

Eve O'Sullivan

Subject: FAO Ewa Babiarczyk - Mulroy Environmental Ltd. - H0176-01 Galway C.C. - Tullyvogheen closed landfill - Request for Further Information 29th January, 2021
Attachments: Further Information Report Tullyvogheen LF Groundwater Leachate & LF Gas Monitoring.16.09.2021.pdf

From: Padraic Mulroy <ptmulroy@mulroyenvironmental.ie>
Sent: Thursday 16 September 2021 06:03
To: Licensing Staff <licensing@epa.ie>
Cc: 'Colin Ryder' <cryder@galwaycoco.ie>; ameegan@mulroyenvironmental.ie
Subject: FAO Ewa Babiarczyk - Mulroy Environmental Ltd. - H0176-01 Galway C.C. - Tullyvogheen closed landfill - Request for Further Information 29th January, 2021

Re: Application for Historic Landfill Certificate of Authorisation by Galway County Council in respect of Tullyvogheen, Clifden, Co Galway – Request for Further Information on 29th January, 2021

Dear Mrs. Babiarczyk,

A request for further information with regard to the application was received by Galway County Council from the EPA on the 29th January, 2021. A further information response was submitted to the EPA on the 26th February, 2021. As requested, groundwater and leachate monitoring and landfill gas monitoring were carried out at Tullyvogheen Landfill in early July, 2021.

A letter was received by Galway C.C. on 15th July 2021 from the EPA with regard to the afore-mentioned groundwater and leachate monitoring and landfill gas monitoring results.

Paragraph 4 of the request for information received on the 15th July, 2021 states the following:

'REGULATION 7(2) COMPLIANCE REQUIREMENTS

1. Please submit the leachate monitoring, groundwater monitoring and landfill gas monitoring results, as required in, respectively, Points 4 and 5 of the Agency's Notice issued on 29th January 2021.'

Please find attached a Further Information report which deals with the afore-mentioned request.

Please call if you have any questions.

Yours sincerely,

Padraic Mulroy
BSc., MSc. MIEI, MIPSS, CSc.,
BREEAM AP, CEEQUAL Assessor, LEED Green Associate
Managing Director
Mulroy Environmental



Mulroy Environmental,

30 Lisroland View,
Knockbridge,
Dundalk,
County Louth



Mobile: 086-8770380
Tel.: 042-9384750
Fax.: 042-9384750
E-mail: ptmulroy@mulroyenvironmental.ie
Web: www.mulroyenvironmental.ie

Disclaimer

"This e-mail is confidential and intended solely for the use of the individual to whom it is addressed. If you are not the intended recipient, be advised that you have received this email in error and that any use, dissemination, forwarding, printing, or copying of this email is strictly prohibited. If you have received this email in error please contact the sender and destroy this email. Any views or opinions presented are solely those of the author and do not necessarily represent those of Mulroy Environmental Ltd. Although this email and any attachments are believed to be free of any virus or other defects, which might affect any computer or IT system into which they are received, no responsibility is accepted by Mulroy Environmental Ltd. for any loss or damage arising in any way from the receipt or use thereof"

'Le do thoil cuimhnigh ar an imshaol roimh priontail an ríomhphost seo...Please consider the environment before printing this email!'

*For inspection purposes only.
Consent of copyright owner required for any other use.*



MULROY
environmental

**GALWAY COUNTY COUNCIL
TULLYVOGHEEN HISTORIC LANDFILL,
CLIFDEN, COUNTY GALWAY**

**CERTIFICATE OF AUTHORISATION APPLICATION -
FURTHER INFORMATION REPORT
- GROUNDWATER, LEACHATE &
LANDFILL GAS MONITORING, JULY 2021**

14th September 2021

DOCUMENT ISSUE STATUS

REPORT ISSUE	REFERENCE NO.	DATE		
FINAL	385-01	16/09/21		
TITLE	NAME	POSITION	SIGNATURE	DATE
AUTHOR	Andrena Meegan	Project Manager	<i>A. Meegan</i>	13/09/21
MANAGING DIRECTOR	Padraic Mulroy	Project Director	<i>Padraic Mulroy</i>	16/09/21

1 INTRODUCTION

An application for a Certificate of Authorisation for Tullyvogheen Historic Landfill was submitted on the 10th July, 2020. A request for further information with regard to the application was received by Galway County Council from the EPA on the 29th January, 2021. A further information response was submitted to the EPA on the 26th February, 2021. As requested, groundwater and leachate monitoring and landfill gas monitoring were carried out at Tullyvogheen Landfill in early July, 2021.

A letter was received by Galway C.C. on 15th July 2021 from the EPA with regard to the afore-mentioned groundwater and leachate monitoring and landfill gas monitoring results.

Please find below the requested information and note that for ease of reference we have highlighted the EPA's text from the paragraph 4 of the aforementioned letter in blue italics.

Paragraph 4 of the request for information received on the 15th July, 2021 states the following:

REGULATION 7(2) COMPLIANCE REQUIREMENTS

1. Please submit the leachate monitoring, groundwater monitoring and landfill gas monitoring results, as required in, respectively, Points 4 and 5 of the Agency's Notice issued on 29th January 2021.

On the 5th July, 2021, three groundwater samples and a leachate sample were collected from within the site at locations BH1, BH2, BH3 and LC1 and submitted for laboratory analysis. The results of the 2021 sampling are compared with those results of the groundwater monitoring carried out in January 2014. It should be noted that the leachate well LC2 could not be accessed at the time of sampling in July, 2021 and as such, a sample could not be taken.

2 GROUNDWATER & LEACHATE MONITORING

2.1 Laboratory Suite

The laboratory suite for July 2021 was as follows:

Physico-chemical Parameters (Field)

- pH;
- Electrical Conductivity; and
- Dissolved oxygen (DO).

Inorganic Analysis

- Heavy Metals - Arsenic (As), Boron (B), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Nickel (Ni), Manganese (Mn), Mercury (Hg) and Zinc (Zn);

- Total Dissolved Solids; and
- Ammoniacal Nitrogen (as N).

Major Cations and Anions

- Potassium (K);
- Sodium (N);
- Calcium (Ca); and
- Magnesium (Mg).

Oxygen Demand/Organic Carbon

- Chemical Oxygen Demand; and
- Biological Oxygen Demand.

Microbiological Testing

Total Viable Count @22oC

Total Viable Count @37oC

Total coliforms (i.e. Confirmed)

Faecal coliforms (i.e. Confirmed)

Enterococci

Clostridium perfringens

Trace Organic Analysis

- Volatile Organic Compound;
- Semi-volatile Organic Compound;

The following table, Table 1 represent the results of the 2014 and 2021 inorganic, BOD and microbiological analyses on the 3 groundwater samples and leachate samples. The results of the Volatile Organic Compound (VOC) and Semi-volatile Organic Compound (sVOC) analyses are located in tables Tables A1.1 and A1.2 in Appendix 1. These results are compared against the following Generic Assessment Criteria, statutory limits, Interim Guideline Values and Threshold Values. A detailed description of each of the following Generic Assessment Criteria is given in Section 3:

- Parametric and Indicator Values of S.I. No. 122 of 2014 European Union (Drinking Water) Regulations 2014;
- The parametric values of Statutory Instrument No. 106 (Drinking Water Regulations) of 2007;
- The Interim Guideline Values from *Towards Setting Guideline Values For The Protection Of Groundwater In Ireland – Interim Report*;
- The Threshold Values from EC Environmental Objectives (Groundwater Regulations) Statutory Instrument No. 9, 2010; and
- *National Institute of Public Health and the Environment of the Netherlands - The Soil Protection Guidelines (Dutch Criteria)* – Intervention and Target Values.

The raw validated laboratory results from Eurofins Chemtest and CLS are located in Appendix 2.

2.2 Groundwater & Leachate Monitoring Results

2.2.1 Physicochemical Analysis

pH values vary across the site with the lowest being 6.9 in LC2 and BH1 and the highest, 7.4 in BH3. The pH of the groundwater neutral and is within normal ranges for groundwater and leachate samples. The pH values in the boreholes appear to have decreased slightly since 2014.

Electrical conductivity values were highest in the downgradient borehole BH2 at 2,000 μ S/cm which also exceeded the EC Statutory Instrument No. 9, 2010 Threshold Value of 800 μ S/cm. The electrical conductivity varied little in the other 2 groundwater wells and the leachate well varying from 640 μ S/cm to 740 μ S/cm.

The electrical conductivity value in the leachate well LC01 decreased from 1,300 μ S/cm to 740 μ S/cm.

Dissolved oxygen concentrations ranged from 7.9mg/l to 8.1mg/l. The dissolved oxygen concentration value in the leachate well LC01 increased from 5.5mg/l in 2014 to 8.0mg/l in 2021.

2.2.2 Total Dissolved Solids

The results obtained for Total Dissolved Solids was highest in the downgradient groundwater sample taken from BH2 at 1,300mg/l which exceed the corresponding EPA Interim Guideline Value. The Total Dissolved Solids varied little in the other 2 groundwater wells and the leachate well varying from 420mg/l to 480mg/l.

2.2.3 Ammoniacal Nitrogen

The results obtained within the groundwater samples for Ammoniacal Nitrogen ranged significantly from 0.074mg/l in BH3 (i.e. downgradient borehole) to 18.4mg/l in BH1 (i.e. the upgradient borehole) and to 20.1mg/l in the leachate well LC01. All of the values exceed the Threshold Value of 0.065mg/l from the EC Environmental Objectives (Groundwater Regulations) Statutory Instrument No. 9, 2010.

