Cyfoeth Naturiol Cymru Natural Resources Wales	**EPR Compliance Assessment Report**	Report ID: PP3139GB/0217317

This form will report compliance with your permit as determined by an NRW officer

Site	Hafod Quarry Landfill			Permit Ref	PP3139GB		
Operator/ Permit holder	Cory Environmental (Central) Ltd						
Date	02/07/2014			Time in	10:00	Out	16:00
What parts of the permit were assessed	Natural Resources Wales Gas Audit 2-3 July 2014						
Assessment	Audit	EPR Activity:	Installation X	Waste Op		Water Discharge	
Recipient's name/position	Ian Craven - Site manager						
Officer's name	Tony Roberts, Tyrone Ward, Neil Herbert			Date issued	18/08/2014		

Section 1 - Compliance Assessment Summary

This is based on the requirements of the permit under the Environmental Permitting Regulations. A detailed explanation and any action you may need to take are given in the "Detailed Assessment of Compliance" (section 3). This summary details where we believe any non-compliance with the permit has occurred, the relevant condition and how the non-compliance has been categorised using our Compliance Classification Scheme (CCS). CCS scores can be consolidated or suspended, where appropriate, to reflect the impact of some non-compliances more accurately. For more details of our CCS scheme, contact your local office.

Permit Conditions and Compliance Summary			Condition(s) breached
a) Permitted activities	1. Specified by permit	A	
b) Infrastructure	1. Engineering for prevention & control of pollution	A	
	2. Closure & decommissioning	N	
	3. Site drainage engineering (clean & foul)	N	
	4. Containment of stored materials	A	
	5. Plant and equipment	A	
c) General management	1. Staff competency/ training	N	
	2. Management system & operating procedures	C3	1.1.1
	3. Materials acceptance	A	
	4. Storage handling, labelling, segregation	A	
d) Incident management	1. Site security	A	
	2. Accident, emergency & incident planning	N	
e) Emissions	1. Air	C2	3.3.1
	2. Land & Groundwater	A	
	3. Surface water	N	
	4. Sewer	NA	
	5. Waste	N	
f) Amenity	1. Odour	A	
	2. Noise	A	
	3. Dust/fibres/particulates	A	
	4. Pests, birds & scavengers	A	
	5. Deposits on road	A	
g) Monitoring and records, maintenance and reporting	1. Monitoring of emissions & environment	A	
	2. Records of activity, site diary, journal & events	A	
	3. Maintenance records	A	
	4. Reporting & notification	A	
h) Resource efficiency	1. Efficient use of raw materials	NA	
	2. Energy	NA	

KEY: **C1, C2, C3, C4** = CCS breach category (*** suspended scores are marked with an asterisk**),
A = Assessed (no evidence of non-compliance), **N** = Not assessed, **NA** = Not Applicable, **O** = Ongoing non-compliance – not scored

Number of breaches recorded	2	**Total compliance score** (see section 5 for scoring scheme)	35

If the Total No Breaches is greater than zero, then please see Section 3 for details of our proposed enforcement response

Section 2 – Compliance Assessment Report Detail

This section contains a report of our findings and will usually include information on:

- the part(s) of the permit that were assessed (e.g. maintenance, training, combustion plant, etc)
- where the type of assessment was 'Data Review' details of the report/results triggering the assessment
- any non-compliances identified
- any non-compliances with directly applicable legislation
- details of any multiple non-compliances
- information on the compliance score accrued inc. details of suspended or consolidated scores.
- details of advice given
- any other areas of concern
- all actions requested
- any examples of good practice.
- a reference to photos taken

This report should be clear, comprehensive, unambiguous and normally completed within 14 days of an assessment.

Site audit carried out on the 2-3 July 2014 as part of the ongoing review of landfill gas collection performance and reduction of fugitive emissions.

Auditors: Tony Roberts (Senior Environment Officer), Tyrone Ward (PPC Compliance Officer) and Neil Herbert (PPC Compliance Officer).

Detailed audit findings are presented in the audit report attached.

Non-compliances:

CCS 3 - Condition 1.1.1 Management condition - Oil was noted on the stone close to the gas engine housing which was coming from the crank case breather. The contaminated material has been removed and replaced.

Action - The option to re-route the crank case breather discharge back into the engine for combustion has been investigated and is not considered a practical option on this engine.

CCS2 – Condition 3.3.1 Fugitive emissions - The methane emissions survey report shows high emissions across the main steep flank on cell 3.

Action – Improve the gas extraction efficiency at Hafod Landfill through improvement of extraction infrastructure and the de-watering of perched leachate within the gas infrastructure by 31 October 2014.

A meeting was held to discuss the audit findings with Cory Management on 12 August 2014. Options to improve the gas infrastructure and de-watering were discussed. A plan provided by Cory for 12 new wells 'Proposed New Gas Wells' has been attached to the report as an appendix.

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Operator/ Permit	Cory Environmental (Central) Ltd	Date	02/07/2014

Section 3- Enforcement Response	**Only one of the boxes below should be ticked**
You must take immediate action to rectify any non-compliance and prevent repetition. Non-compliance with your permit conditions constitutes an offence and can result in criminal prosecutions and/or suspension or revocation of a permit. Please read the detailed assessment in Section 2 and the steps you need to take in Section 4 below.	
Other than the provision of advice and guidance, at present we do not intend to take further enforcement action in respect of the non-compliance identified above. This does not preclude us from taking enforcement action if further relevant information comes to light or advice isn't followed.	
In respect of the above non-compliance you have been issued with a warning. At present we do not intend to take further enforcement action. This does not preclude us from taking additional enforcement action if further relevant information comes to light or offences continue.	X
We will now consider what enforcement action is appropriate and notify you, referencing this form.	

Section 4- Action(s)

Where non-compliance has been detected and an enforcement response has been selected above, this section summarises the steps you need to take to return to compliance and also provides timescales for this to be done.

Criteria Ref.	**CCS Category**	**Action Required/Advised**	**Due Date**
See Section 1 above			
C2	C3	The option to re-route the crank case breather discharge back into the engine for combustion has been investigated and is not considered a practical option on this engine.	N/A
E1	C2	Improve the gas extraction efficiency at Hafod Landfill through improvement of extraction infrastructure and the de-watering of perched leachate within the gas infrastructure.	31/10/2014

Section 5 - Compliance notes for the Operator

To ensure you correct actual or potential non-compliance we may

- advise on corrective actions verbally or in writing
- require you to take specific actions in writing
- issue a notice
- require you to review your procedures or management system
- change some of the conditions of your permit
- decide to undertake a full review of your permit

Any breach of a permit condition is an offence and we may take legal action against you.

- We will normally provide advice and guidance to assist you to come back into compliance either after an offence is committed or where we consider that an offence is likely to be committed. This is without prejudice to any other enforcement response that we consider may be required.
- Enforcement action can include the issue of a formal caution, prosecution, the service of a notice and or suspension or revocation of the permit.

See our Enforcement and Civil Sanctions guidance for further information

This report does not relieve the site operator of the responsibility to

- ensure you comply with the conditions of the permit at all times and prevent pollution of the environment
- ensure you comply with other legislative provisions which may apply.

