the drillers log to be situated in Opencast Backfill for its entire 10 m depth.

Results of monitoring of the surrounding installations GMBH6-07 and GMBH07-05 have not indicated the presence of landfill gas at levels significantly above background. It is therefore considered that any potential landfill gas migration in this direction is limited.

The landfill gas risk assessment for the Bryn Pica Landfill Site has not indicated any potential receptors to landfill gas migration in a westerly direction from the location of gas monitoring borehole GMBH06-06 (not identified with 750m). Furthermore, a significant height different exists between the site and the nearest receptor and in this respect the potential risk associated with the subsurface landfill gas migration in this direction is considered to be very low.

It was previously reported that, 2 additional gas extraction wells (ref ID: BYPW1203 and BYPW1204) were installed within the landfill near to the location of the ground monitoring installation GMBH06-06 (installed in Sept-12). These gas wells were specifically aimed at reducing the levels of landfill gas observed in the external gas monitoring borehole GMBH 06-06.

Monitoring results provided by the Landfill Gas Operator (Infinis Ltd.) for the period Jan-15 to Dec-15 indicate that these wells have been kept under slight extraction (i.e. suction). The average extraction pressure for the referenced monitoring period was calculated as follows:

- BYPW1203 average pressure during 2013 = -1.6 mbar
- BYPW1204 average pressure during 2013 = -2.7 mbar

4. SUMMARY / RECOMMENDATIONS

4.1 Amgen Cymru and its nominated landfill gas contractor (Infinis) have carried out landfill gas monitoring as required by the Bryn Pica Landfill Site Environmental Permit during 2015 (No. DP3732SQ).

4.2 Infinis has undertaken monthly monitoring of 80 gas extraction wells located in Phases 1, 2, 3 and 4 of the Bryn Pica Landfill Site. Raw landfill gas monitoring results, taken from within the landfill waste illustrate a good level of gas extraction and control. This is illustrated in the absence of any prolonged build up of landfill gas (i.e. positive landfill gas pressures) along with low concentrations of Oxygen in the majority of gas wells sampled at the site.

4.3 Amgen Cymru has undertaken monthly landfill gas monitoring of 18 ground monitoring installations located around the Bryn Pica Landfill Site. It has previously been noted that the Bryn Pica Landfill has two areas of subsurface landfill gas migration. A small degree of migration is noted on the south western margin of the phase 1 landfill, near to the location of ground monitoring installation GMBH06-06. This is reasonably limited in nature and due to the lack of any potential receptors near to this locality it is not considered to be of concern.

4.4 Ground monitoring boreholes located around the northern margin of the 'unlined' Phase 1 landfill continue to illustrate sub surface landfill gas migration of a notable extent. Elevated levels of methane (i.e. above the site specific trigger level of 1.0 % by Vol) were recorded on several occasions throughout 2015. These were typically accompanied by reduced levels of oxygen in ground gas samples (i.e. < 18% by Vol).

4.5 Results of sub-surface gas monitoring should continue to be reviewed monthly by the operator to guard against any potential reverse in trend identified above.

APPENDIX A

Drawings

AC2016/ENV/01/01 – Location Plan
AC2016/ENV/02/02 – Landfill Gas System Infrastructure

APPENDIX B

Tables Not In Text

Table 4.1 - Statistical summary of Sub Surface Landfill Gas monitoring carried out at the Bryn Pica Landfill during the period Jan 15 – Dec 15.

APPENDIX C

Raw Landfill Gas Monitoring Data (PDF Version Only)