The result obtained within the leachate sample taken from LC01 for Ammoniacal Nitrogen decreased significantly from 93mg/l in 2014 to 20.1mg/l in LC01 in 2021. These levels would be expected and are typical of leachate from domestic waste.

Generally it would be expected that ammonia levels in BH1 would be lower than those values obtained in the downgradient boreholes, BH2 and BH3. It should be noted that the ammonia levels in 2014 and in 2021 were higher in the upgradient BH1 than in the downgradient boreholes BH2 and BH3. It is possible that the levels of ammonia detected in BH1 are attributable to agricultural practices or forestry practices hydraulically upgradient of the site.

2.2.4 Major Cations

The results obtained within the groundwater samples for potassium ranged from 10mg/l in BH1 (i.e. the upgradient borehole) to 2.3mg/l in BH103 (i.e. the downgradient borehole). The value obtained for the sample from BH1

exceeded the EPA Interim Guideline Value (IGV). The potassium/sodium ratios ranged from 0.01 to 0.12. A ratio greater than 0.4 generally would indicate an impact by domestic leachate.

The result obtained within the leachate sample for potassium for LC01 was 6mg/l which marginally exceeded the EPA Interim Guideline Value (IGV) of 5mg/l. This level was also reflected in the Potassium/Sodium ratio of 0.32. A ratio greater than 0.4 generally would indicate an impact by domestic leachate. It should be noted that the Potassium/Sodium ratio was 0.51 in LC01 in 2014. This would indicate that the groundwater is undergoing intrinsic remediation.

The results obtained for sodium, calcium and magnesium were all less than their respective Parametric Indicator Value of S.I. No. 122 of 2014 European Union (Drinking Water) Regulations 2014 and respective EPA Interim Guideline Values.

2.2.5 Biological Oxygen Demand/Chemical Oxygen Demand

Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were carried out on the groundwater and leachate samples.

Biological Oxygen Demand (BOD)

The results obtained within the groundwater samples for BOD ranged from <1mg/l in BH3 (i.e. the downgradient borehole) to 8mg/l in BH1 (i.e. upgradient borehole). The values for BH1 and BH2 exceeded their respective Parametric Indicator Value of S.I. No. 122 European Union (Drinking Water) Regulations 2014 of 2.2mg/l.

The result obtained within the leachate sample for BOD for LC01 was 102mg/l which significantly exceeded Parametric Indicator Value of S.I. No. 122 European Union (Drinking Water) Regulations 2014 of 2.2mg/l.

Chemical Oxygen Demand (COD)

The results obtained within the groundwater samples for COD ranged from 22mg/l in BH3 (i.e. the downgradient borehole) to 239mg/l in BH2 (i.e. also downgradient borehole). All 3 values significantly exceeded the EPA Interim Guideline Value (IGV) of 5mg/l.

The result obtained within the leachate sample for COD for LC01 was 3,580mg/l which significantly exceeded the EPA Interim Guideline Value (IGV) of 5mg/l.

The COD increased in all 3 boreholes and in the leachate well from those levels observed in 2014.

2.2.6 Heavy Metals

Of the 12 heavy metals analysed, the reported concentrations for all parameters are within their corresponding Dutch Criteria Intervention and Target Levels, Parametric and Indicator Values of S.I. No. 122 of European Union (Drinking Water) Regulations 2014, their corresponding EPA Interim Guideline Values (IGVs) and their corresponding Threshold Values quoted in the E.C. Environmental Objectives (Groundwater Regulations) 2010 and 2016 with the exception of:

Table 1. Results of inorganic laboratory analysis on groundwater samples taken from boreholes BH1, BH2 and BH3 and Leachate Wells LC01 and LC02 at Tullyvoughen Landfill on the 29th January 2014 and on 5th July 2021

Parameter	Units	S.I. No. 122 of 2014 European Union (Drinking Water) Regulations 2014 Parametric & Indicator Values	EPA Guideline Values - From Interim Report on 'Towards Setting Guideline Values for the Protection of Groundwater in Ireland'. Interim Guideline Values	EC Environmental Objectives (Groundwater Regulations) Statutory Instrument No. 9, 2010. Threshold Values	EC Environmental Objectives (Groundwater Regulations) Statutory Instrument No. 366, 2016. Threshold Values	Analytical Results								
						ON-SITE BOREHOLES								
						BH1 (January 2014)	BH1 (July 2021)	BH2 (January 2014)	BH2 (July 2021)	BH3 (January 2014)	BH3 (July 2021)	LC01 (January 2014)	LC01 (July 2021)	LC02 (January 2014)
Physico-Chemical Parameters														
pH		-	6.5<pH<9.6	-	-	7.6	6.9	8.10	7.0	7.7	7.4	7.3	6.9	7.2
Electrical cond. (EC)	µS/cm	2500	1000	800-1875	800-1875	1100	740	550	2000	490	640	1300	740	1500
Dissolved oxygen (DO)	mg/l	-	-	-	-	7.5	7.9	7.5	8.0	8.0	8.1	5.5	8.0	5.1
Standard Chemistry														
Ammonia as NH3-N	mg/l	-	0.15	-	-	8.6	14.3	0.86	1.54	0.40	0.058	72	15.6	47
Ammonium as NH4	mg/l	0.3	-	0.065-0.175	-	11	18.4	1.1	2.0	0.51	0.074	93	20.1	60
Total dissolved solids	mg/l	-	1000	-	-	630	480	330	1300	300	420	770	480	890
Total suspended solids	mg/l	-	-	-	-	-	610	-	1700	-	200	-	2500	-
Major Cations														
Potassium K	mg/l	-	5	-	-	9.4	10	12	3.1	3	2.3	19	6	20
Sodium Na	mg/l	200	150	150	-	47	85	26	320	25	30	37	19	53
K/Na Ratio						0.20	0.12	0.46	0.01	0.12	0.08	0.51	0.32	0.38
Calcium Ca	mg/l	-	200	-	-	170	100	81	110	62	54	57	100	140
Magnesium Mg	mg/l	-	50	-	-	17	20	8.1	8	16	17	16	11	20
Heavy Metals														
Arsenic (As)	µg/l	10	10	7.5	7.5	3	0.75	6.00	1.9	28	0.36	3.00	<0.20	1.50
Boron (B)	µg/l	1000	1000	750	-	520	220	500	72	600	35	810	130	810
Cadmium (Cd)	µg/l	5	5	3.75	-	<0.08	<0.11	<0.08	<0.11	0.35	0.58	<0.08	<0.11	<0.08
Chromium (Cr)	µg/l	50	30	37.5	-	<1.0	<0.50	<1.0	<0.50	<1.0	<0.50	<1.0	<0.50	2.0
Copper (Cu)	µg/l	2000	30	1500	-	1.1	<0.50	<1.0	<0.50	<1.0	3.1	<1.0	<0.50	<1.0
Iron (Fe)	µg/l	200	200	-	-	<20	490	30	980	<20	5.1	260	19	2900
Lead (Pb)	µg/l	10	10	18.75	7.5	<1.0	<0.50	<1.0	<0.50	1.3	<0.50	1.7	<0.50	<1.0
Nickel (Ni)	µg/l	20	20	15	-	4.2	3.9	4.4	7.1	<1.0	0.58	8.2	<0.50	16
Manganese (Mn)	µg/l	50	50	-	-	1800	810	1100	920	970	1100	880	600	1300
Mercury (Hg)	µg/l	1	1	0.75	0.75	-	0.06	-	0.06	-	0.06	-	0.07	-
Zinc (Zn)	µg/l	-	100	-	75	-	7.3	-	<2.5	-	<2.5	-	<2.5	-
Oxygen Demand/Organic Carbon														
BOD	mg/l	2.20	-	-	-	-	8	-	3	-	<1	-	102	-
COD	mg/l	-	20	-	-	27	60	12	239	10	22	100	3,580	100
Microbiological														
Total Viable Count @22°C	CFU/100ml	-	-	-	-	-	730	-	1,100	-	1,300	-	7,000	-
Total Viable Count @37°C	CFU/100ml	-	-	-	-	-	310	-	3,300	-	72	-	15,000	-
Total coliforms (i.e. Confirmed)	CFU/100ml	0	-	-	-	-	0	-	<10000	-	0	-	<10000	-
Faecal coliforms(i.e. Confirmed)	CFU/100ml	0	-	-	-	-	0	-	<10000	-	0	-	<10000	-
Enterococci	CFU/100ml	0	-	-	-	-	0	-	<10000	-	0	-	<10000	-
<i>Clostridium pefringens</i>	CFU/100ml	0	-	-	-	-	100	-	55,000	-	<100	-	<10000	-

Note:

450
450

Red & bold font with yellow highlight indicates where EC Environmental Objectives (Groundwater Regulations) Statutory Instruments No. 9 2010 and/or No. 366, 2016 have been exceeded.

Red & bold Font indicates where EPA Interim Guideline Values or SI 122, 2014 Indicator or Parametric Values are exceeded

< = Less than

'-' = No EPA Interim Guideline Values, SI 9, 2010 Threshold Values or SI 122, 2014 Indicator or Parametric Values are available

'~' = No analysis conducted on sample

- *Iron*

Values of 490µg/l and 980µg/l were obtained in BH1 and BH2 respectively. These values exceed the corresponding Indicator Value of S.I. No. 122 of European Union (Drinking Water) Regulations 2014. These values would be expected as iron, which is sensitive to oxygen levels, is typically reduced to its more mobile Fe²⁺ species and released or leached from soil and bedrock into groundwater during anaerobic (i.e. reducing) conditions.