Non-compliance scores and categories

CCS category	Description	Score
C1	A non-compliance which could have a **major** environmental effect	60
C2	A non-compliance which could have a **significant** environmental effect	31
C3	A non-compliance which could have a **minor** environmental effect	4
C4	A non-compliance which has **no** potential environmental effect	0.1

Operational Risk Appraisal (Opra) - Compliance assessment findings may affect your Opra score and/or your charges. This score influences the resource we use to assess permit compliance.

Section 6 – General Information

Data protection notice

The information on this form will be processed by the Natural Resources Wales (NRW) to fulfill its regulatory and monitoring functions and to maintain the relevant public register(s). The NRW may also use and/or disclose it in connection with:

- offering/providing you with its literature/services relating to environmental matters
- consulting with the public, public bodies and other organisations (e.g. Health and Safety Executive, local authorities) on environmental issues
- carrying out statistical analysis, research and development on environmental issues
- providing public register information to enquirers
- investigating possible breaches of environmental law and taking any resulting action
- preventing breaches of environmental law
- assessing customer service satisfaction and improving its service
- Freedom of Information Act/Environmental Information Regulations request.

The NRW may pass it on to its agents/representatives to do these things on its behalf. You should ensure that any persons named on this form are informed of the contents of this data protection notice.

Disclosure of information

The NRW will provide a copy of this report to the public register(s). However, if you consider that any information contained in this report should not be released to the public register(s) on the grounds of commercial confidentiality, you must write to your local area office within twenty working days of receipt of this form indicating which information it concerns and why it should not be released, giving your reasons in full.

Customer charter

What can I do if I disagree with this compliance assessment report?

If you are unable to resolve the issue with your site officer, you should firstly discuss the matter with the officer's line managers. If you wish to raise your dispute further through our official Complaints and Commendations procedure, phone our general enquiry number 0300 065 3000 (Mon to Fri 08.00–18.00) and ask for the Customer Contact team or send an email to enquiries@naturalresourceswales.gov.uk. If you are still dissatisfied you can make a complaint to the Public Services Ombudsman for Wales. For advice on how to complain to the Ombudsman phone their helpline on 0845 607 0987.

Cyfoeth Naturiol Cymru Natural Resources Wales

Natural Resources Wales Technical Review Of Landfill Gas Management Systems

Mr Ian Craven
Area Manager
Cory Environmental
Hafod Quarry Landfill Site
Bangor Road
Johnstown
Wrexham
LL146ET

Hafod Landfill Gas Review
Permit No: BS8621IW

August 12th 2014

Background

The U.K. Government has set a target of a unilateral 34% reduction of greenhouse gases (GHG) by 2020 compared to 1990. The Welsh Government climate change strategy includes a target to reduce greenhouse gas emissions by 3% every year.

Natural Resources Wales Corporate Plan for 2014-2017 makes a commitment to reduce GHG emissions in order to help meet the Government's overall GHG reduction target.

This technical audit has been carried out as a key part of the strategy to reduce methane emissions from active landfill sites in Wales.

As part of the ongoing audit and review programme an element of best practice and benchmarking of landfill in Wales will be included in our approach, to establish a consistent standard of operation and a better estimate of emissions and extraction efficiencies as well as to address sites with known local issues such as:

i. significant numbers of odour complaints received from the general public;
ii. evidence of lateral landfill gas migration beyond the site boundary. other issues such as high trace gas levels and evidence of thermal events.

iii. High Hydrogen Sulphide and associated health and safety issues
iv. High emissions (Point or diffuse)
v. Degrading or Insufficient infrastructure
vi. Changes in the gas production curve

Please find the Landfill gas infrastructure and Methane Emissions Survey conducted on the 2nd and 3rd July 2014 , with a list of comments and actions attached.

Review

The review took place on the 2nd and 3rd July and involved Officers from the Natural Resources Wales Specialist Landfill Gas Group, accompanied by Ian Craven – Cory Area Manager.

The team inspected the gas treatment compound, followed by the gas field and working areas. The newly emplaced capping area was also assessed for emissions as well as the steep flank of cell 3.

All sampling was performed with a calibrated Geotechnical Instruments GA2000+ and the Gazomat Inspectra laser methane Analyser.

Cory responses to the summary of initial findings sent by NRW within 2 days of the completion of the audit are included in the text of the document *in italics* to ensure the operators immediate responses to findings are aired in context. Further NRW responses are included below the Cory response as part of the text below.

Summary

Gas flow to the compound has reduced from 650m3/hr in 2013 to 600m3/hr despite consistent waste inputs. The potential gas overhead from benchmarking is calculated at approximately 241m3/hr. The methane emissions survey report shows high emissions across the main steep flank on cell three including a large emission under pressure at the toe of the flank which is pushing out methane at 45% concentration. Some of the steep flank has been capped which is welcome but emissions are evident from welds and some of the pipework protruding through the cap. Of the 60 wells inspected 28 were off or had no apparent flow and some were restricted by condensate blockage. The conclusion that is reached from the findings is that there must be an improvement in gas extraction efficiency at Hafod Landfill by the improvement of extraction infrastructure and the de-watering of perched leachate within the gas infrastructure.

GAS PRODUCTION RATE, EXTRACTION EFFICIENCY AND GASSIM MODELLING

Prior to undertaking an assessment of a landfill gas management system it is necessary to make an accurate estimate of how much gas the site is producing so that the effectiveness of the system, i.e. the proportion of the generated gas that it captures, can be determined.
Provided that both the quantity and types of waste deposited at the site are known, the volume of gas that is likely to be produced by a site can be estimated using computer models such as GasSim and available evidence from monitoring data and other research as detailed below.
Gas production rate has been cross referenced to actual gas readings and the state of the gas field as observed during the site and data reviews. This has been cross referenced where appropriate to a range of standard figures for production waste per tonne per annum.
The two GasSim models previously submitted for Hafod Landfill as part of the first LFG Audit in 2010 predicted that in 2009/2010 landfill gas would be produced at a rate of between 500m3/hr (Cory model) and 2100 m3/hr (Egniol model) . Peak production of between 550m3/hr and 2200m3/hr is predicted to occur between 2009 and 2027 respectively in each model.

Because the models previously analysed do not reflect the situation on site with regard to gas production, further simple calculations based on a lower range of production at 6m3 of gas per tonne of waste up to10m3 per tonne of waste have been used, this produces a figure of 890 and 1484 m3/hr respectively.
The average of these 2 figures is 1187m3/hr of landfill gas. This figure is close to the 1113 m3/hr using a total figure of gas per tonne of waste of 150m3. This figure is then averaged over a 20 year period.

Research on actual landfill gas production calculated from an idealised tonne of landfill waste and the lowest end predictions (from the Jenbacher web site and various academic research (Emcon Associates 1980; Tchobanoglous et al 1994, and Oonk 1994 (sustainable landfill foundation)), shows that at the lowest end of the production range it can be estimated that each tonne of waste will produce 145m3 of LFG.
Hafod Landfill has accepted waste since 2006. It has been progressively filled with non-hazardous municipal, commercial and industrial waste.
Approximately 1.2 million tons of waste had been landfilled at Hafod Quarry which is just over 20% of the sites total capacity of 5,000,000m3.
Subsequently the site has accepted approximately 90-100,000 tonnes per annum then the total amount of waste deposited at the site is now 1.7 million

tonnes. Using the Jenbacher forecast of 145m3 gas per tonne this would equate to 1406m3/hr as an average over 20 years.
As the waste in the site is all under 10 years then the gassing potential is still high, however given the reduction in the bio-degradable fraction due to landfill allowance scheme then a conservative estimate of total gas production at this moment in time using a figure of 5m3/t/yr (below the normal range) gives a total gas production of 913m3/hr @ 50% CH4.
Flow at the site in 2013 was 650m3/hr @ 44.7 %, which when normalised to 50% equates to 581m3/hr. LFTGNO3 guidance document specifies a collection efficiency of 85% for operational landfills without final capping as a best practice benchmark. Taking the very lowest estimate from the figures above, the benchmark for extraction in 2013 was 776m3/hr which is the most conservative estimate and gas production could be significantly higher.
This gave an overhead at the time of the 2013 review of 195m3/hr to reach the benchmark extraction efficiency.

