Comhairle Chontae Luimnigh

Tier 2 –Site Investigation Reports

VOLUME 1

For

Churchtown Landfill Site

Newcastle West

Co. Limerick

EPA Ref: S22-02465

19 October 2013

Prepared by:

Barry Murphy EE

Environment Section

Limerick County Council

Table of Contents

1. Introduction

1.1 Background

Limerick Co Council operated a historic landfill site at Churchtown, Newcastle West during the period 1950 to 1986. In accordance with the requirements of the *Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations 2008 (S.I. No. 524 of 2008)*, Limerick County Council is required to achieve Certification of Authorisation for the site. The Certification process requires that an Environmental Risk Assessment is carried out in accordance with the EPA document – **'Code of Practice: *Environmental Risk Assessment for Unregulated Waste Disposal Sites*'**.

In accordance with the EPA Code of Practice, the Environment Risk Assessment is carried out in three phases;

- Tier 1 Conceptual Site Model and Risk Screening and Prioritisation
- Tier 2 Site Investigations and Testing
- Tier 3 Refinement of CSM and Quantitive Risk Assessment.

This report contains the results of the Tier 2 site investigations carried out at Churchtown historic landfill site during the period November 2012 to August 2013. The investigations were carried out in accordance with the EPA Code of Practice: *Environmental Risk Assessment for Unregulated Waste Disposal Sites.* The site investigations were carried out in three phases:

- Preliminary Investigation March 2012
- Main investigation December 2012
- Additional Investigation March 2013

The onsite investigations were designed and supervised by *Tobin Consulting Engineering* and the Environment Section of Limerick Co Council.

1.2 Limitations

This report consolidates the factual information obtained from each phase of the Tier 2 site investigations and provides information on the contamination sources, pathways and receptors at Churchtown landfill site.

The *Tier 1 Report for Churchtown Landfill Site* contains information on the operational history of the site together with geological information and the preliminary environmental risk assessment which is not included in this report. The Tier 1 Report also contains a detailed draft report produced by *Tobin Consulting Engineers* titled *Newcastle Risk Assessment for Churchtown Landfill Site- September 2007* which provides information on the extensive site investigation and monitoring carried out at the site in 2007.

This report contains mainly factual information intended for use and interpretation in a separate follow on report, *Tier 3 Report for Churchtown Landfill.*

1.3 Report structure

This report is divided into two volumes. Volume one contains:

- Reports and surveys carried out directly by Limerick Co Council
- Summary of surveys and investigations produced by external Consultants
- Additional site information on the waste body, existing leachate collection system and capping layer.

Volume two contains:

- Site investigation and survey reports produced by external Consultants
- Ongoing LFG monitoring 2013
- Appendices for site investigations carried out by directly by Limerick Co Council.
- Ecological Assessment
- Historical monitoring data from 2001 to 2003
- Environment assessment of receiving waters.
- Gas Sim Model

Table 1 shows a schedule of the location with the report of the various investigations and surveys.

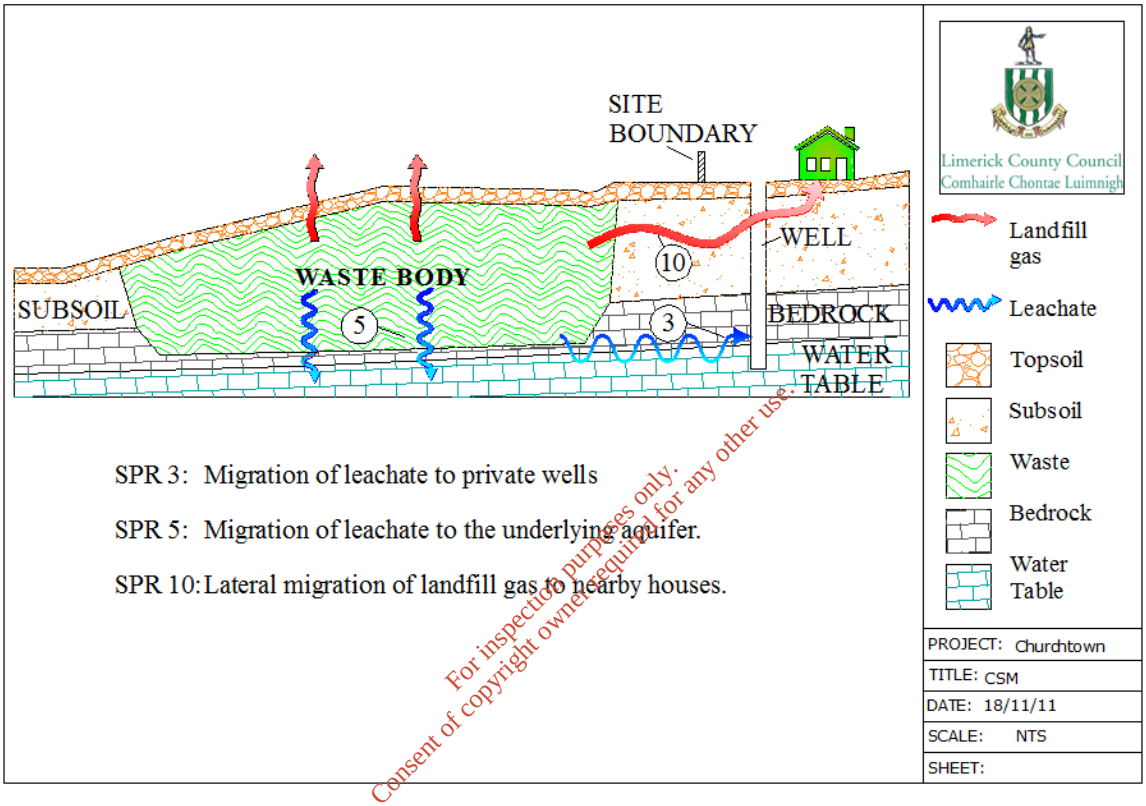
Table 1: Schedule of Site Investigation and Survey Reports.