- *Manganese*

Values of 810µg/l, 920µg/l and 1,100µg/l were obtained in BH1, BH2 and BH3 respectively. A value of 600µg/l was obtained in LC01. These values exceed the corresponding Indicator Value of S.I. No. 122 of European Union (Drinking Water) Regulations 2014 which is 50µg/l. Like iron, these values would be expected as manganese is typically reduced to its more mobile Mn²⁺ species and released or leached from soil and bedrock into groundwater during anaerobic (i.e. reducing) conditions which occur in domestic waste landfills.

2.2.7 Microbiological Testing

Total and Faecal (i.e. Thermotolerant *E. coli*) coliforms and *Enterococci* bacterial species were found in the samples taken from the downgradient well BH2 and the leachate well, LC01 while none were found in the upgradient well, BH1 or the downgradient well BH3. *Clostridium perfringens* bacterial species were found in all 3 monitoring wells and the leachate well. The levels found ranged from <100 in BH3 to 55,000CFUs in BH2. The levels of bacteria found in the on-site groundwater well and leachate well are most likely as a result of agricultural practices (i.e. run-off of animal faeces) on upland areas surrounding the site. It should be noted that there are no residences with septic tanks upgradient or within the vicinity of the site. As such, it is very unlikely that the source of the coliforms found is from a human source or from the historical waste deposited on site.

2.2.8 Volatile Organic Compounds/Benzene, Toluene, Ethylbenzene, Xylenes (BTEX) & MTBE

The results of the Volatile Organic Compounds analysis for groundwater and leachate samples are located on Table A1.2. The BTEX and MTBE results are among those VOC results recorded in Table A1.1. As can be seen from Table A1.1, all of the VOCs analysed were below their respective Method Detection Limits. It should be noted that Benzene, Toluene, Chlorobenzene, Ethylbenzene, p/m-Xylenes, o-Xylene and 1,2,4-Trimethylbenzene were detected at various trace levels in the groundwater and leachate wells in January 2014.

2.2.9 Semi-Volatile Organic Compounds (sVOC)/ Polyaromatic Hydrocarbons (PAHs)

The results of the Semi-Volatile Organic Compounds and Polyaromatic Hydrocarbon analysis for groundwater and leachate samples are located on Table A1.2 located in Appendix 1. As can be seen from Table A1.2, all of the sVOCs analysed were below their respective Method Detection Limits.

3 LANDFILL GAS MONITORING

Landfill gas monitoring was carried out on 2 occasions, on the 30th June, 2021 and on the 3rd July, 2021. Landfill gas concentrations were measured using a GA5000 Landfill Gas analyser. The GA5000 instrument was borrowed by Mulroy Environmental Ltd. from Galway County Council who submitted the meter for external calibration during the month of June.

The results of the 2 landfill gas monitoring rounds are summarised in the following tables, Table 2 and Table 3.

As can be seen from both tables, the levels of oxygen (O₂), carbon dioxide (CO₂), methane (CH₄) and nitrogen (N₂) were measured in the initial 10 seconds and then recorded again after 60 seconds (i.e. the steady reading). As can be seen from Tables 2 and 3, there were elevated levels of methane in both leachate wells on both dates. On the 1st round of monitoring a methane level of 3.7% (i.e. steady) was found in BH3. However, this decreased to 0.5% on the 2nd round of monitoring.

It should be noted that only trace levels of methane were found in the leachate wells in April, 2014. Please find extracts of relevant landfill gas monitoring section from the 2014 GQRA report in Appendix 3. It should be noted that groundwater monitoring and leachate wells were installed in January 2014 and left to equilibrate for 3 months before monitoring.

A number of factors may explain the high levels of methane encountered in the most recent round. It is likely that the natural peat underlying lying the waste is contributing significantly to the levels observed. With the levels of ammonia and potassium observed in the leachate taken from LC01, it is possible that the 'Carbon: Nitrogen: Phosphorus: Potassium Ratio' has changed from 2014 with the relatively higher levels of ammonia and potassium making the environment more favourable to methanogenesis which is naturally occurring in the existing blanket peat. It is also possible that the methane being generated in July, 2021 was at peak levels due to the seasonal lowering of the groundwater table and also the increase in ground temperature. The weather was very dry/warm at the time of sampling. It should also be noted that the standing water level of leachate was significantly lower in LC01 in July 2021 than the round taken in April 2014 which would be expected. The standing water table was at 48.34mAOD in 2014 while the standing water table was at 46.51mAOD in 2021 (i.e. almost 2m lower). This may also have enhanced methanogenesis within the underlying peat layer. The influence of the peat layer on the groundwater chemistry within the leachate well was very noticeable given the high levels of peat derived tannins found in the leachate sample and the pH of 6.9.

It is important to note that the risk from landfill gas from the site to potential receptors does not change. There are no offsite residences nor constructed buildings on site that can be defined as a confined space nor are there site services (i.e. stormwater or foulwater drainage pipework) that can act as a pathway into a confined space. It should be noted that there are 2 'Rego' mobile welfare site offices on site which are for the use of Galway County Council staff. However, these units are sealed at the bottom (i.e. there is no viable pathway into these units). An important factor to consider is the presence of the culverted stream passing through the site. This culvert would serve to release a significant portion of the landfill gases which may build up within the waste body and underlying peat.

Table 2. Landfill Gas Readings on 30th June , 2021 at Former Landfill at Tullyvogheen, Clifden, County Galway

Gas Well Reference No.	Total Depth of well (m)	O ₂ %		CO ₂ %		CH ₄ %		Peak CH ₄ %	H ₂ S ppm		CO ppm		Balance (Nitrogen) 60 secs	Barometric Pressure mb	Relative Pressure mb	Weather conditions
		Initial	60 secs	Initial	60 secs	Initial	60 secs		Initial	60 secs	Initial	60 secs				
BH1	11.62	3.6	3.6	0.9	8.8	0.1	1.6	1.6	0	0	0	0	85.9	1024	-0.42	Dry Conditions, 15°C
BH2	16.86	20.6	20.6	0	0	0	0	0.2	0	2	0	1	78.8	1024	0.11	
BH3	10.24	13.4	13.4	3.8	3.8	0.1	3.7	3.7	0	3	0	1	79	1023	-0.65	
LC1	6.025	0	0	12.5	12.4	53.7	53.7	53.7	0	1	0	0	33.9	1024	-0.62	
LC2	9.165	0.1	0.1	15	14.1	34.1	34.1	34.1	0	4	0	2	51.6	1022	0.16	

Notes:

Department of the Environment publication on the 'Protection of New Buildings and Occupants from Landfill Gas' (1994).

Lower Explosive Limit (LEL) for methane = 5% - Exceedance underlined

Upper Explosive Limit (LEL) for methane = 15% - Exceedance highlighted in yellow and **red bold**

Landfill gas survey using GA5000

For inspection purposes only.
Consent of copyright owner required for any other use.

Table 3. Landfill Gas Readings on 3rd July, 2014 at Former Landfill at Tullyvogheen, Clifden, County Galway

Gas Well Reference No.	Total Depth of well (m)	O ₂ %		CO ₂ %		CH ₄ %		Peak CH ₄ %	H ₂ S ppm		CO ppm		Balance (Nitrogen) 60 secs	Barometric Pressure mb	Relative Pressure mb	Weather conditions
		Initial	60 secs	Initial	60 secs	Initial	60 secs		Initial	60 secs	Initial	60 secs				
BH1	11.62	3	3.5	9.6	9.1	0.6	0.8	0.8	0	0	0	0	86.5	1010	3.35	Damp Conidtions, some drizzle, 14°C
BH2	16.86	21	21	0.4	0.2	0.7	0.7	0.7	0	0	0	0	78.8	1010	0.04	
BH3	10.24	9.9	9.9	6.1	6.1	0.5	0.5	0.5	0	0	0	0	83.7	1010	-0.07	
LC1	6.025	0	0	12.9	12.9	36.7	36.7	36.7	0	0	0	0	50.5	1010	0.05	
LC2	9.165	0.3	0.3	15.1	15.1	34.9	34.9	34.9	0	0	0	0	49.9	1010	7.59	

Notes:

Department of the Environment publication on the 'Protection of New Buildings and Occupants from Landfill Gas' (1994).

Lower Explosive Limit (LEL) for methane = 5% - Exceedance underlined

Upper Explosive Limit (LEL) for methane = 15% - Exceedance highlighted in yellow and **red bold**

Landfill gas survey using GA5000

For inspection purposes only.
Consent of copyright owner required for any other use.

Therefore, the COP Risk Assessment submitted with the COA Application will remain the same (i.e. there are no required changes to Source-Pathway-Receptor Linkages 10 and 11).

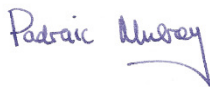
4 CONCLUSIONS

The results of the groundwater and leachate monitoring and landfill gas monitoring indicate that the site is undergoing intrinsic remediation with the groundwater chemistry and redox conditions within the waste body and saturated zone changing gradually with time. For the most part, the groundwater data indicates that the quality of groundwater is improving on site.

The results of the ammonia analysis showing an increase since 2014 are not conclusive, as it is possible that hydraulically upgradient sources of contamination from agricultural practices are impacting on groundwater entering the site (i.e. there is evidence of groundwater contamination not solely from the landfill waste). It is also possible that the low groundwater table and extended dry weather at the time of sampling were contributing factors in an increase in methanogenesis within the waste body and also an increase in the concentration of contaminants found in the groundwater and leachate.