The gas extracted from the site in July 2014 has now fallen to 600m3/hr at 44.9% CH4 which equates to 538m3/hr gas normalised to 50%. This means that the current lower extraction rate results in a potential gas overhead of 241m3/hr. (As explained above this is more likely to be an underestimate)
The results from the landfill gas emissions survey appear to confirm these figures as a reasonable estimate.

GAS MANAGEMENT COMPOUND (Actions in bold)

1. Gas flow and quality were read from the sampling valve at the gas main on the negative pressure side of the booster. The readings are reproduced in the table below and include the readings from the audit performed in 2013:

Table 1 Gas Management Compound Readings Hafod Landfill

Sample Point	CH4	CO2	O2	BAL	DP	CO	H2S	Flow (m3/hr)
Engine November 2013	44.7	34.9	0.8	19.2	-74.6	40	83	650
Engine July 2nd 2014	45.3	35.2	1.3	18	-69	134	99	600
Gas Main – prior to pre-treatment GUP 2nd July	45.8	35.3	1.3	17.5	-67.9	123	115	
Engine July 3rd 2014	44.9	35.7	1.3	18.2	-64.8	73	79	570-580

2. Gas extraction rate from the site has reduced whilst emissions from the flank and other areas of the site are high. (See attached methane emissions survey). **ACTION: Reduce emissions and improve gas extraction efficiency by 31st October 2014.**

NB: A meeting was held to discuss the audit findings with Cory Management on 12 August 2014. Options to improve the gas infrastructure and de-watering were discussed. A plan provided by Cory for 12 new wells 'Proposed New Gas Wells' has been attached to the report as an appendix.

3. Oil was noted on the stone close to the gas engine housing which was coming from the crank case breather. This is to be re-routed back through the engine in the near future. It was noted that by the second morning of the audit the contaminated material had been removed and

replaced with railway ballast. Thank you for the swift response to this issue.

ACTION: report on progress in re routing of crank case breather back into the engine. The following response has been received from Cory prior to the issue of the full audit findings:

On the CAT 3516 engines the crankcase emissions are sucked from the engine via a fixed pump which then sends the emissions to the exhaust via a Vokes filter unit. Since the audit the filters have been replaced and secondary containment installed to catch any possible residue entering the outside of the genset.. In addition to the removal of any contaminated stone, the side of the genset container has also been thoroughly cleaned of any oil/dirt residue.

Thank you for this explanation and the swift replacement of filters

ACTION 2. Please explain if this is best practice, as many of the engines at sites regulated by NRW re-route the crank case breather discharge back into the engine for combustion.

PHOTO 1 Oil Contamination From Crank Case Breather Pipe

PHOTO 2- Oil Contaminated Ground Removed

GAS EXTRACTION FIELD

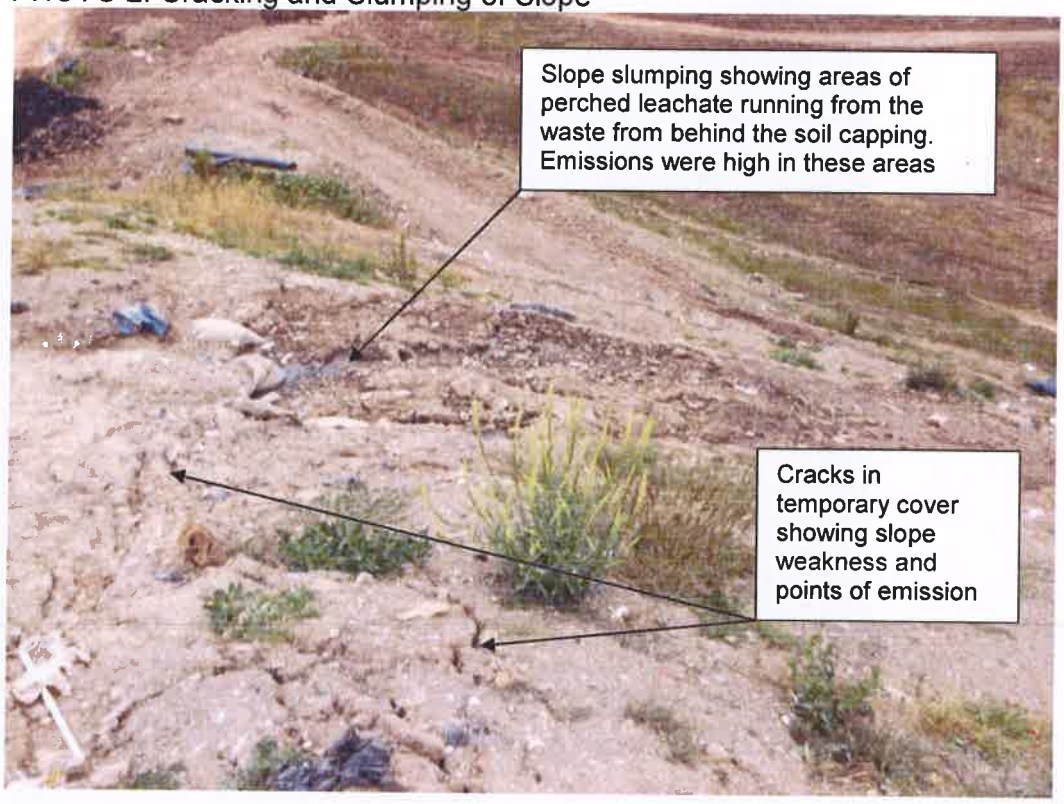
1. The Methane Emissions Survey Report shows that surface emissions ranging from 10ppm through to percentage levels of methane were detected on parts of the site as recorded by the Gazomat methane detector. Emissions were prevalent across the whole of the Northern flank, proceeding from East to West and from the boundary of cell two and three. In some cases emissions were accompanied by strong odours.

2. The methane emissions survey attached to this report shows 26 points of emission ranging from 17ppm (parts per million) to 60% gas by volume. (Grid references provided in emissions survey for exact location of emission). The record of emission points was limited by survey time and this is to be considered representative.

3. There were high emissions from areas of the flank which have not been capped, even with the re-worked regulation layer in place (intermediate cover) and sounds of gas bubbling through water under the cap.

   ACTION: An action plan should be designed and submitted to NRW for approval to improve the extraction efficiency at the site. The plan should include a perched and basal de-watering strategy, analysis of wells which are switched off which might be brought back on line, wells which require re-sealing, wells which are redundant and any new wells or re-drills which might be required. This would include a strategy for accessing and extracting gas at depth in a sustainable manner.