Description	Company	Report location
Trail Hole Report	Limerick Co Council	Main Report in Chapter 2.1, Appendix to report contained Volume 2 - Appendix 1
Slit Trench Report	Limerick Co Council	Main Report in Chapter 2.2, Appendix to report contained in Volume 2 - Appendix 2
Geophysical Survey	Minerex Geophysics Ltd	Report summarised in Chapter 2.3, full report contained in Volume 2 - Appendix 3
Pump Test	Tobin Consulting Engineers	Report summarised in Chapter 2.4, full report contained in Volume 2 - Appendix 4
Gas Monitoring Boreholes	Limerick Co Council	Report contained in Chapter 3.2, Appendix to report contained in Volume 2 - Appendix 5
VOC Surface Emissions and Flux Box Survey	Odour Monitoring Ireland	Report summarised in Chapter3.3, full report contained in Volume 2 – Appendix 6.
VOC monitoring adjacent to Old Landfill Site.	AWN Consulting	Report summarised in Chapter3.4, full report contained in Volume 2 – Appendix 7.
Environmental Assessment of receiving waters for Churchtown Landfill.	Limerick Co Council	Report summarised in Chapter3.5, full report contained in Volume 2 – Appendix 8.
Survey, sampling and analysis of Waste Materials from Landfill in Churchtown, Newcastle West	BHP Laboratories	Report summarised in Chapter4, full report in Volume 2 – Appendix 9

Description	Company	Report location
Historic Sampling Analysis from Pumping Station	Limerick Co Council	Information summarised in Chapter 4.5, information contained in Volume 2 – Appendix 10
LFG Model for Churchtown Landfill Site	Tobin Consulting Engineers	Report summarised in Chapter 5.3, full report in Volume 2 – Appendix 11
Appropriate Assessment: Screening Document	Limerick Co Council	Report summarised in Chapter 6, full report in Appendix 12

1.4 Tier 1 Risk Assessment

The preliminary CSM and risk screening for the site is contained in the Limerick Co Council report *Tier 1 Report for Churchtown Historic Landfill Site*. The site is classified as a HIGH risk site in accordance with the EPA Code of Practice. The CSM for the site is contained in the Tier 1 report and is reproduced below:



2 Onsite Site investigations

The objective of the site investigations was to provide information to confirm or otherwise the HIGH risk classification for the site as well as informing the quantitative risk assessment to be undertaken as part of the Tier 3 Report.

The intrusive onsite investigations consisted of trial holing and slit trenching and the installation of additional monitoring boreholes. The non-intrusive investigation consisted of two geophysical surveys.

2.1 Trial Hole Report

2.1.1 Objective

The objectives of excavating trial holes were to provide information on:

- The age and composition of the waste
- Volume of the waste
- Extent of the waste
- Potential for LFG and leachate production
- Depth to bedrock and water table
- Condition of existing capping layer
- Allow sampling of the waste and leachate

2.1.2 Methodology

10 trial holes were excavated during the preliminary site investigation carried out between the 13th and the 18th February 2012. One additional trial hole, TH11 was excavated on the 3rd December 2012 to provide information to provide information on the source of high conductivity levels detected during the geophysical survey.

The location of the trial holes are shown in **Volume 2 -Appendix 1** on Drg ref: C -01.

The trial hole logs including photographs and detailed descriptions are shown in **Volume 2 - Appendix 1.**

The trial holes were excavated on a 40 x 40 metre rectangular grid. The location of each trial hole was set out using a one metre sub accuracy GPS. Minor changes were made to TH05 and TH09 to avoid an overhead power line.

The trial hole excavations were carried out under the supervision of Mr Barry Murphy, Executive Engineer, Limerick Co Council. A 20 T tracked excavator was used which permitted a maximum depth of 5 metres for the trial holes.

The top soil and subsoil was stripped and set to one side for latter reinstatement. The nature and depth of the capping layer was recorded and photographed. The excavation was continued in 300 m layers down to a maximum depth of 5 metres.

The trial holes were photographed and logged in accordance with British Standards BS5930:1999+A2: Code of Practice for Site Investigations. The trial hole locations were mapped onto the site specific topographical map drawn to Irish National Grid coordinates.

The trial holes were monitored for landfill gas (LFG) using a GFM series handheld gas monitor. The spoil heap was also monitored for LFG using the gas monitor and a 1 metre long searcher bar driven into the soil heap.

The factual information obtained from the trial holes in conjunction with the geophysical survey and analytical and sampling results are presented in Chapter 5 of this report.

2.2 Slit Trench Report

2.2.1 Objective

The objectives of taking the slit trenches were:

- Establish the extent of the waste around the site perimeter
- Provide information on the capping layer.