Please do not hesitate to contact me if you have any questions.

Yours sincerely,



Padraic Mulroy

BSc., MSc., MIPSS, MIEI, C.Sci., BREEAM AP, LEED Green Assoc.

Managing Director

Mulroy Environmental Ltd.

*For inspection purposes only.
Consent of copyright owner required for any other use.*

APPENDIX 1

TABLES A1.1 RESULTS OF VOLATILE ORGANIC COMPOUND LABORATORY ANALYSIS ON GROUNDWATER SAMPLES TAKEN FROM BOREHOLES BH1, BH2 AND BH3 AND LEACHATE WELL LC01 AT TULLYVOUGHEEN CLIFDEN, GALWAY ON THE 5TH JULY 2021

TABLES A1.2 RESULTS OF SEMI-VOLATILE ORGANIC COMPOUND/POLYAROMATIC HYDROCARBON LABORATORY ANALYSIS ON GROUNDWATER SAMPLES TAKEN FROM BOREHOLES BH1, BH2 AND BH3 AND LEACHATE WELL LC01 AT TULLYVOUGHEEN CLIFDEN, GALWAY ON THE 5TH JULY 2021

For inspection purposes only
Consent of copyright owner required for any other use

Table A1.1. Results of Volatile Organic Compound laboratory analysis on groundwater samples taken from boreholes BH1, BH2 and BH3 and Leachate Well LC01 at Tullyvougheen Clifden, Galway on the 5th July 2021

Parameters	Units	Standards		Guidelines		Analytical Results			
		Dutch Criteria Level TV	Dutch Criteria Level IV	EPA Guideline Values - From Interim Report on 'Towards Setting Guideline Values for the Protection of Groundwater in Ireland' INTERIM GUIDELINE VALUES	EC Environmental Objectives (Groundwater Regulations) Statutory Instrument No. 9, 2010 THRESHOLD VALUES	WA-BH1-01	WA-BH2-01	WA-BH3-01	WA-LC01-01
Dichlorodifluoromethane	ug/l	-	-	-	-	< 0.001	<0.001	< 0.002	<0.001
Chloromethane	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Vinyl Chloride	ug/l	0.00001	0.00500	-	0.000375	<0.001	<0.001	<0.001	<0.001
Bromomethane	ug/l	-	-	-	-	<0.005	<0.005	<0.005	<0.005
Chloroethane	ug/l	-	-	-	-	<0.002	<0.002	<0.002	<0.002
Trichlorofluoromethane	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
trans-1,2-Dichloroethene	ug/l	0.00001	0.02000	-	-	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethene	ug/l	0.00001	0.01000	-	-	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethane	ug/l	0.00700	0.90000	0.03	-	<0.001	<0.001	<0.001	<0.001
tert-butyl methyl ether	ug/l	-	9.20000	0.03	-	<0.001	<0.001	<0.001	<0.001
cis-1,2-Dichloroethene	ug/l	0.00001	0.02000	-	-	<0.001	<0.001	<0.001	<0.001
Bromochloromethane	ug/l	-	-	-	-	<0.005	<0.005	<0.005	<0.005
1,2-Dichloroethane	ug/l	0.00700	0.40000	0.003	0.00225	<0.002	<0.002	<0.002	<0.002
1,1,1-Trichloroethane	ug/l	0.00001	0.30000	0.5	-	<0.001	<0.001	<0.001	<0.001
1,1-Dichloropropene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Benzene	ug/l	0.00020	0.03000	0.001	0.00075	<0.001	<0.001	<0.001	<0.001
Dibromomethane	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
1,2-Dichloropropane	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Bromodichloromethane	ug/l	-	-	-	-	<0.005	<0.005	<0.005	<0.005
Trichloroethene	ug/l	0.02400	0.50000	0.07	-	<0.001	<0.001	<0.001	<0.001
Trichloromethane	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Tetrachloromethane	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Tribromomethane	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
cis-1,3-Dichloropropene	ug/l	-	-	-	-	<0.010	<0.010	<0.010	<0.010
trans-1,3-Dichloropropene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
1,1,2-Trichloroethane	ug/l	0.00001	0.03000	-	-	<0.010	<0.010	<0.010	<0.010
Toluene	ug/l	0.00700	0.00000	0.01	-	<0.001	<0.001	<0.001	<0.001
1,3-Dichloropropane	ug/l	-	-	-	-	<0.002	<0.002	<0.002	<0.002
Dibromochloromethane	ug/l	-	-	-	-	<0.010	<0.010	<0.010	<0.010
1,2-Dibromoethane	ug/l	-	-	-	-	<0.005	<0.005	<0.005	<0.005
Tetrachloroethene	ug/l	0.0000100	0.04000	0.002	-	<0.001	<0.001	<0.001	<0.001
1,1,1,2-Tetrachloroethane	ug/l	-	-	-	-	<0.002	<0.002	<0.002	<0.002
Chlorobenzene	ug/l	0.0070000	0.18000	0.001	-	<0.001	<0.001	<0.001	<0.001
Ethylbenzene	ug/l	0.0040000	0.15000	0.01	-	<0.001	<0.001	<0.001	<0.001
p/m-Xylene	ug/l	0.00020	0.07000	0.01	-	<0.001	<0.001	<0.001	<0.001
Styrene	ug/l	0.00600	0.30000	-	-	<0.001	<0.001	<0.001	<0.001
o-Xylene	ug/l	0.00020	0.07000	0.01	-	<0.001	<0.001	<0.001	<0.001
1,2,3-Trichloropropane	ug/l	-	-	-	-	<0.050	<0.050	<0.050	<0.050
Isopropylbenzene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Bromobenzene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
2-Chlorotoluene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Propylbenzene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
4-Chlorotoluene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
1,2,4-Trimethylbenzene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
4-Isopropyltoluene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
1,3,5-Trimethylbenzene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
1,3-Dichlorobenzene	ug/l	0.00300	0.05000	-	-	<0.001	<0.001	<0.001	<0.001
1,4-Dichlorobenzene	ug/l	0.00300	0.05000	-	-	<0.001	<0.001	<0.001	<0.001
sec-Butylbenzene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
tert-Butylbenzene	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
1,2-Dichlorobenzene	ug/l	0.00300	0.05000	0.003	-	<0.001	<0.001	<0.001	<0.001
n-Butylbenzene	ug/l	-	-	-	-	<0.050	<0.050	<0.050	<0.050
1,2-Dibromo-3-chloropropane	ug/l	-	-	-	-	<0.001	<0.001	<0.001	<0.001
1,2,4-Trichlorobenzene	ug/l	0.00001	0.01000	0.0004	-	<0.001	<0.001	<0.001	<0.001
1,2,3-Trichlorobenzene	ug/l	0.00001	0.01000	-	-	<0.002	<0.002	<0.002	<0.002
Hexachlorobutadiene	ug/l	-	-	0.0001	-	<0.001	<0.001	<0.001	<0.001

Notes:

<u>553</u>	Values are underlined wherever Dutch-TV is exceeded
553	Values are shaded yellow and in bold wherever Dutch-IV, EPA Interim Guideline Values or SI 9, 2010 Threshold Values are exceeded
-	'-' = No Dutch TV or IV, EPA Interim Guideline Values or SI 9, 2010 Threshold Values available

Table A1.2. Results of Semi-volatile Organic Compound laboratory analysis on groundwater samples taken from boreholes BH1, BH2 and BH3 and Leachate Well LC01 at Tullyvoughen Landfill, Galway on the 5th July 2021