PHOTO 2: Cracking and Slumping of Slope



4. The site in cross section showed numerous weeps indicating perching of leachate at discrete levels in the waste. **ACTION: all wells and well logs should be checked for perching and where required and possible, pumps should be installed by the 31st October 2014.**

5. High emissions were noted from some defects in the placed geo-membrane. All folds/ creases/Boot detail. (See emissions survey) **ACTION: These should be patched as soon as possible but no later than during the next phase of temporary capping.**

PHOTO 3: Emission From Extrusion Weld in Boot Detail

6. Referencing the gas well survey (attached as a separate document) 28 wells out of a total of 60 inspected were either switched off or had no apparent flow. **ACTION the reasons for infrastructure being redundant should be investigated as a matter of urgency. This is particularly so in the areas of high emission namely phases 2 and 3. This will be aided by the submission of a clearly labelled and current as built survey drawing.**

7. Emissions were detected in discrete areas on the new plastic temporary capping and several pipes which were protruding through the cap were sealed with tape which was leaking. (see photo below)

PHOTO 4 : Poorly sealed vertical pipe protruding through the capping.

ACTION: End caps should be fitted ASAP

The following response has been received from Cory prior to the issue of the full audit findings:

This has already been actioned.

It is presumed that new end caps have been fitted to all such vertical pipe-work on site. How were the end caps sealed? Were they push fit, threaded?

8. Gas was noted bubbling with audible high pressure from the toe of the Northern batter (close to the pool of drained leachate). High gas pressures at depth can cause such outbreaks. This situation is exacerbated by the number of pin wells (some of which are off) in the area and the lack of deep well extraction to intercept gas at depth below perched water.

   ACTIONS for Points 1 and 7 (points 1 and 2 in initial audit summary). : Gas extraction efficiency must be improved in these areas and critically between phase two and three. There is a lack of deep well extraction in this area. Deep well extraction with suitable diameters for pump insertion and lower SDR ratios for vertical pipe-work for improved strength should be considered. Careful attention should be paid to the depth of slotting, plain casing and de-watering regime to ensure the lower half of the Northern flank can be targeted effectively.

   The following response has been received from Cory prior to the issue of the full audit findings:

   As you know Cory have gone to great lengths to install a large area of temporary LLDPE capping to the lower and middle sections of the Northern flank, and this work is still progressing well. We have spent considerable time installing drains to channel any leachate weeps into a drainage system down to the sump in the inter-cell bund of Cell 3, from where it is pumped away for off site disposal. The emissions you refer to were largely above this area of capping and within in the unfinished sump area at the toe of the Northern flank. At the time of your visit we had three new pin wells which had not yet been connected into the extraction system, due to this area still requiring the installation of the temporary cap. The area to the west of the Northern flank that has suffered localised slumping will be re-profiled over the next few weeks by constructing an access road out of clay. The purpose of this is to allow the formation of a landform which allows us to continue the temporary capping in this area and to drain a few existing leachate seepages on this flank. This will further reduce any localised odours in this area and allow us to shed further surface water to reduce leachate generation along this flank.

   Whilst we acknowledge that there may still be areas that require further gas extraction, especially now the temporary capping is preventing any gas escape, we would like to point out that there were 20 x 15m deep sacrificial wells installed into the area of Cell 2 and 3 in November 2013, and another 12 permanent gas wells (between 13 and 31m

depth) drilled in April 2014. I have attached the latest installation file for the 12 gas wells in April 2014.

As part of our regular review on the adequacy of gas infrastructure at the site, we are currently looking at any further areas where we can install additional infrastructure, and will take on board your comments regarding slotting and dewatering of the wells. Please note that all our permanent wells have 160mm casing to allow pneumatic pumps to be installed. As per our usual approach, we will submit any gas well installation proposals to NRW for approval prior to any installation being undertaken on site. Consequently, in the next few weeks we will submit our proposals for additional infrastructure in this area.

The work performed to help drain parts of the flank and install a temporary plastic cap is a very welcome development and should improve some of the issues in the long term. The cap is however only an addendum to a properly functioning and comprehensive extraction system in the body of the waste. Where excess gas is being produced which the existing system cannot capture it will accumulate under the cap and eventually find its way out or build pressure. The critical thing here is for the gas extraction systems efficiency to match the gas production rate as closely as possible or fugitive emissions will remain an issue despite capping.

The drainage channels are useful and will help prevent the accumulations of perched leachate under the capping. It was noted however that the pipe-work associated with these channels can act as a conduit for gas and must be correctly sealed.

The emissions were not restricted to above the cap, there was bubbling through water under the cap egress through the sides of the capping and through tears and breaches in capping infrastructure. Please check the grid references on the accompanying methane emissions survey.

The three pin wells are a welcome addition to the gas extraction infrastructure, however for such significant emissions pin wells can only provide a small near-surface extraction effect. Improved extraction targeting deep gas which is pushing out horizontally by advection is required.

The reasoning given above does not address however the fact that of the 60 wells examined during the audit 28 wells were off or had no apparent flow. Urgent action is required to restore extraction to areas where the extraction system is not working as it should as delineated in the points above and the attached methane emissions and well surveys, which should be read carefully and the findings therein should be acted upon. You stated that 'there may still be areas that require

further gas extraction' have you identified these areas? Do they concur with the findings of this report?
The installation of 12 new wells in April 2014 is welcome and undoubtedly contributed to extraction efficiency at the site. It still remains the fact however that emissions are high and control of gas requires improvement.
You state that 'all our permanent wells have 160mm casing to allow pneumatic pumps to be installed'. During the audit the site Manager stated that there were no pumps actively pumping leachate from gas wells on site as problems were encountered retrieving the existing pumps from 160mm wells. At depth if there is any deformity in the vertical pipe-work then using 160mm pipe makes retrieving the pump very difficult and leaves little margin for error.
ACTION : Please confirm the number of pumps in gas wells that are actively extracting leachate and the number of redundant in well pumps trapped in vertical gas wells by the 31st October 2014. Could you please also supply the pump checking and maintenance schedule that is used to ensure effective operation of pumps in the field.

9. Much of the infrastructure on the Northern flank was not working or was having limited effect. Has your regular review of the gas infrastructure drawn the same conclusion? Please see the well survey/field results report accompanying this report and the comments therein.

ACTION: Check the existing infrastructure for defects and poor sealing ensure individual well histories are undertaken to identify where the main diagnostic issues lie. Check operational well depths and compare with waste depths in this area.
The following response has been received from Cory prior to the issue of the full audit findings:

This is done as part of a regular quarterly gas field assessment, with bentonite seals checked as part of ongoing gas balancing.

ACTION: Please could you submit the results of your last quarterly gas field assessment including the conclusions in regard to the field and what actions were or are proposed to be taken as a result of the survey.

5. Several wells and associated pipe-work were unusually warm to touch and had high levels of CO. In well 32 the CO reached levels in excess of 1400ppm. This is high and could be indicative of a thermal

event. These three wells (highlighted to the Area manager during the Audit) should be bag sampled and tested for CO as soon as possible. There may be some cross interference effects so it would be advisable to check the readings with a H2S filter in place.