2.2.2 Methodology

12 Slit Trenches were excavated on the 15th February 2012, using a 20-tonne tracked machine fitted with a 450 mm wide bucket. An additional 3 number slit trenches were excavated on the 20th April 2013. The slit trenches were excavated under the supervision of Ms Carol Sweetnam, Executive Scientist, Regional Waste Office.

The location of the slit trenches is shown on drawing ref: C-02 contained in **Volume 2 - Appendix 2**

The slit trench logs including photographs are shown in **Volume 2 - Appendix 2**.

The extent of the slit trenches were logged using a sub metre hand held GPS. Each slit trench was photographed and a brief description was given of the waste encountered ad the condition of the capping layer.

It was not possible to extend Slit Trenches SL07 to SL14 to the site boundary due to a line of mature trees. No slit trenches were taken along the eastern perimeter of the site as the Tier 1 Risk Assessment Report (Tobin, 2007) established that the waste body extends onto the residential properties.

Slit trenches SL03 to SL06 show that the waste body extends beyond the northern boundary of the site. Slit trenches SL07 to SL14 show that the waste body extends very close to the southern boundary of the site. SL04 and SL15 show the extent of the waste body.

The information obtained from the slit trenches and the geophysical survey is used to define the extent of the waste body in Chapter 5.8 of this report.

2.3 Geophysical Report by Minerex Geophysics Ltd.

Minerex Geophysics Ltd. carried out a geophysical survey in 2012 consisting of EM31 ground conductivity, 2D resistivity and seismic refraction profiling. The main objective of the survey was to determine the extent and volume of the waste body and depth to bedrock.

In June 2013, Minerex carried out a further seismic survey of 8 short profiles in properties located along the eastern boundary of the site. The aim of the survey was to define the landfill boundary as precisely as possible.

The survey report and detailed results are contained in **Volume 2 -Appendix 3** and should be consulted for a detailed description of the site. The main findings of the geophysics report are:

- The boundary of the waste is well defined when combining the geophysics surveys, slit trenches and historic maps;
- The waste body extends beyond the northern and eastern present site boundaries. The eastern boundary of the site has been accurately defined using seismic profiling.
- The base of the quarry floor is 63 – 65 m AOD. The existing ground level varies from 68 to 78 m AOD. The thickness of the waste body is 5 to 15 metres;
- The waste body is approximately 1.86 Ha and contains approximately 186,000 m^3 of waste.
- The resistivity data shows that it is likely that some leachate has penetrated in to the bedrock occurs at the north-east of the site.

The factual information obtained from geophysical report in conjunction with trial holing and slit trenching, analytical and sampling results are presented in Chapter 5 of this report.

2.4 Pump Test Report – Tobin Consulting Engineers

Tobin's Consulting Engineers supervised the installation of two additional groundwater monitoring boreholes and three gas monitoring boreholes in November and December 2013. The additional monitoring boreholes were installed by Irish Drilling Limited and the factual site report is contained in **Volume 2 – Appendix 4**

A 5 day pump test was carried out in December 2013 to provide information on the groundwater flow regime at the site.

The additional site investigation and pump test results are contained in **Volume 2 – Appendix 4** and should be consulted for a full description of the test.

The main findings of the additional monitoring boreholes and pump test are:

- The direction of groundwater flow is from the north east to south west direction towards the tributary of the Dooally River.
- The underlying limestone has a moderate to low permeability estimated as 4.5 x 10^{-7} m/s.
- The transmissivity of the bedrock is low to moderate and estimated at 2 m^2/d.
- The landfill site does not have a major impact on the Dooally River.

3 Onsite Surveys and Monitoring

7 onsite surveys were carried out as part of the Tier 2 Site investigations. 4 related to LFG, 2 related to human presence and one to surface water quality in the nearby Dooally River.

3.1 Landfill Gas Survey 2012

A Landfill Gas (LFG) survey was taken as part of the Tier 2 Preliminary Site Investigation carried out in December 2012. The purpose of the survey was to check for the present of LFG in houses surrounding the landfill site and to check for the presence of LFG during and after the excavation of the trial holes.

The gas survey was carried out by Mr Barry Murphy, Executive Engineer, Limerick Co Council.

The measurements were taken with a GFM 450 Series hand held gas detector. Searcher bars were used to sample the subsoils to a maximum depth of 1 metre. Searcher bars were also used to detect the presence of LFG in the spoil heaps created during excavation of the trail holes.

Picture 1: Monitoring of spoil heap for LFG

The gas sampling locations are shown on Figure 1 below.