Parameters	Units	Standards		Guidelines		Analytical Results			
		Dutch Criteria Level TV	Dutch Criteria Level IV	EPA Guideline Values - From Interim Report on 'Towards Setting Guideline Values for the Protection of Groundwater in Ireland' INTERIM GUIDELINE VALUES	EC Environmental Objectives (Groundwater Regulations) Statutory Instrument No. 9, 2010. THRESHOLD VALUES	WA-BH1-01	WA-BH2-01	WA-BH3-01	WA-LC01-01
Phenol	ug/l	0.20000	2.00000	0.00050	-	<0.0005	<0.0005	<0.0005	<0.0005
2-Methyl-4,6-Dinitrophenol	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2-Chlorophenol	ug/l	0.00030	0.10000	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2,4-Dichlorophenol	ug/l	0.00020	0.03000	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2,4-Dimethylphenol	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
4-Chloro-3-methylphenol	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2,4,6-Trichlorophenol	ug/l	0.00001	0.01000	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2,4,5-Trichlorophenol	ug/l	0.00001	0.01000	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Pentachlorophenol	ug/l	0.00004	0.00300	0.00200	-	<0.0005	<0.0005	<0.0005	<0.0005
2-Methylphenol	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
4-Methylphenol	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2-Nitrophenol	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
4-Nitrophenol	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
1,3-Dichlorobenzene	ug/l	0.00300	0.05000	-	-	<0.0005	<0.0005	<0.0005	<0.0005
1,4-Dichlorobenzene	ug/l	0.00300	0.05000	-	-	<0.0005	<0.0005	<0.0005	<0.0005
1,2-Dichlorobenzene	ug/l	0.00300	0.05000	-	-	<0.0005	<0.0005	<0.0005	<0.0005
1,2,4-Trichlorobenzene	ug/l	0.00001	0.01000	0.00040	-	<0.0005	<0.0005	<0.0005	<0.0005
Nitrobenzene	ug/l	-	-	0.01000	-	<0.0005	<0.0005	<0.0005	<0.0005
Azobenzene	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Hexachlorobenzene	ug/l	0.00000009	0.00050	0.00003	-	<0.0005	<0.0005	<0.0005	<0.0005
Acenaphthylene	ug/l	-	-	0.00010	-	<0.0005	<0.0005	<0.0005	<0.0005
Acenaphthene	ug/l	-	-	0.00010	-	<0.0005	<0.0005	<0.0005	<0.0005
Fluorene	ug/l	-	-	0.00010	-	<0.0005	<0.0005	<0.0005	<0.0005
Pyrene	ug/l	-	-	0.00010	-	<0.0005	<0.0005	<0.0005	<0.0005
Benzo(b)fluoranthrene	ug/l	-	-	0.00050	-	<0.0005	<0.0005	<0.0005	<0.0005
Naphthalene	ug/l	0.00001	0.07000	0.00100	-	<0.0005	<0.0005	<0.0005	<0.0005
Anthracene	ug/l	0.000007	0.00500	10.00000	-	<0.0005	<0.0005	<0.0005	<0.0005
Phenanthrene	ug/l	0.000003	0.00500	0.00010	-	<0.0005	<0.0005	<0.0005	<0.0005
Fluoranthrene	ug/l	0.000003	0.00100	0.00100	-	<0.0005	<0.0005	<0.0005	<0.0005
Benzo(a)anthracene	ug/l	0.0000001	0.00050	0.00010	-	<0.0005	<0.0005	<0.0005	<0.0005
Chrysene	ug/l	0.0000030	0.00020	0.00010	-	<0.0005	<0.0005	<0.0005	<0.0005
Benzo(a)pyrene	ug/l	0.0000005	0.00005	0.00001	0.000000075	<0.0005	<0.0005	<0.0005	<0.0005
Benzo(ghi)perylene	ug/l	0.0000003	0.00005	0.00005	-	<0.0005	<0.0005	<0.0005	<0.0005
Benzo(k)fluoranthrene	ug/l	0.0000004	0.00005	0.00005	-	<0.0005	<0.0005	<0.0005	<0.0005
Indeno(1,2,3-cd)pyrene	ug/l	0.0000004	0.00005	0.00005	-	<0.0005	<0.0005	<0.0005	<0.0005
Dibenzo(a,h)anthracene	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2-Chloronaphthalene	ug/l	-	0.006	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2-Methylnaphthalene	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Carbazole	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Isophorone	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Dibenzofuran	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Dimethyl phthalate	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Diethyl phthalate	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Di-n-butylphthalate	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Di-n-octylphthalate	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Bis(2-ethylhexyl)phthalate	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Butylbenzylphthalate	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
4-Chloroaniline	ug/l	-	0.030	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2-Nitroaniline	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
3-Nitroaniline	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
4-Nitroaniline	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
N-Nitrosodimethylamine	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2,4-Dinitrotoluene	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
2,6-Dinitrotoluene	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Bis(2-chloroethyl)ether	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Bis(2-Chloroisopropyl)Ether	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
4-Bromophenylphenylether	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
4-Chlorophenylphenylether	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Hexachloroethane	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Hexachlorobutadiene	ug/l	-	-	0.00010	-	<0.0005	<0.0005	<0.0005	<0.0005
Hexchlorocyclopentadiene	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Bis(2-chloroethoxy)methane	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
N-nitrosodi-n-propylamine	ug/l	-	-	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Phenols									
Total Phenols	mg/l					<0.030	<0.030	<0.030	<0.030

Notes:
 553 Values are underlined wherever Dutch-TV is exceeded
 553 Values are shaded yellow and in bold wherever Dutch-IV, EPA Interim Guideline Values or SI 9, 2010 Threshold Values are exceeded
 - ' - = No Dutch TV or IV, EPA Interim Guideline Values or SI 9, 2010 Threshold Values available

APPENDIX 2

RAW VALIDATED LABORATORY GROUNDWATER & LEACHATE
RESULTS FROM EUROFINS CHEMTEST LTD. UK

RAW VALIDATED LABORATORY GROUNDWATER & LEACHATE
RESULTS FROM CLS, ROSMUC, GALWAY

*For inspection purposes only.
Consent of copyright owner required for any other use.*



Final Report

Report No.: 21-23356-1
Initial Date of Issue: 12-Jul-2021
Client: MULROY ENVIRONMENTAL
Client Address: 30 Lisroland View
Knockbridge
Dundalk
County Louth
Ireland
Contact(s): Andrena Meegan
Padriac Mulroy
H. Clerkin

Project: Tullvoughen Clifden

Quotation No.: Q21-22960

Order No.:

No. of Samples: 4

Turnaround (Wkdays): 5

Date Approved: 12-Jul-2021

Approved By:

Details: Glynn Harvey, Technical Manager

Date Received: 07-Jul-2021

Date Instructed: 07-Jul-2021

Results Due: 13-Jul-2021

*For inspection purposes only.
Consent of copyright owner required for any other use.*

Results - Water

Project: Tullvoughen Clifden

Client: MULROY ENVIRONMENTAL		Chemtest Job No.:		21-23356	21-23356	21-23356	21-23356
Quotation No.: Q21-22960		Chemtest Sample ID.:		1236142	1236143	1236144	1236145
		Client Sample ID.:		WA-GW1-01	WA-GW2-01	WA-GW3-01	WA-LC01-01
		Sample Location:		GW1	GW2	GW3	LC01
		Sample Type:		WATER	WATER	WATER	WATER
		Date Sampled:		05-Jul-2021	05-Jul-2021	05-Jul-2021	05-Jul-2021
Determinand	Accred.	SOP	Units	LOD			
Temperature	N		°C	N/A	10.0	10.0	10.0
pH	U	1010		N/A	6.9	7.0	6.9
Electrical Conductivity	U	1020	µS/cm	1.0	740	2000	640
Suspended Solids At 105C	U	1030	mg/l	5.0	610	1700	200
Total Dissolved Solids	N	1020	mg/l	1.0	480	1300	420
Dissolved Oxygen	N	1150	mg O2/l	0.50	7.9	8.0	8.1
Ammonia (Free) as N	N	1220	mg/l	0.050	0.058	< 0.050	< 0.050
Calcium	U	1455	mg/l	2.00	100	110	54
Potassium	U	1455	mg/l	0.50	10	3.1	2.3
Magnesium	U	1455	mg/l	0.20	20	8.0	17
Sodium	U	1455	mg/l	1.50	85	320	30
Arsenic (Dissolved)	U	1455	µg/l	0.20	0.75	1.9	0.36
Boron (Dissolved)	U	1455	µg/l	10.0	220	72	35
Cadmium (Dissolved)	U	1455	µg/l	0.11	< 0.11	< 0.11	0.58
Chromium (Dissolved)	U	1455	µg/l	0.50	< 0.50	< 0.50	0.50
Copper (Dissolved)	U	1455	µg/l	0.50	< 0.50	< 0.50	3.1
Iron (Dissolved)	N	1455	µg/l	5.0	490	980	5.1
Mercury (Dissolved)	U	1455	µg/l	0.05	0.06	0.06	0.06
Manganese (Dissolved)	U	1455	µg/l	0.50	810	920	1100
Nickel (Dissolved)	U	1455	µg/l	0.50	3.9	7.1	0.58
Lead (Dissolved)	U	1455	µg/l	0.50	< 0.50	< 0.50	< 0.50
Zinc (Dissolved)	U	1455	µg/l	2.5	7.3	< 2.5	< 2.5
Dichlorodifluoromethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Chloromethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Bromomethane	U	1760	µg/l	5	< 5	< 5	< 5
Chloroethane	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Trichlorofluoromethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Trans 1,2-Dichloroethene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
cis 1,2-Dichloroethene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Bromochloromethane	U	1760	µg/l	5	< 5	< 5	< 5
Trichloromethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1,1-Trichloroethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Tetrachloromethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloropropene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Benzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dichloroethane	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Trichloroethene	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0

Results - Water

Project: Tullvoughen Clifden

Client: MULROY ENVIRONMENTAL		Chemtest Job No.:		21-23356	21-23356	21-23356	21-23356
Quotation No.: Q21-22960		Chemtest Sample ID.:		1236142	1236143	1236144	1236145
		Client Sample ID.:		WA-GW1-01	WA-GW2-01	WA-GW3-01	WA-LC01-01
		Sample Location:		GW1	GW2	GW3	LC01
		Sample Type:		WATER	WATER	WATER	WATER
		Date Sampled:		05-Jul-2021	05-Jul-2021	05-Jul-2021	05-Jul-2021
Determinand	Accred.	SOP	Units	LOD			
1,2-Dichloropropane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Dibromomethane	U	1760	µg/l	10	< 10	< 10	< 10
Bromodichloromethane	U	1760	µg/l	5	< 5	< 5	< 5
cis-1,3-Dichloropropene	N	1760	µg/l	10	< 10	< 10	< 10
Toluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Trans-1,3-Dichloropropene	N	1760	µg/l	10	< 10	< 10	< 10
1,1,2-Trichloroethane	U	1760	µg/l	10	< 10	< 10	< 10
Tetrachloroethene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3-Dichloropropane	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Dibromochloromethane	U	1760	µg/l	10	< 10	< 10	< 10
1,2-Dibromoethane	U	1760	µg/l	5	< 5	< 5	< 5
Chlorobenzene	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1,1,2-Tetrachloroethane	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
o-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Styrene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Tribromomethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Bromobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2,3-Trichloropropane	N	1760	µg/l	50	< 50	< 50	< 50
N-Propylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
2-Chlorotoluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
4-Chlorotoluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Tert-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Sec-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3-Dichlorobenzene	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
4-Isopropyltoluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
N-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dibromo-3-Chloropropane	U	1760	µg/l	50	< 50	< 50	< 50
1,2,4-Trichlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Hexachlorobutadiene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2,3-Trichlorobenzene	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Methyl Tert-Butyl Ether	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
N-Nitrosodimethylamine	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Phenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50