The following response has been received from Cory prior to the issue of the full audit findings:

Out of interest please can you confirm if you used a H2S filter when sampling the gas extraction system at Hafod? We have checked against the previous monitoring conducted on the 1st July and the reading for Gas Well 32 shows 0ppm CO, 9ppm H2S and low H2. This reading was taken with a H2S filter in place, and you are right that cross interference can take place without the required H2S filter. We have sampled this well twice previously and the results did not show any further cause for concern. The line of 3 sacrificial wells marked as for 5 (not 2 as we mistakenly identified on site) was warm and I bagged a sample the same day on the 3rd August and sent for analysis. The results are attached below but show low CO at 28ppm, 689ppm H2S and relatively high hydrogen, all of which can be common in newly decomposing wastes, which these wells would be extracting from in this area.
We can confirm that the H2S filter was not used on site during the audit and the issues with cross interference and false readings were discussed with the site Manager on the day. We were concerned that the warmth in the pipes was above the normal range and this can be as a result of a heating of the waste within the landfill. Thank you for confirming the levels of CO. The hydrogen production in new waste is well documented but usually subsides on establishment of the full methanogenic phase within the Farquhar- Rovers degradation curves.
ACTION: Although CO levels are relatively low at 28ppm, this presumes it is not rising and in the absence of direct proof of a thermal event within the waste there is no explanation for the raised temperature of the pipe-work. It would be prudent therefore to increase the sampling frequency of the wells in question and check the CO more regularly (along with CH4/CO2 ratio).

10. Condensates were heard pulsing in much of the connection pipe work. **ACTION: Check all pipework for condensate traps and re-lay to the correct fall or ensure that the system is able to dewater non-manually.**

The following response has been received from Cory prior to the issue of the full audit findings:

Pipework is continually reviewed as part of everyday operations and the condensate pulsing in a few gas wells in the active area of tipping on Cell 2/3 are continually relayed to allow active gas extraction on the current tipping area. We feel it is best to do this than completely isolate the wells in an area whilst working around them. All connection pipes will be relayed in this area, once the final levels are reached in the next few weeks.
Thank you for the clarification on this issue. However it is important that wherever possible pipes are laid to the correct falls to allow gravity de-watering without deforming which allows condensate to aggregate in low spots in the pipe-work.

ACTION: Lay all pipes to recommended falls for de-watering by gravity wherever possible.

11. Methane gas up to 5% was detected in bubbles coming through a pool of groundwater approximately 20m outside the lined area.
ACTION: The source of this gas should be investigated through the taking of representative samples and trace gas analysis.

The following response has been received from Cory prior to the issue of the full audit findings:

Once we can establish a safe method of sampling we will attempt to take some representative samples for further testing. If the NRW has any suggestions on how this may be done we would welcome any expertise or assistance provided.

This is very welcome as we feel it is vital that the source of this gas is identified as soon as possible. General guidance and techniques for sampling surface water is contained in the EA's LFTGN 02, however we recommend that to take a representative sample you contact a recognised specialist sampling contractor.

12. Labelling of pipe work is very confusing and the new drawings provided by the site manager on the day were also incorrectly labelled.
ACTION: Please provide an up to date as built survey drawing showing the new numbering system alongside the old.

The following response has been received from Cory prior to the issue of the full audit findings:

This has now been done as a matter of urgency after the incorrect plan was provided by mistake. A new location plan with amended well numbering and the explanation of which wells have been decommissioned will be sent through. Subsequently all the GAMS ID's have also been changed to reflect what is being monitored.

ACTION 2: Thank you for the updated information concerning this issue. Please forward the revised drawing at your earliest convenience.

13. Many wells in phase 1 (the restored phase) were turned off or had no apparent flow.
ACTION: The reason for these wells being redundant should be investigated and findings reported to NRW.

The following response has been received from Cory prior to the issue of the full audit findings:

The wells in Phase 1 which are turned off or had no flow, would have been monitored as having no flow or little flow, and balanced to reflect if they were unproductive. An in depth exercise was conducted as part of the last gas field review, prior to the installation of new replacement wells in Cells 1, 2 and 3, and was forwarded to the NRW at the time. Some of the wells in Phase 1 have been decommissioned as part of this exercise, but those in the restored area have been left for now, in order to minimise any disruption caused in this area to the sky larks and other ground nesting birds found here.

ACTION 2: Please can you provide details of any further actions you will take post the nesting bird season. There are issues in this area with gas migration and it would be useful to rationalise such a marked drop in productivity in this area in relatively new waste.

14. Methane levels of between 15 and 100ppm were consistently detected in the air at the base of the site in the area of the toe of the Northern batter and towards the top of the flank between phases 2 and 3. This is indicative of a reduction in effectiveness or other inadequacies in the gas extraction system.

PHOTO 5: Methane Detection in Air Above The Landfill Surface

ACTION: Take steps to improve the landfill gas extraction system efficiency as soon as possible. NRW intends to perform follow up surveys to ensure the levels of landfill gas in the air are significantly reduced. Action should be taken by the Operator to expedite the actions in this report before any future such surveys are undertaken.

15. Has a comprehensive gas well dipping programme taken place? This may help to identify wells suitable for pumping perched leachate.
ACTION: Please submit the results (depth to base, depth to water) along with proposals to install any pumps (where required) as soon as practicable

16. There appeared to be a lack of of well coverage in the newly tipped and covered areas on the Western side of the slope of phase three.
ACTION: Install extraction infrastructure by the 31st October 2014.

PHOTO 6 : Areas Of Landfill With Little Apparent Gas Infrastructure.

17. Air leaks were noted on some of the well couplings.

PHOTO 7: Air Leak in Well Head Coupling

17. There were some wells with no control valve at the well head.
ACTION: Please fit control valves to well head where required within 7 days of the date of this report.

18. Some Tefen valves were sticking and locking allowing air into the system. The unidentified Pin Well next to SCAV01, had its valve blown out of the pipe-work due to the build up of positive pressure. The valve was switched off despite the build up of positive pressure. (See Photo 8 below).
ACTION: Please inspect all tefen valves during the next round of sampling and replace or repair as necessary. Investigate why this well was switched off when there was positive pressure building in the line.

PHOTO 8: Valve Closed and Tefen Valve Blown Due to Positive Pressure

19. The bentonite around some of the wells appeared to be in need of rehydration, re-bentoniting or both. **ACTION: Please check wells for adequate sealing and perform repairs as necessary.**

20. Hydrogen Sulphide stickers should be attached to all wells showing greater than 100ppm H2S.

Methane Emissions Survey Sheet

Site	Hafod Landfill	**Date**	2nd and 3rd July 2014		
Instrument	Gazomat Inspectra TDL (Serial No.: 1470311)	**Test gas reading**	N/A		
Next Calibration due	2014	**Background reading**	1.8ppm		
Weather conditions:	Dry, warm and sunny (rained prior to visit)			**Atm. Press.**	1009 & 1005
Survey Undertaken by:	T Roberts, N Herbert, T Ward				

General comments / observations

This technical review is being carried out as a key part of Natural Resources Wales Strategy to reduce methane emissions from active landfill sites in England and Wales. The objectives of the site review include ensuring that the site is being operated and maintained so as to maximise gas collection efficiency and minimise fugitive landfill gas emissions. Treating the gas in a manner that minimises point source emissions.

An ATEX certified, Gazomat Inspectra Laser Methane Analyser was used to perform emissions testing at the site. Surface capping, seams and structures on the site were tested in order to establish potential sources of methane egress. Grid references were taken (using a Garmin satellite positioning system) at each point where raised levels of methane were detected.