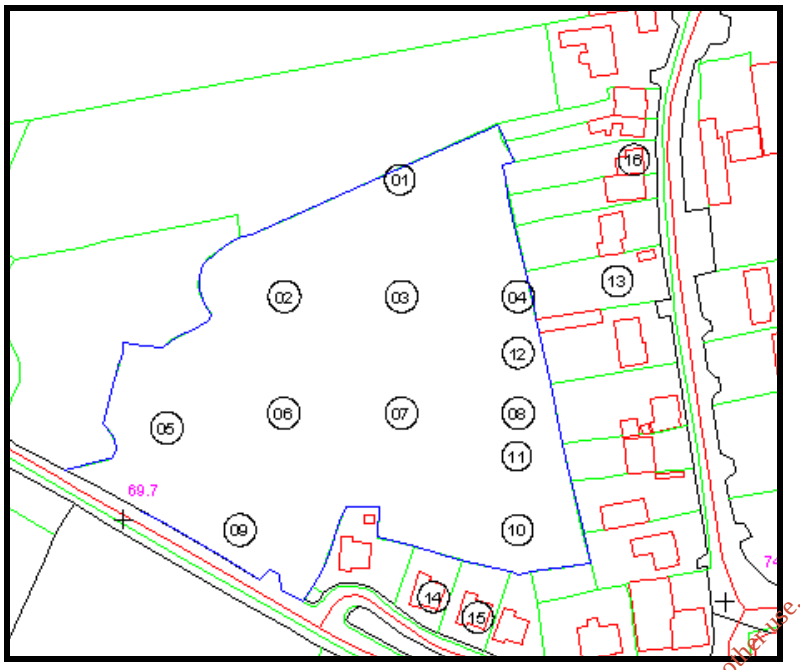


Figure 1: Location of Gas Survey monitoring points

The results of the LFG survey are presented in Table 2 below:

Table 2 Landfill Gas Monitoring Results

Location No	Location Description	Type	Time/Date	% CH_4	% CO_2	H_2S ppm	Pressure mb
1	TH01	Surface	18/02/2011	0	0.1		`1007
2	TH02	Surface	17/02/2012	0.1	0.1	0	1016
3	TH03	Surface	17/02/2012	0.1	0.1	0	1016
4	TH04	Surface	17/02/2012	0	0.1	0	1016
5	TH05	Surface	17/02/2012	0	0.1	0	1016
6	TH06	Surface	17/02/2012	0.1	0.1	0	1016
7	TH07	Surface	17/02/2012	0.1	0.1	0	1016
8	TH08	Surface	17/02/2012	0.1	0.1	0	1016

Location No	Location Description	Type	Time/Date	% CH_4	% CO_2	H_2S ppm	Pressure mb
9	TH09	Surface	17/02/2012	0.1	0.1	0	1016
10	TH10	Surface	18/02/2012	0	0.1	0	1007
11	Eastern Boundary	Subsurface	18/02/2012	0	0.1	0	1007
12	Eastern Boundary	Subsurface	18/02/2012	0.1	0.1	0	1007
13	Eastern Boundary	Subsurface	18/02/2012	0.1	0.1	0	1007
14	No.2 Evergreen Close	Living Room	18/02/2012	0.1	0.1	0	1007
15	No. 3 Evergreen Close	Living Room	18/02/2012	0	0.1	0	1007
16	Dwelling House	Living Room	18/02/2012	0	0.1	0	1007

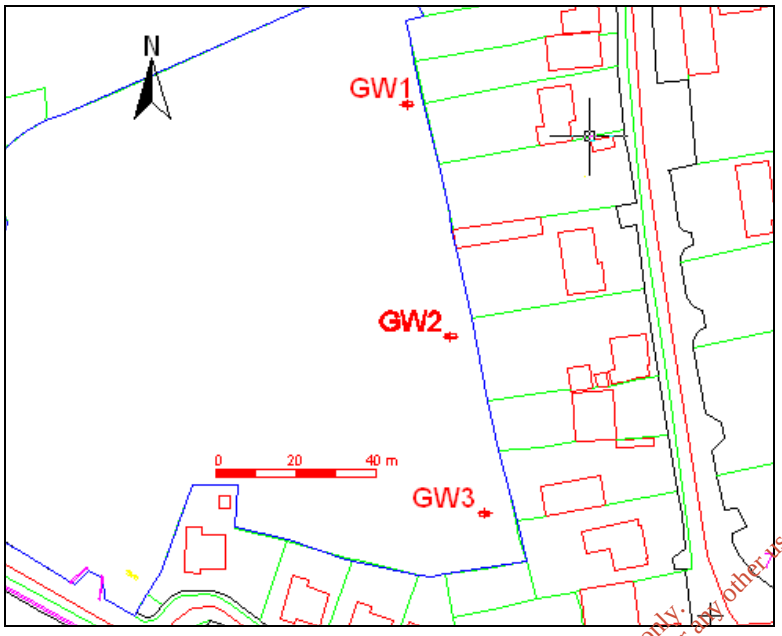
LFG was not detected at any location within the site during and after the excavation of trial holes in December. LFG was not detected in any of the three houses sampled.

3.2 Gas Monitoring Boreholes

Three gas monitoring boreholes were installed in December 2012 along the eastern boundary of the site in order to assess the level of LFG at the eastern perimeter of the site. The purpose of the boreholes was to check for the presence and concentration of LFG along the eastern perimeter of the site.

The location of the boreholes is shown in Figure 2 below:

Figure 2: Location of Gas Monitoring Boreholes



The boreholes were monitored using a handheld gas monitoring Model GF 450. The following parameters were recorded on each visit:

- Methane
- Carbon Dioxide
- Oxygen
- Differential pressure between borehole and atmosphere
- Gas Flow
- Atmospheric pressure

The rise /fall in atmospheric pressure were gauged from data taken at Shannon meteorological station.