Results - Water

Project: Tullvoughen Clifden

Client: MULROY ENVIRONMENTAL		Chemtest Job No.:		21-23356	21-23356	21-23356	21-23356
Quotation No.: Q21-22960		Chemtest Sample ID.:		1236142	1236143	1236144	1236145
		Client Sample ID.:		WA-GW1-01	WA-GW2-01	WA-GW3-01	WA-LC01-01
		Sample Location:		GW1	GW2	GW3	LC01
		Sample Type:		WATER	WATER	WATER	WATER
		Date Sampled:		05-Jul-2021	05-Jul-2021	05-Jul-2021	05-Jul-2021
Determinand	Accred.	SOP	Units	LOD			
2-Chlorophenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Bis-(2-Chloroethyl)Ether	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
1,3-Dichlorobenzene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
1,4-Dichlorobenzene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
1,2-Dichlorobenzene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2-Methylphenol (o-Cresol)	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Bis(2-Chloroisopropyl)Ether	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Hexachloroethane	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
N-Nitrosodi-n-propylamine	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
4-Methylphenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Nitrobenzene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Isophorone	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2-Nitrophenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2,4-Dimethylphenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Bis(2-Chloroethoxy)Methane	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2,4-Dichlorophenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
1,2,4-Trichlorobenzene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Naphthalene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
4-Chloroaniline	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Hexachlorobutadiene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
4-Chloro-3-Methylphenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2-Methylnaphthalene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Hexachlorocyclopentadiene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2,4,6-Trichlorophenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2,4,5-Trichlorophenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2-Chloronaphthalene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2-Nitroaniline	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Acenaphthylene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Dimethylphthalate	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2,6-Dinitrotoluene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Acenaphthene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
3-Nitroaniline	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Dibenzofuran	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
4-Chlorophenylphenylether	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2,4-Dinitrotoluene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Fluorene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Diethyl Phthalate	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
4-Nitroaniline	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
2-Methyl-4,6-Dinitrophenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Azobenzene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50

Results - Water

Project: Tullvoughen Clifden

Client: MULROY ENVIRONMENTAL		Chemtest Job No.:		21-23356	21-23356	21-23356	21-23356
Quotation No.: Q21-22960		Chemtest Sample ID.:		1236142	1236143	1236144	1236145
		Client Sample ID.:		WA-GW1-01	WA-GW2-01	WA-GW3-01	WA-LC01-01
		Sample Location:		GW1	GW2	GW3	LC01
		Sample Type:		WATER	WATER	WATER	WATER
		Date Sampled:		05-Jul-2021	05-Jul-2021	05-Jul-2021	05-Jul-2021
Determinand	Accred.	SOP	Units	LOD			
4-Bromophenylphenyl Ether	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Hexachlorobenzene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Pentachlorophenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Phenanthrene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Anthracene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Carbazole	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Di-N-Butyl Phthalate	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Fluoranthene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Pyrene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Butylbenzyl Phthalate	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Benzo[a]anthracene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Chrysene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Bis(2-Ethylhexyl)Phthalate	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Di-N-Octyl Phthalate	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Benzo[b]fluoranthene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Benzo[k]fluoranthene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Benzo[a]pyrene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Indeno(1,2,3-c,d)Pyrene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Dibenz(a,h)Anthracene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Benzo[g,h,i]perylene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
4-Nitrophenol	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
Total Phenols	U	1920	mg/l	0.030	< 0.030	< 0.030	< 0.030

For information purposes only. Consent of the client is required to publish any other results.

Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1020	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Conductivity Meter
1030	Total Suspended Solids	Total suspended solids	Filtration of a mixed sample through a standard glass fibre filter and determination of the mass of residue retained dried at 105°C.
1150	Dissolved Oxygen	Dissolved Oxygen (DO)	Electrometric determination (on site preferred), using oxygen sensitive membrane electrode.
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1455	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1760	Volatile Organic Compounds (VOCs) in Waters by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics. (cf. USEPA Method 8260)	Automated headspace gas chromatographic (GC) analysis of water samples with mass spectrometric (MS) detection of volatile organic compounds.
1790	Semi-Volatile Organic Compounds (SVOCs) in Waters by GC-MS	Semi-volatile organic compounds	Solvent extraction / GCMS detection
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols. Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.

For inspection purposes only. Consent of copyright owner required for any other use.

Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"
SOP	Standard operating procedure
LOD	Limit of detection

Comments or interpretations are beyond the scope of UKAS accreditation

The results relate only to the items tested

Uncertainty of measurement for the determinands tested are available upon request

None of the results in this report have been recovered/corrected

All results are expressed on a dry weight basis

The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols

For all other tests the samples were dried at < 37°C prior to analysis

All Asbestos testing is performed at the indicated laboratory

Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

- A - Date of sampling not supplied
- B - Sample age exceeds stability time (sampling to extraction)
- C - Sample not received in appropriate containers
- D - Broken Container
- E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 30 days from the date of receipt

All water samples will be retained for 14 days from the date of receipt

Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:

customerservices@chemtest.com



CERTIFICATE OF ANALYSIS

Client : Padraic Mulroy
 Mulroy Environmental
 30 Lisroland View
 Knockbridge
 Dundalk CO Louth

Report No. : 454827
 Date of Receipt : 05/07/2021
 Start Date of Analysis : 05/07/2021
 Date of Report : 19/07/2021
 Order Number : Tullyvogheen LF
 Sample taken by : Client

Lab No	Sample Description	Test	Ref.	Result	Units
1270357	WA-GW1-01	T.V.C. @ 22°C (Pour Plate)	I,R	730	cfu/ml
		T.V.C. @ 37 (Pour Plate)	I,R	310	cfu/ml
		BOD	I,R	8	mg/l
		COD	I,R	60	mg/l
		Ammonia as NH3-N	I,R	14.3	mg/l
		Ammonium as NH4	I,R	18.4	mg/l
		Clostridium Perfringens in Water	I,R	100 Result obtained from a 1 in 100 dilution.	cfu/100ml
		Total Coliforms (Filtration) (Environmental Waters)	I,R	0	cfu/100ml
		Enterococci (Waters- Incubated at 37°C and 44 °C)	I,R		cfu/100ml
1270358	WA-GW2-01	Faecal Coliforms Filtration	I,R	0	cfu/100ml
		T.V.C. @ 22°C (Pour Plate)	I,R	1,100	cfu/ml
		T.V.C. @ 37 (Pour Plate)	I,R	3,300 est	cfu/ml
		BOD	I,R	3	mg/l
		COD	I,R	239	mg/l
		Ammonia as NH3-N	I,R	1.54	mg/l
		Ammonium as NH4	I,R	1.99	mg/l
		Clostridium Perfringens in Water	I,R	55,000 Result obtained from a 1 in 10,000 dilution.	cfu/100ml
		Total Coliforms (Filtration) (Environmental Waters)	I,R	< 10,000 Result obtained from a 1 in 10,000 dilution.	cfu/100ml
1270359	WA-GW3-01	Enterococci (Waters- Incubated at 37°C and 44 °C)	I,R	<10,000 Result obtained from a 1 in 10,000 dilution	cfu/100ml
		Faecal Coliforms Filtration	I,R	< 10,000 Result obtained from a 1 in 10,000 dilution.	cfu/100ml
		T.V.C. @ 22°C (Pour Plate)	I,R	1,300	cfu/ml
		T.V.C. @ 37 (Pour Plate)	I,R	72	cfu/ml
		BOD	I,R	<1	mg/l
		COD	I,R	22	mg/l
		Ammonia as NH3-N	I,R	0.058	mg/l
		Ammonium as NH4	I,R	0.074	mg/l
		Clostridium Perfringens in Water	I,R	< 100 Result obtained from a 1 in 100 dilution.	cfu/100ml
1270360	WA-LC1-01	Total Coliforms (Filtration) (Environmental Waters)	I,R	0	cfu/100ml
		Enterococci (Waters- Incubated at 37°C and 44 °C)	I,R	0	cfu/100ml
		Faecal Coliforms Filtration	I,R	0	cfu/100ml
		T.V.C. @ 22°C (Pour Plate)	I,R	7,000 est	cfu/ml
		T.V.C. @ 37 (Pour Plate)	I,R	15,000 est	cfu/ml
		BOD	I,R	102	mg/l
		COD	I,R	3580	mg/l
		Ammonia as NH3-N	I,R	15.6	mg/l
		Ammonium as NH4	I,R	20.1	mg/l
Clostridium Perfringens in Water	I,R	< 10,000 Result obtained from a 1 in 10,000 dilution.	cfu/100ml		

	Total Coliforms (Filtration) (Environmental Waters)	I,R	< 10,000 Result obtained from a 1 in 10,000 dilution.	cfu/100ml
	Enterococci (Waters- Incubated at 37°C and 44 °C)	I,R	<10,000 Result obtained from a 1 in 10,000 dilution	cfu/100ml
	Faecal Coliforms Filtration	I,R	< 10,000 Result obtained from a 1 in 10,000 dilution.	cfu/100ml



Approved by:

James Feighan
Scientific Project
Manager

See below for test specifications and accreditation status.