Day 1:- 2nd July 2014

Point ref.	Methane Reading	Feature and / or Grid Reference	Description / Comment
1.	896	SJ3103345435	Cell 3 Northern Flank Eastern section (uncapped). Slope in the process of being regraded (to be completed in the next two days) in preparation for final geomembrane deployment. This layer will form the drainage layer (regulating layer under temporary cap) See Photo 1.1
2.	219	SJ 3102145435	As above but approx 20m west.
3.	9.7%	SJ 3102245442	Cell 3 Northern Flank Eastern section (uncapped). One of the drainage pipes in cover layer
4.	100	SJ 3101045442	Cell 3 Northern Flank Eastern section (uncapped). Crack in soil/cover
5.	100	SJ3099845446	Cell 3 Northern Flank Eastern section (uncapped). Edge of geomembrane capped flank.
6.	349	SJ30991 45450	Gas well protruding through geomembrane and only sealed with gaffer tape. Cell 3 Northern Flank Eastern section (capped). See Photo 1.2
7.	17	SJ3098445453	Gas well protruding through geomembrane and only sealed with gaffer tape. Cell 3 Northern Flank Eastern section (capped).
8.	0.3%	SJ3097545458	Well 707 or 20. Highly malodorous

Point ref.	Methane Reading	Feature and / or Grid Reference	Description / Comment
9.	1.1%	SJ 30957 45452	Fold/crease in geomembrane. This needs to be patched when the next geomembrane deployment occurs. Staff should check rest of existing temp cap for similar folds and have them patched. Photo 1.3
10.	**72**	**SJ30945444**	**Ambient Air (2m off ground) downwind of tipping face. Strong odour**
11.	920	SJ 3095345437	KOP
12.	7.8%	SJ 3094645428	Plastic seal around Leachate Well MP2 (to the east of well) see photo 1.4
13.	10.2%	SJ 3092945430	Plastic seal around Leachate Well MP2 (to the west of well)
14.	0.2%	MP2	Boot detail around the well.
15.	219	SJ3091645436	Anchor Trench
16.	345	Sj3090945439	Anchor Trench
17.	0.9%	SJ3090145440	Anchor Trench
18.	92		Cell 3 North Flank, Western section. Uncapped. Significant leachate weeping/breakouts in this area.
19.	5.7%		Cell 3 North Flank, Western section. Uncapped. Significant leachate weeping/breakouts in this area, gas bubbling at this point.
20.	523	SJ3087545461	North Flank Cell 3, Western Corner
21.	258	Sj3087145475	North Flank Cell 3, Western Corner leachate outbreak, slump
22.	0.5%	SJ30861454780	???????
23.	60.9%	Pin Well on 2nd Bench	Next to SCAV01
24.	0.9%	SJ3090945486	Fold/crease in geomembrane. This needs to be patched when the next geomembrane deployment occurs. Staff should check rest of existing temp cap for similar folds and have them patched.
25.	0.2%	KOP	Kop around well
26.	347	LMP3	LMP 3 around well

Point ref.	Methane Reading	Feature and / or Grid Reference	Description / Comment
27.	5%	SJ309804516	Surface Water sump, OUTSIDE LINER SYSTEM. Gas bubbling. Possible Landfill or Coal Gas. Sample required to investigate further. See Photo 1.5.

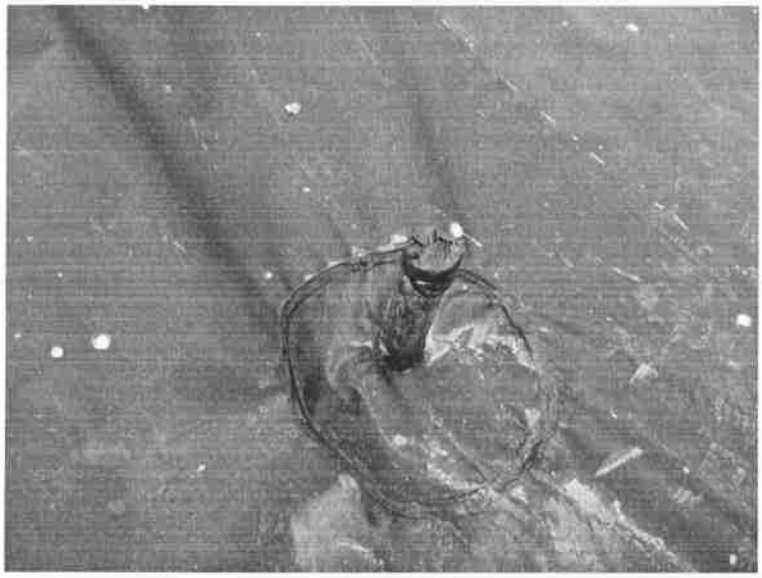
Day 2:- 3rd July 2014

Point ref.	Methane Reading	Feature and / or Grid Reference	Description / Comment
1.	0.2 - 3.7%	SJ309804516	Surface Water sump, OUTSIDE LINER SYSTEM. Gas bubbling. Possible Landfill or Coal Gas. See Photo 1.5.
2.	45%	SJ3099145480	Leachate sump. Gas bubbling from leachate pool. See Photo 1.5.
3.	0.3% 0.6%	SJ3090045520	Another surface water feature outside landfill with gassing pool of water. Approx. 10m from waste and 5 m from containment bund.
4.	1221	SJ3089145522	Outer edge of the containment bund i.e. near the geosynthetic (groundwater drainage) layer.

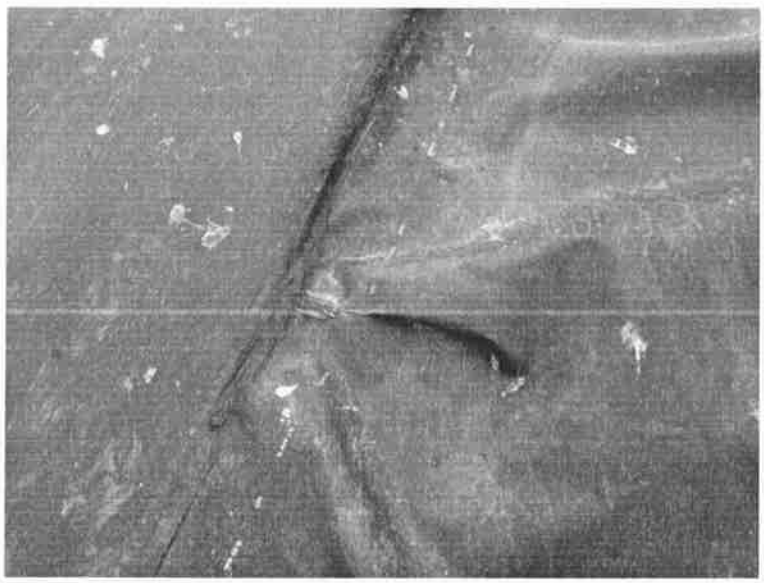
Comments

- High emissions from areas of the flank which has not been capped, even with reworked regulation layer (intermediate cover).
- High emissions noted from some defects in the placed geomembrane. All folds/ creases ("fishmouth") should be patched during the next phase of temporary capping.
- Gas wells to be reconnected or properly sealed off. Do not use gaffer tape.
- High emission still on areas of the flank and proposals for additional wells discussed (see later discussion of main report).
- Gas pressure high along toe of cell 3 North (e.g. leachate sump) indicating that gas collection not wholly effective.
- Methane rich gas detected outside containment bund. Source of gas needs to be established (e.g. coal or landfill)
- Whilst a previous NRW visit identified evidence of stability issues at the facility (which the operator has attempted to address by regrading, capping and other measures) we did note potential signs of a new rotational slip under one of the areas where the temporary cap has been placed. The entire cell 3 flank should be subject to careful monitoring (and where necessary subject to mitigation works to prevent slippage). Moving forward the operator should review the appropriate gradients for temporary waste slopes especially when progressing into the new operational area (i.e. cell 4+).