The results of the monitoring with appropriate certification for the gas monitor is contained in **Volume 2 - Appendix 5** of this report. A summary of methane levels for each borehole is shown on the following page:

Table 3: Methane Readings at Churchtown boreholes

Date	Atmospheric Pressure (mbar)	GW1 (%)	GW2 (%)	GW3 (%)
14/03/2013	1011 steady	24.8	38.2	63.6
24/05/2013	1014 steady	35.7	4.3	72.8
04/06/2013	1027 falling	26.4	3.2	10.3
25/06/2013	1030 rising	30.4	1.1	0.0
05/07/2013	1028 falling	36.5	4.1	73.6
09/08/2013	1015 steady	28.6	4.2	4.0

Note: No differential pressure was recorded between the boreholes and atmosphere and no gas flows were recorded.

3.3 Gas Survey by Odour Monitoring Ireland

Odour Monitoring Ireland carried out a Volatile Organic Compound (VOC) walkover surface emissions survey and a flux box survey in May 2013. The main objective of the survey was to quantify landfill gas surface emissions on and adjacent to the site.

The survey report is contained in **Volume 2-Appendix 6** and should be consulted for a full description of the survey and results.

The main findings of the report are:

- The total VOC's emissions as methane from the permanently capped areas within the site is less than the guidance value of 100 ppm in LFTGN 07.
- The total VOC's as methane exceed the guidance value of 500 ppm at the top of boreholes GW1 and GW3.
- The flux chamber results within the site complied with the guideline limit values in LFTGN 07.

- Elevated VOC's were recorded with the hand held monitor at two localised hotspots to the east of the site, 129 ppm in the undeveloped site and 634 ppm in one garden.

- The flu chamber results exceed the guideline limits in LFTGN at three locations to the east of the site.

- Insufficient differential pressure was recorded as GW1, GW2 and GW3 to create gas flows.

3.4 Gas Survey by AWN Consulting

AWN Consulting carried out a Volatile Organic Compound (VOC) monitoring survey at five locations on and adjacent to the Churchtown landfill site in June 2013. Active monitoring was carried out over a 2 hour period at each location on the 4th June 2013 Passive monitoring was conducted at three locations adjacent to the eastern perimeter of the site between the 4th June and the 4th July 2013.

The main objective of the survey was to quantify landfill gas emissions at private properties located along the eastern perimeter of the site.

The survey report is contained in **Volume 2 - Appendix 7** and should be consulted for a full description of the survey and results.

The main findings from the gas survey are:

- Benzene levels exceeded Council Directive 2008/50/EC annual mean level of 5 µg/m^3 at two locations, a large garden shed and domestic garage.

- The concentrations of VOC detected at all locations during active sampling were below the limits of detection

Comment Benzene is very mobile in the environment and its source is likely to be of recent origin. There may be a secondary source of contamination at the site connected with leakage of fuel from storage tanks. Further investigations and long term monitoring

may be required to establish the source of the benzene and to establish an annual mean level.

3.5 Environmental Assessment of Receiving Waters

There are no surface water outfalls from the Churchtown landfill and consequently the Tier 1 Report did not identify any significant environmental risk to surface waters. However, the hydrogeological report for the site identified the possibility of a groundwater connection between the site and the Dooally River which flows approximately 500 metres to the south of the site.

Limerick Co Council carried out a biological water quality survey in May 2013 on the Dooally River in the vicinity of the landfill site. The sampling was carried out by Mr Rob Imbusch, Scientist, Limerick Co Council in accordance with the EPA Q-rating scheme.

The report is contained in **Volume 2 – Appendix 8** and should be consulted for full details of the site.

The key find of the report is that Churchtown landfill site is not having an impact on the biological water quality of the Dooally River in the vicinity of the site.

3.6 Survey of Possible Receptors

The extent of the waste body is larger than envisaged at the time of the Tier 1 Desktop study particularly with regard to the eastern boundary. Consequently, an insitu survey was required to update the number of human receptors sitting directly over the waste body and within 50 metres of the site.

The survey shows that there is one shed which extends directly over the waste body, as shown on Picture 1 below.

Picture 2 Building Directly Over Waste Body

- 1 building directly over the waste body, as discussed above and as shown on Picture 1 above;
- 15 properties within 50 metres of the waste body;
- 57 properties within 250 metres of the waste body.

3.7 Survey of Private Wells

There are no private wells within 250 metres of the landfill site. The closest private well is located 260 metres to the south-west of the landfill site on the lands of Mr. Peter Leonard. This well was installed in 2007. The well was bored to a depth of 40 metres. The well is used to supply water for cattle and horses only and is not used for human consumption. The well has never been sampled, to date.

The houses to the south and east of the site are supplied from the Newcastle West public water supply. The Newcastle West supply is supplied from the River Deal, the intake is located 3.5km south-east of NCW. The cluster of houses located 500 metres of the south-west are on the Killaughteen group water scheme which is supplied from the Newcastle West public water supply.