This report only relates to items tested and shall not be reproduced but in full with the permission of CLS.

0cfu is reported in waters, this refers to 'not detected in volume tested'

It is recommended that water samples requiring microbiological analysis should be tested within 24 hours of sampling. CLS will test food, water and swabs samples within 24 hours of receipt.

Where samples have been taken by the Client, results apply to the samples as received.

For inspection purposes only. Consent of copyright owner required for reuse.



In-House Test	Specification	Measurement of Uncertainty	17025	GMP/FDA*	ISO**
T.V.C. @ 22°C (Pour Plate)	CLS 95	+/- 0.14	Yes	No	Yes
T.V.C. @ 37 (Pour Plate)	CLS 95	+/- 0.35	Yes	No	Yes
BOD	CLS 12	+/- 9.33 %	Yes	No	Yes
COD	CLS 52	+/- 4.48 %	Yes	No	Yes
Ammonia as NH3-N	Konelab CLS 40	+/- 5.13 %	Yes	No	Yes
Ammonium as NH4	Konelab CLS 40	+/- 5.13 %	Yes	No	Yes
Clostridium Perfringens in Water	CLS 43	+/- 0.07	Yes	No	Yes
Total Coliforms (Filtration) (Environmental Waters)	CLS 16	+/- 0.29	Yes	No	Yes
Enterococci (Waters- Incubated at 37°C and 44 °C)	CLS 42	+/- 0.16	Yes	No	Yes
Faecal Coliforms Filtration	CLS 16 based on The Microbiology of Recreational and Environmental Waters 2000	+/- 0.10	Yes	No	Yes

*Analysis carried out in a GMP approved, FDA inspected facility (MedPharma site only).

**Laboratory Analysis, Sampling, Food Safety Monitoring and Analysts on Contract are all ISO 9001 certified.

For environmental samples of lakes and rivers sampled by CLS, accreditation is not being claimed on this report.

Lab No	Sample ID	Sample Condition on Receipt	Sampling Date
1270357	WA-GW1-01	Good condition	05/07/2021
1270358	WA-GW2-01	Good condition	05/07/2021
1270359	WA-GW3-01	Good condition	05/07/2021
1270360	WA-LC1-01	Good condition	05/07/2021

For inspection purposes only. Consent of copyright owner required for other use.

APPENDIX 3

RELEVANT EXTRACT OF 2014 PHASE II/GQRA TULLYVOGHEEN
LANDFILL REPORT ON LANDFILL GAS MONITORING RESULTS

TABLE A1.1. RESULTS OF S-P-R LINKAGE PRIORITISATION ON
FORMER LANDFILL AT TULLYVOGHEEN, CLIFDEN, COUNTY
GALWAY

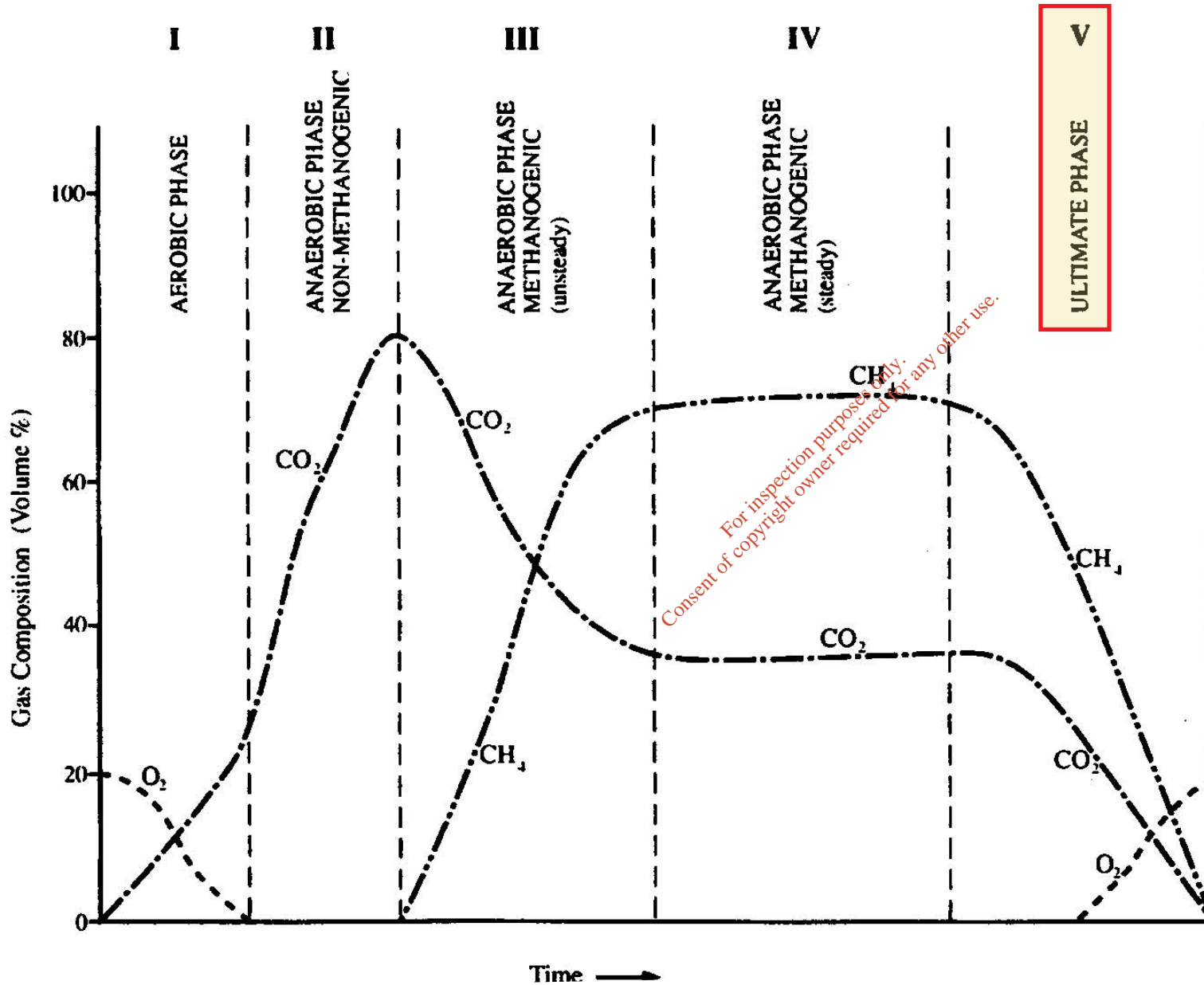
*For inspection purposes only.
Consent of copyright owner required for any other use.*


Table 6. Landfill Gas Readings on 21st April, 2014 at Former Landfill at Tullyvogheen, Clifden, County Galway

Gas Well Reference No.	Total Depth of well (m)	O ₂ %		CO ₂ %		CH ₄ %		Peak CH ₄ %	H ₂ S ppm		CO ppm		Barometric Pressure mb	Relative Pressure mb	Weather conditions
		Initial	60 secs	Initial	60 secs	Initial	60 secs		Initial	60 secs	Initial	60 secs			
BH101	12.0	19.6	19.7	0.1	0.1	0.2	0	0.2	0	0	0	0	1020	-0.44	Bright sunny, dry, 12-13°C.
BH102	17.5	20.1	20.1	0.1	0.1	0.1	0	0.1	0	0	3	0	1020	-0.44	Bright sunny, dry, 12-13°C.
BH103	10.0	19.3	19.3	0.2	0	0.2	0	0	0	0	1	0	1020	-0.44	Bright sunny, dry, 12-13°C.
LC1	6.1	18.9	19.1	0.5	0.2	1.1	0.5	1.1	0	0	0	0	1020	-0.44	Bright sunny, dry, 12-13°C.
LC2	9.0	18.7	18.9	0.7	0.2	0.8	0.3	0.8	0	0	0	0	1020	-0.44	Bright sunny, dry, 12-13°C.

For inspection purposes only.
Consent of copyright owner required for any other use.

Chart 1. Idealised Degradation Phases for Domestic Waste



Client: Galway C.C.		
Project: Tier 2 Site Investigation & Tier 3 GORA of Former Landfill at Tullyvogheen, Clifden, County Galway		
		Figure: Degradation Phases for Organic Wastes
Chart No.:	1	Drawn By: DG Checked By: PM
Scale:	NA	Date: 8 th July, 2014

10 LANDFILL GAS RISK ASSESSMENT

Following the sampling of groundwater and leachate from the 3 groundwater monitoring wells and the 2 leachate wells on the 29th January, 2014, a 2-inch rubber bung fitted with a gas tap was fitted to each well. Potential landfill gas was allowed to equilibrate for 82 days before testing on the 21st April, 2014. Landfill gas concentrations were measured using a GA2000 Landfill Gas analyser. The GA2000 instrument was hired by Mulroy Environmental from Odour Monitoring Ireland who calibrated the instrument to the factory standards prior to its handover.

The results of the landfill gas monitoring are summarised in the following table, Table 6. As can be seen from Table 6, the levels of oxygen (O₂), carbon dioxide (CO₂), methane (CH₄) and nitrogen (N₂) were measured in the initial 10 seconds and then recorded again after 60 seconds (i.e. the steady reading). As can be seen from Table 6, maximum methane levels were found in leachate well, LC1 at 1.1% with this decreasing to 0.5% after 60 seconds. As can be seen from Table 6, the levels found are significantly less than the Lower Explosive Limit (LEL) for methane, which is 5%, and as such, no mitigation measures are required to protect operatives on site.