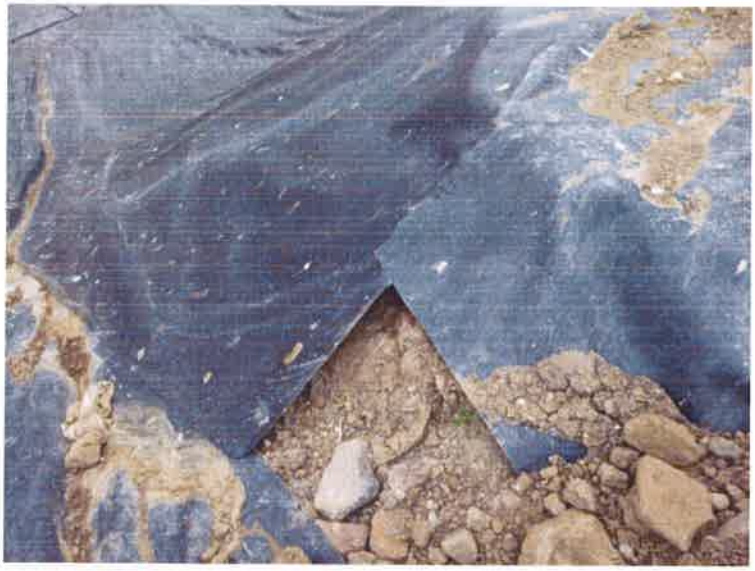
Photograph 1.1:- North Flank Cell 3, Eastern section. Showing area of flank in process of being regraded



Photograph 1.2. Showing well sealed with gaffer tape.



Photograph 1.3:- leak in geomembrane folds.



Photograph 1.4:- geomembrane around Leachate well MP2.

Photograph 1.5 showing (from left to right) the leachate sump, the containment bund and surface water sump. Methane rich gas bubbling in both the leachate sump and surface water sump.

2nd & 3rd July 2014 Hafod Landfill Gas Visit Gas Field Results/ Observations

Gas Compound

Barometric Pressure Day 1: 1009mb & Day 2: 1005mb

Monitor ID	Date	CH_4 %	CO_2 %	O_2 %	Balance	Diff mBar	CO ppm	H_2S ppm	Findings
Gas Compound Day 1	**2nd July**	**45.3**	**35.2**	**1.3**	**18**	**-69**	**134**	**99**	• Flow: **600m³/hr** (948Kw) • Crankcase emission not being recirculated back into the engine for further combustion. Emitting directly to air and oil onto ground. • The gas tested at this point has been pre-treated (to remove siloxanes) which may affect the results for CO & H_2S. We therefore took a sample from the main line prior to entry into the GUP, for comparative purposes. See results below.
Gas Main – prior to pre-treatment GUP	2nd July	45.8	35.3	1.3	17.5	-67.9	123	115	
Gas Compound Day 2	**3rd July**	**44.9**	**35.7**	**1.3**	**18.2**	**-64.8**	**73**	**79**	• Flow: **570-580m³** /hr * • *The engine has been de-rated to accommodate the wells that were switched off following yesterday's visit. • There are also scheduled flare maintenance works underway today (burner caps being replaced due to corrosion). • Staining from the crankcase emission noted yesterday has been cleared and the site manager informed us that CORY will be reconfiguring the engine to redirect the crankcase emission back into the engine. This will reduce a potentially significant emission.

2nd & 3rd July 2014 Hafod Landfill Gas Visit Gas Field Results/ Observations

DAY 1:- 2nd July 2014 Hafod Field Results

	Monitor ID	CH_4 %	CO_2 %	O_2 %	Balance	Diff mBar	CO ppm	H_2S ppm	Findings
Very Odourous in this area	707 (GW20)	58.2	45.6	1	0	-24	68	358	50% NAF. **Needs high H2S warning sticker.** Leak on well coupling 0.3% vol CH4 - **investigate and repair.**
	706	57	47	0.6	0	-66.4	77	274	Flow, no control or monitoring valve at wellhead.
	MP1	60.5	40	0.6	0	-12.3	52	210	Flow
	MP1A	0.6	0.4	20.4	78.9	-65.8	7	3	Flow, cracked open **but turned off immediately due to direct air leak.** Site manager informed and leak identified – **please make permanent repair asap**
	HF0020	62.5	41.2	0.3	0	-66.8	55	534	NAF, **needs high H2S warning sticker**
	HF02 (43?)	63	40	0.2	0	-66.8	46	367	On NAF, **Needs high H2S warning sticker**
	H02	68.3	42.7	0.2	0	-66.3	569	260	On, NAF. **Bag Sample immediately. Pipe very hot**
	HF06								On, Flow. (note pipe cool - only 2m from H02)
	HF07	62.8	41.3	2.1	18.8	-66.2	33	147	On, Flow
	HF018								On Flow
	Unidentified Pin Well next to SCAV01								On (cracked) **Tefen valve had been knocked off.** This was reinstalled (Site manager informed) and well closed.
	SCAV01	59.5	42.3	0.3	0	-57	39	162	On, Flow
	PIN 7	31.4	29.4	2.4	37.1	-63.8	17	9	Open, NAF
	PIN 4					-68			On, Flow
	PIN .					-68			Open NAF, No ID, **needs to be numbered.**
	PIN 6					-71.5?			Slight Flow > than mains pressure ?
	PIN7					-71.5 ?			Cracked – Flow

2nd & 3rd July 2014 Hafod Landfill Gas Visit Gas Field Results/ Observations

	Monitor ID	CH_4 %	CO_2 %	O_2 %	Balance	Diff mBar	CO ppm	H_2S ppm	Findings
	PIN8					-72			Cracked – NAF
	705								Cracked NAF- Condensate blockage
	PIN 9								Small Flow 50% open
	PIN 53								Well off. **Gas heard bubbling under liner indicating high positive pressures in surrounding area**
	LMP003								Off
	GW707								Off
	Leachate collection sump (North East Flank) **Gas bubbling through the black leachate and from waste mass near discharge pipe (up to 43%CH4 methane)**								
	Groundwater pond outside liner system. Gas bubbling through water. See comments in Gazomat report for more detail.								
	END OF DAY 1 NOTES								

3rd July 2014 Hafod Field Results

Monitor ID	CH_4 %	CO_2 %	O_2 %	Balance	Diff mBar	CO ppm	H_2S ppm	Findings
602								Open/ flow
34								Open/ flow
703								Closed
Pin Set 3 ?								Open/ flow
35								Open/ flow
Pin Set 10								Open/ flow
009?								Closed
017								Open/ flow