Figure 3: Location of Private Wells

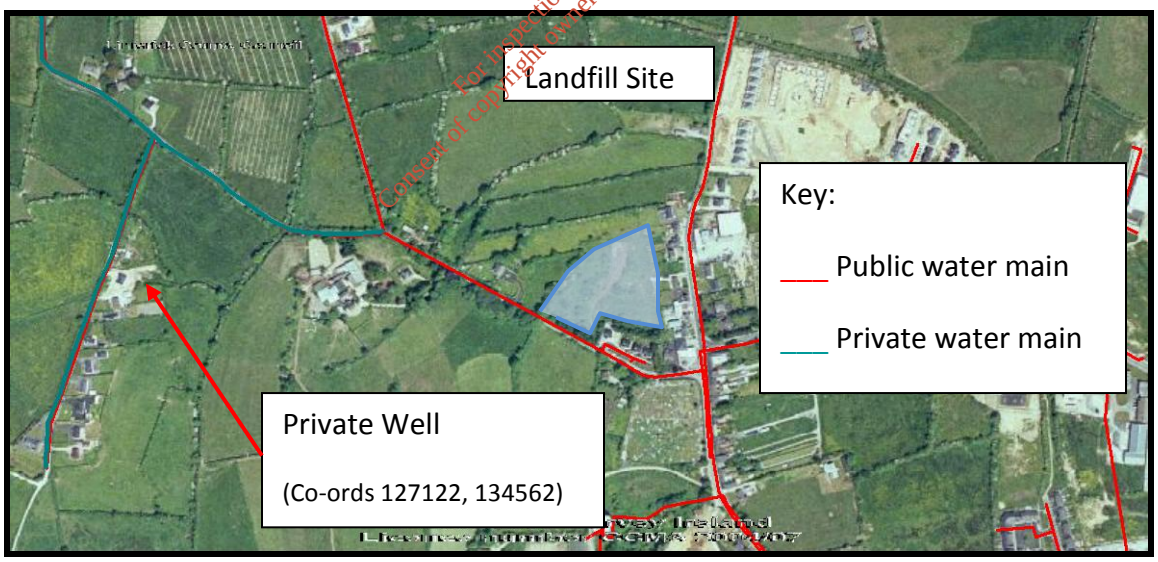


Figure Location of Public Water Mains

4 Tier 2 Sampling and Analysis

4.1 Introduction

The EPA Code of Practice and additional information from *Matrix 1-Guidance for Preliminary Investigations for all Unregulated Waste Disposal Sites* sets out the sampling requirements for site investigations at historic landfills.

The sampling and analysis results for the Tier 2 investigation are contained in **Volume 2 – Appendix 9**. The sampling was carried out in three phases summarised below:

Table 4: Summary of Tier 2 Sampling

Phase	Date	Company	Items
Preliminary Investigation	February 2012	BHP Ltd	Solid Waste Leachate Soil Samples Surface Water Sample
Main Investigation	December 2012	Alcontrol Laboratories	Borehole samples Surface water samples
Additional Investigation	April 2013	City Analysts Ltd	Surface water Boreholes

The solid waste samples were sampled to show comparison with Council Decision 2003/33/EC European Waste Acceptance Criteria (WAC) analysis, as per the BS EN 12457/3 testing standard.

Soil samples were analysed in accordance with BS5930 and tested for particle size analysis, Attenberg Limits and permeability.

The onsite samples during the Preliminary Investigation were taken by Mr Paul O'Sullivan of *BHP*, Thomondgate, Co. Limerick. The following samples were taken:

Table 5: Samples taken by BHP

Sample Type	Sampling Location (bgl = below ground level)	Parameters Tested
Leachate	TH02 – 4.4 metres bgl TH03 – 2.5 metres bgl TH04 – 3.8 metres bgl TH05 – 1.8 metres bgl	Table C.2 of EPA Landfill Manual – *'Landfill Monitoring'*, 2003 *SI 12/2001 - Water Quality (Dangerous Substances) Regulations, 2001*
Solid Waste	TH02 – composite TH03- composite TH04 – composite	*Council Decision - 2003/33/EU* Acceptance Criteria for Landfill for Inert Waste
Surface water	Leonard's Ditch	Table C.2 of EPA Landfill Manual– *'Landfill Monitoring'*, 2003 *SI 12/2001 - Water Quality (Dangerous Substances) Regulations, 2001*
Capping layer	TH04	Particle Size Distribution
Subsoil	TH05	Permeability Attenberg Limits Particle Size Distribution Moisture Content

The analytical and test results are contained BHP report *Survey, sampling and analysis of Waste Materials from Landfill in Churchtown, Newcastle West* -see **Volume 2 - Appendix 9**.

4.2 Solid Waste Analysis

A summary of the solid waste sample analysis results for TH02, TH03 and TH04 with a comparison with the Acceptance Criteria for Landfill for Inert Waste – (*Council Decision - 2003/33/EU*) is presented on the following Tables 6, 7 and 8.

Table 9 provides a comparison of the organic parameters from TH02, TH03 and TH04 with Table 2.1.2.2 of the Acceptance Criteria for Landfill (*Council Decision - 2003/33/EU*). Parameters exceeding the criteria for non-hazardous waste are highlighted in red.