Methane generation in a typical domestic landfill follows the pattern in the attached chart, Chart 1. Typically, it will take about 2 years to pass through phases I, II and III and reach a steady state of methane production (i.e. Phase IV). This steady state may then continue for a further fifteen to twenty years after which methane production will gradually decline (Phase V). At steady state the typical composition of the landfill gas is in the ranges of 50-70% methane and 30-50% carbon dioxide. As can be seen from Tables 6, methane and carbon dioxide levels on site are significantly less than the aforementioned values. Therefore, it is likely that the organic waste observed within the domestic waste has broken down and is in latter stages of Phase 5 'Ultimate Phase'. However, it is also possible that the culvert running through the site has provided a horizontal 'pathway of least resistance' expediting the lateral migration of methane out of the site.

Table A1.1. Results of S-P-R Linkage Prioritisation on Former Landfill at Tullyvogheen, Clifden, County Galway

SOURCE		PATHWAYS					RECEPTORS					
LEACHATE	LANDFILL GAS	GROUNDWATER VULNERABILITY (VERTICAL)	GROUNDWATER FLOW REGIME (HORIZONTAL)	SURFACE WATER DRAINAGE	LANDFILL GAS LATERAL MIGRATION	LANDFILL GAS VERTICAL MIGRATION	LEACHATE - HUMAN PRESENCE	LEACHATE - PROTECTED AREAS	LEACHATE - AQUIFER CLASS	LEACHATE - PUBLIC WATER	LEACHATE - SURFACE WATER	LANDFILL GAS - HUMAN PRESENCE
1A	1B	2A	2B	2C	2D	2E	3A	3B	3C	3D	3E	3F
7	7	3	1	2	0	0	1	1	1	0	3	0.5

Source Pathway Receptor	Formula	Score	% Score	Linkages
SPR 1	$1a * (2a + 2b + 2c) * 3e$	126	42.0	Leachate to SW
SPR 2	$1a * (2a + 2b + 2c) * 3b$	42	14.0	Leachate to GWDTE
SPR 3	$1a * (2a + 2b) * 3a$	28	11.7	Leachate to Private Well
SPR 4	$1a * (2a + 2b) * 3b$	28	11.7	Leachate to GWDTE
SPR 5	$1a * (2a + 2b) * 3c$	28	7.0	Leachate to aquifer
SPR 6	$1a * (2a + 2b) * 3d$	0	0.0	Leachate to PWS
SPR 7	$1a * (2a + 2b) * 3e$	84	35.0	Leachate to SW
SPR 8	$1a * 2c * 3e$	42	70.0	Leachate to SW
SPR 9	$1a * 2c * 3b$	14	23.3	Leachate to GWDTE
SPR 10	$1b * 2d * 3f$	0	0.0	Landfill gas - humans
SPR 11	$1b * 2e * 3f$	0	0.0	Landfill gas - humans
HIGHEST INDIVIDUAL SCORE		42	70.0	Leachate to SW

No house within 250m so not assessed
No house directly on top of waste body.

Risk Classification	Range of Risk Scores
Highest Risk (Class A)	Greater than or equal to 70% for any individual SPR linkage
Moderate Risk (Class B)	Between 40 to 70% for any individual SPR linkage
Lowest Risk (Class C)	Less than or equal to 40% for any individual SPR linkage

For inspection purposes only.
Consent of copyright owner required for any other use.

Table 1a: Leachate: Source/Hazard Scoring Matrix

WASTE TYPE	WASTE FOOTPRINT (ha)		
	≤ 1 ha	> 1 ≤ 5 ha	> 5 ha
C&D ²⁰	0.5	1	1.5
Municipal ²¹	5	7	10
Industrial ²²	5	7	10
Pre-1977 sites ²³	1	2	3
		MAX	10

²⁰Table 1b: Landfill Gas: Source/Hazard Scoring Matrix

WASTE TYPE	WASTE FOOTPRINT (ha)		
	≤ 1 ha	> 1 ≤ 5 ha	> 5 ha
C&D ²⁰	0.5	0.75	1
Municipal ²¹	5	7	10
Industrial ²²	3	5	7
Pre-1977 sites ²³	0.5	0.75	1
		MAX	10

For inspection purposes only. Consent of copyright owner required for any other use.

²⁰ Predominantly inert waste with low biodegradable fraction and/or small industrial waste fraction.

²¹ Typically non-hazardous domestic waste (highly biodegradable) with potentially small hazardous waste fraction and/or small industrial waste fraction, e.g. town dump.

²² Generally industrial waste where hazardous waste was known to have been deposited or there is a strong likelihood that hazardous waste was deposited due to the close proximity of such industries.

²³ Pre 1977 wastes would have been substantially degraded within the landfill.

Table 2a: Leachate Migration: Pathways

Parameters	Points available
GROUNDWATER VULNERABILITY (Vertical pathway)	
Extreme Vulnerability	3
High Vulnerability	2
Moderate Vulnerability	1
Low Vulnerability	0.5
High – Low Vulnerability	2

Table 2b: Leachate Migration: Pathways

Parameters	Points available
GROUNDWATER FLOW REGIME (Horizontal pathway)	
Karstified Groundwater Bodies (Rk) ²⁵	5
Productive Fissured Bedrock Groundwater Bodies (Rf and Lm) ²⁵	3
Gravel Groundwater Bodies (Rg and Lg) ²⁵	2
Poorly Productive Bedrock Groundwater Bodies (Ll, Pl, Pu) ²⁵	1

Table 2c: Leachate Migration: Pathways

Parameters	Points available
SURFACE WATER DRAINAGE ²⁶ (surface water pathway)	
Is there a direct connection between drainage ditches associated with the waste body and adjacent surface water body? Yes	2
If no direct connection	0

²⁵ Refer to DEHLG/EPA/GSI 1999, Groundwater Protection Schemes.

Table 2d: Landfill Gas: Pathway Assuming Receptor Within 250m of Source

Parameters	Points available
LANDFILL GAS LATERAL MIGRATION POTENTIAL	
Sand and Gravel, Made ground, urban, karst	3
Bedrock	2
All other Tills (including limestone, sandstone etc – moderate permeability)	1.5
All Namurian or Irish Sea Tills (low permeability)	1
Clay, Alluvium, Peat	1

* Assigned a score of 0 - Residence approx. 400m to the south of site

Table 2e: Landfill Gas: Pathway Assuming Receptor Located Above Source

Parameters	Points available
LANDFILL GAS VERTICAL (UPWARDS) MIGRATION POTENTIAL	
Sand and Gravel, Made ground, urban, karst	5
Bedrock ²	3
All other Tills (including limestone, sandstone etc – moderate permeability) ²	2
All Namurian or Irish Sea Tills (low permeability)	1
Clay, Alluvium, Peat	1

* Assigned a score of 0 - Residence approx. 400m to the south of site.

Table 3a: Leachate Migration: Receptors

Parameters	Points available
HUMAN PRESENCE (presence of a house indicates potential private wells)	
On or within 50m of the waste body	3
Greater than 50m but less than 250m of the waste body	2
Greater than 250m but less than 1km of the waste body	1
Greater than 1 km of the waste body	0

* Residence approx. 415m to the south of site

Table 3b: Leachate Migration: Receptors

Parameters	Points available
PROTECTED AREAS (SWDTE or GWDTE)	
Within 50m of the waste body	3
Greater than 50m but less than 250m of the waste body	2
Greater than 250m but less than 1km of waste body	1
Greater than 1 km of the waste body	0
Undesignated sites ²⁴ within 50m of site of the waste body	1
Undesignated sites ²⁴ greater than 50m but less than 250m of the waste body	0.5
Undesignated sites ²⁴ greater than 250m of the waste body	0

* SAC 002031 The Twelve Bens/Garraun Complex

Table 3c: Leachate Migration: Receptors

Parameters	Points available
AQUIFER CATEGORY ²⁶ (resource potential)	
Regionally Important Aquifers (Rk, Rf, Rg)	5
Locally Important Aquifers (Ll, Lm, Lg)	3
Poor Aquifers (Pl, Pu)	1

²⁴ The term 'Undesignated sites' refers to wetland sites that are not designated under the Habitats or Birds Directive or Wildlife Act but are considered to be important on a local scale. Consultation with NPWS is required to identify such sites.

²⁶ This element needs to be determined during the site inspection (including walkover survey). The presence of a direct link between surface water drainage from the waste body and any adjacent surface water body implies the existence of a pathway.

Table 3d: Leachate Migration: Receptors

PUBLIC WATER SUPPLIES (other than private wells)	
Within 100m of site boundary	7
Greater than 100m but less than 300m or within Inner SPA (SI) for GW supplies	5
Greater than 300m but less than 1km or within Outer SPA (SO) for GW supplies	3
Greater than 1km (karst aquifer)	3
Greater than 1km (no karst aquifer)	0

Table 3e: Leachate Migration: Receptors

Parameters	Points available
SURFACE WATER BODIES	
Within 50m of site boundary	3
Greater than 50m but less than 250m	2
Greater than 250m but less than 1km	1
Greater than 1km	0

Table 3f: Landfill Gas: Receptor

Parameters	Points available
HUMAN PRESENCE	
On site or within 50m of site boundary	5
Greater than 50m but less than 150m	3
Greater than 150m but less than 250m	1
Greater than 250m	0.5