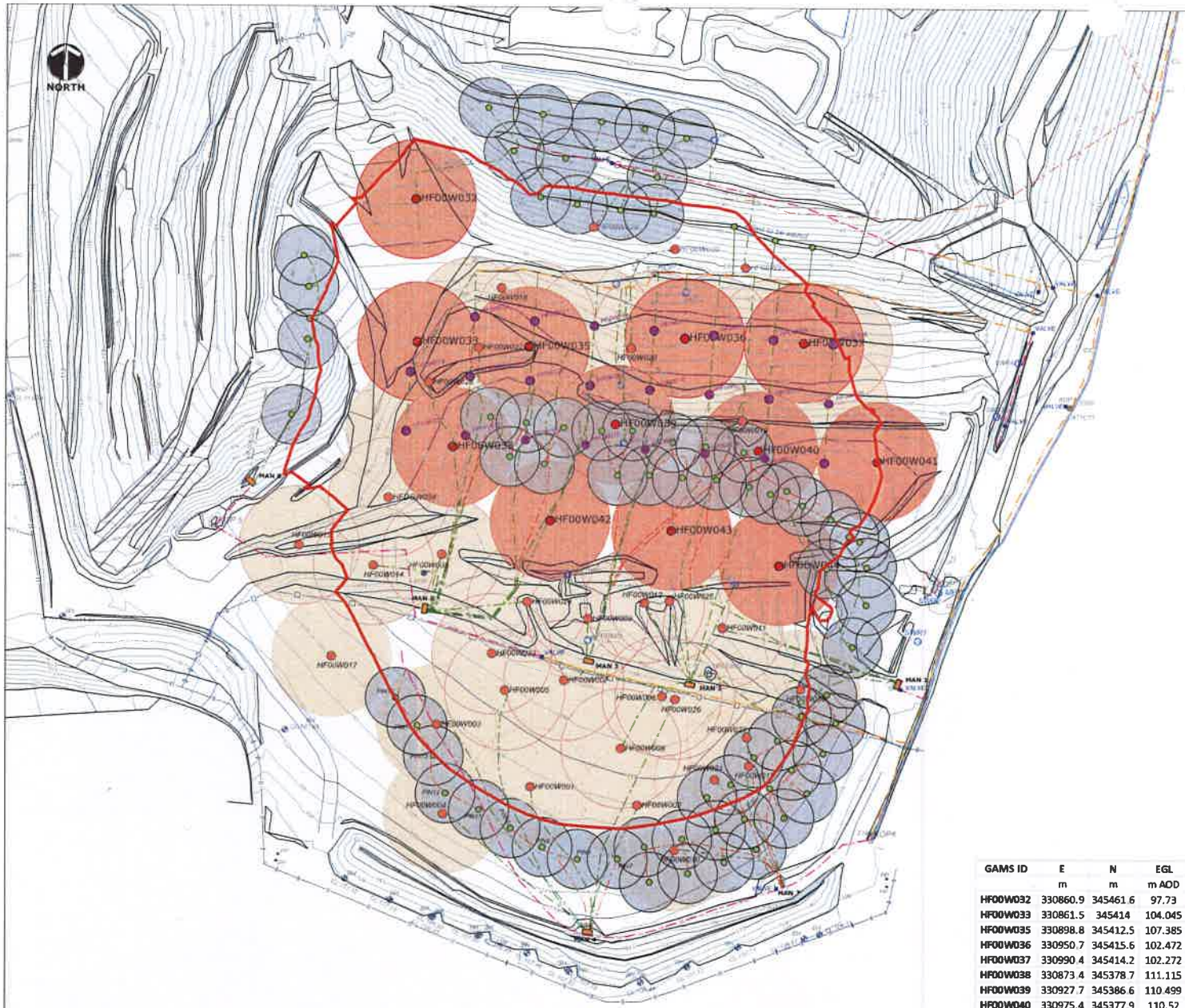
2nd & 3rd July 2014 Hafod Landfill Gas Visit Gas Field Results/ Observations

Monitor ID	CH_4 %	CO_2 %	O_2 %	Balance	Diff mBar	CO ppm	H_2S ppm	Findings
602	48.1	37.6	0.5	12.9	-24.4	26	69	
009					-7			Open/ flow. Condensate audible **needs dewatering.**
T04								Open/ NAF
PIN 7								Open/ flow. Air leak on TEFEN valve **please replace**
GW 32	71.7	42.3	0.4	0	-36.8	1490	111	Open. Warm condensate audible needs dewatering. **This needs to be shut off until CO readings normalise. H_2 low. Please arrange for a bag sample to be taken asap.**
12	41.1	32.6	2.1	24.3	-6.8	130	10	On/ Flow, New Well
Pin 6								On flow intermittent, H_2 low
006	14.1	23.5	0.8	61.7	-27.3	86	11	On/FLOW (**Rehydrate Well Seal)**
15								Off
16								Open, Flow. Water in connecting pipework
008								Open, Flow. New well
19	43.3	37.9	1	19	-62.3	100	59	Open, Flow. **Warm check with bag sample**
001								Open, NAF
FLT02								Open, NAF
28								Open, NAF
18								NAF
007								Open, FLOW, New Well ?
31?	50.5	40.9	1	7.3	-58	252	39	Very warm. Open NAF, **Water present, please investigate. Bag Sample**
005								Off
605								Open, NAF, Water blockage, **investigate**
006								On
607								Open/ NAF

2nd & 3rd July 2014 Hafod Landfill Gas Visit Gas Field Results/ Observations

Monitor ID	CH_4 %	CO_2 %	O_2 %	Balance	Diff mBar	CO ppm	H_2S ppm	Findings
606								Open/ NAF
608								Off
15								Open, NAF
27								Off
604								Open/ NAF
605								Open/ NAF
003								Water pulsing
END OF DAY 2 NOTES								

- As-build Drawing supplied (Dated Jun 2014) but was inaccurate and we have asked for updated drawing to be provided showing all infrastructure.



GAMS ID	E	N	EGL	Liner	Offset	Drill Depth	IC Comments
	m	m	m AOD	m AOD	m	m	m
HF00W032	330860.9	345461.6	97.73	76.755	3	18	18
HF00W033	330861.5	345414	104.045	76.154	3	24.9	24 (Install pump)
HF00W035	330898.8	345412.5	107.385	73.702	3	30.7	30
HF00W036	330950.7	345415.6	102.472	73.543	3	25.9	26
HF00W037	330990.4	345414.2	102.272	83.778	3	15.5	15
HF00W038	330873.4	345378.7	111.115	78.746	3	29.4	30
HF00W039	330927.7	345386.6	110.499	72.758	3	34.7	33 Subject to drilling (install pump)
HF00W040	330975.4	345377.9	110.52	83.639	3	23.9	24
HF00W041	331015.3	345374.4	111.057	95.976	3	12.1	12
HF00W042	330905.9	345354.3	113.41	75.672	3	34.7	33 subject to drilling
HF00W043	330946.4	345351	113.011	78.034	3	32	30 (Install pump)
HF00W044	330982.4	345339.3	112.213	90.403	3	18.8	18
EGL based on June 2014 survey							180mm x 91m 160mm x 265m

All locations are to be surveyed in immediately prior to drilling and drill depths recalculated based on survey information

Key

- Proposed New Well
- Limit of 15m depth of waste

CORY environmental
Units 3-6 Greyfriars Business Park,
Frank Foley Way, Stafford, ST16 2ST
Tel: 01785 251555

HAFOD

Proposed New Gas Wells

Drawn	Date	Scale @ A1
TJG	6-8-14	1:1000

HAF103