The solid waste samples indicate that the waste body at Churchtown can be considered as non-hazardous in accordance with EU Waste Acceptance Criteria;

Table 6 Waste Acceptance Criteria for Trial Hole – TH02

Determinant	TH02			Limit Values for Inert Waste (*Council Decision 2003/33/EC*)			Limit Values for Non-Hazardous Waste (*Council Decision 2003/33/EU*)		
	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)
Arsenic	0.002	<0.001	0.002	0.1	0.5	0.06	0.4	2	0.3
Barium	0.012	0.004	0.012	7	20	4	30	100	20
Cadmium	<0.001	0.001	0.006	0.03	0.04	0.02	0.6	1	0.3
Total Chromium	0.04	0.002	0.011	0.2	0.5	0.1	4	10	2.5
Copper	0.49	0.027	0.096	0.9	2	0.6	25	50	30
Mercury	<0.0002	<0.0002	<0.0002	0.003	0.01	0.002	0.05	0.2	0.03
Molybdenum	0.012	0.001	0.002	0.3	0.5	0.2	5	10	3.5
Nickel	0.18	0.004	0.027	0.2	0.4	0.12	5	10	3
Lead	0.024	0.011	0.032	0.2	0.5	0.15	5	10	3
Antimony	<0.001	<0.001	<0.001	0.02	0.06	0.1	0.2	0.7	.015
Selenium	0.004	0.001	0.001	0.06	0.1	0.04	0.3	0.5	0.2
Zinc	0.21	0.014	0.039	2	4	1.2	25	50	15
Chloride	18.8	2.49	16.7	550	800	460	10000	15000	8500
Fluoride	0.74	0.16	0.52	4	10	2.5	60	150	40
Sulphate	254	24.7	224.7	560	1000	1500	10000	20000	7000
Dissolved Organic Carbon	108	120	510	240	500	160	380	800	250
Total Dissolved Solids	378	1012	-	2500	4000	-	40000	60000	-
Phenol Index	0.008	0.012	0.124	0.5	1	0.3			

Table 7 Waste Acceptance Criteria for Trial Hole – TH03

Determinant	TH03			Limit Values for Inert Waste (*Council Decision 2003/33/EC*)			Limit Values for Non Hazardous Waste (*Council Decision 2003/33/EC*)		
	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)
Arsenic	<0.001	<0.001	0.001	0.1	0.5	0.06	0.4	2	0.3
Barium	0.024	0.006	0.036	7	20	4	30	100	20
Cadmium	<0.001	0.001	0.006	0.03	0.04	0.02	0.6	1	0.3
Total Chromium	0.07	0.012	0.018	0.2	0.5	0.1	4	10	2.5
Copper	0.31	0.18	0.049	0.9	2	0.6	25	50	30
Mercury	<0.0002	<0.0002	<0.002	0.003	0.01	0.002	0.05	0.2	0.03
Molybdenum	0.008	0.002	0.003	0.3	0.5	0.2	5	10	3.5
Nickel	0.039	0.019	0.054	0.2	0.4	0.12	5	10	3
Lead	0.024	0.009	0.036	0.2	0.5	0.15	5	10	3
Antimony	<0.001	<0.001	<0.001	0.02	0.06	0.1	0.2	0.7	.015
Selenium	0.002	0.001	0.001	0.06	0.1	0.04	0.3	0.5	0.2
Zinc	0.16	0.024	0.022	2	4	1.2	25	50	15
Chloride	98	10.7	231	550	800	460	10000	15000	8500
Fluoride	0.68	0.15	0.25	4	10	2.5	60	150	40
Sulphate	101	127	459	560	1000	1500	10000	20000	7000
Dissolved Organic Carbon	82	270	670	240	500	160	380	800	250
Total Dissolved Solids	458	880	-	2500	4000	-	40000	60000	-
Phenol Index	0.122	0.036	0.212	0.5	1	0.3			

Table 8 Waste Acceptance Criteria for Trial Hole – TH04

Determinant	TH04			Limit Values for Inert Waste (*Council Decision 2003/33/EC*)			Limit Values for Non Hazardous Waste (*Council Decision 2003/33/EU*)		
	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)	2 l/kg (mg/kg Dry Substance)	10 l/kg (mg/kg Dry Substance)	0.1 l/kg (mg/l)
Arsenic	<0.001	<0.001	0.002	0.1	0.5	0.06	0.4	2	0.3
Barium	0.036	0.014	0.041	7	20	4	30	100	20
Cadmium	<0.001	0.011	0.007	0.03	0.04	0.02	0.6	1	0.3
Total Chromium	0.019	0.008	0.032	0.2	0.5	0.1	4	10	2.5
Copper	0.3	0.21	0.049	0.9	2	0.6	25	50	30
Mercury	<0.0002	<0.0002	<0.002	0.003	0.01	0.002	0.05	0.2	0.03
Molybdenum	0.012	0.001	0.001	0.3	0.5	0.2	5	10	3.5
Nickel	0.043	0.008	0.054	0.2	0.4	0.12	5	10	3
Lead	0.021	0.006	0.031	0.2	0.5	0.15	5	10	3
Antimony	<0.001	<0.001	<0.001	0.02	0.06	0.1	0.2	0.7	.015
Selenium	0.001	0.001	0.001	0.06	0.1	0.04	0.3	0.5	0.2
Zinc	0.11	0.036	0.029	2	4	1.2	25	50	15
Chloride	80	19.1	229	550	800	460	10000	15000	8500
Fluoride	0.62	0.6	0.43	4	10	2.5	60	150	40
Sulphate	208	19.1	295	560	1000	1500	10000	20000	7000
Dissolved Organic Carbon	360	180	610	240	500	160	380	800	250
Total Dissolved Solids	1010	568	-	2500	4000	-	40000	60000	-
Phenol Index	0.245	0.048	0.185	0.5	1	0.3			

Table 9 Organic Parameters for Solid Waste Samples

Determinant (mg/kg)	**TH02**	**TH03**	**TH04**	**Limit Values for Inert Waste** (*Council Decision 203/33/EC*)
Total Organic Carbon	75,000 See Note 1	92,500 See Note 1	111,200 See Note 1	30,000
BTEX	<0.01	<0.01	<0.01	6
PCBs	<0.001	<0.001	<0.001	1
Mineral Oil (C10 to C40)	<0.1	<0.1	<0.1	500
PAHs (16)	<0.005	<0.005	<0.005	-

Note 1: EC Council decision 2003/33/EC allows a higher limit to be admitted by a competent authority provided that the Dissolved Organic Carbon value is less than 800 mg/l.

4.3 Leachate Analysis

Liquid samples were analysed to show comparison with Table C.2 of EPA Landfill Monitoring Manual 2003.

The key finding of the BHP report is that the water samples meet the standards set down in SI 12/01 Water Quality (Dangerous Substances) Regulations 2001.

- The leachate samples from the trial holes indicate very low levels of contamination. The ammonia levels from the 4 trial holes samples indicate slightly elevated levels in the range 64 to 75 mg/l.
- The leachate does not contain elevated levels of heavy metals or organic parameters;
- The water sample from Leonard's ditch does not exhibit parameters associated with leachate.

Table 10 Leachate Parameters

Determinant	Units	TH02	TH03	TH04	TH05	Leonard's Stream	Typical Methanogenic Leachate *Note 1
Water Level	m	4.4	2.5	3.8	1.8	N/A	N/A
Temperature	^{O}C	11	11	12.6	12.4	9.8	N/A
pH-value		6.6	6.48	6.4	6.76	6.68	7.35
Conductivity	uS/cm	1942	1667	1418	681	429	10,000
Ammonia (as NH_3-N)	mg/l	64.6	75.28	70.73	63.75	0.43	902
Nitrate (as NO_3)	mg/l	1.55	0.81	0.9	2.66	0.53	3.1
Nitrite (as NO_2)	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
Total Oxidised Nitrogen (as N)	mg/l	0.35	0.18	0.2	0.6	0.12	-
BOD_5	mg/l	11	9	25	28	3	253
COD	mg/l	158	437	659	84	44	1,770
Calcium	mg/l	48.9	75.4	82.4	65.8	54.2	117
Magnesium	mg/l	15.6	22.49	21.16	17.86	16.83	166
Sodium	mg/l	34.51	34.56	36.54	39.77	62.11	1,400
Potassium	mg/l	32.05	21.99	41.87	44.68	34.1	791
Iron	ug/l	560	453	652	893	<1	1,530
Manganese	ug/l	206	11	24	406	759	300
Cadmium	ug/l	<0.1	<0.1	<0.1	<0.1	<0.1	<10
Total Chromium	ug/l	<1	<1	1	<1	<1	70
Copper	ug/l	<1	<1	<1	<1	<1	70

Determinant	Units	TH02	TH03	TH04	TH05	Leonard's Stream	Typical Methanogenic Leachate *Note 1
Nickel	ug/l	<1	<1	<1	<1	<1	140
Lead	ug/l	2	2	2	3	3	130
Zinc	ug/l	12	12	13	14	7	780
Arsenic	ug/l	<0.9	<0.9	<0.9	<0.9	<0.9	9
Boron	ug/l	9	11	16	8	12	-
Mercury	ug/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.1
Sulphate	mg/l	6.1	19.9	5.42	9.63	10.43	35
Chloride	mg/l	47.8	71.7	47.5	47.6	51.27	1,950
Molybate Reactive Phosphorus (as P)	mg/l	0.23	0.24	0.24	0.75	0.15	2.7
Total Cyanide	mg/l	0.05	0.119	0.031	0.032	0.015	-
Fluoride	mg/l	0.13	<0.05	<0.05	0.14	0.12	-
Atrazine	ug/l	<1	<1	<1	<1	<1	-
Dichloromethane	ug/l	<1	<1	<1	<1	<1	-
Simazine	ug/l	<1	<1	<1	<1	<1	-
Toluene	ug/l	<1	<1	<1	<1	<1	-
Tributyltin	ug/l	<0.001	<0.001	<0.001	<0.001	<0.001	-
Total Xylenes	ug/l	<1	<1	<1	<1	<1	-

*** Note 1:** Median Values for Methanogenic Leachates Sampled from Large Landfills with a Relatively Dry High Waste Input Rate' (Table 7.2, EPA Landfill Manual – *'Landfill Site Design'* 2000)

4.4 Geotechnical Testing

BHP carried out geotechnical testing on two soil samples taken at Churchtown landfill site. The purpose of the samples was to provide information on the insitu subsoils and on the composition of the existing capping layer.

A sample of the subsoil from beneath the waste at TH10 was sampled and analysed for

- Permeability
- Attenberg Limits
- Particle Size Distribution
- Moisture Content

The detailed soil analysis results are contained in Volume 2 - **Appendix 9**, the results are summarised below:

Liquid Limit	40
Plasticity Limit	19
Plasticity Index	21
Moisture Content	22.2%
% CLAY	52%
% SILT	35%
Permeability	1 x 10^{-10} m/s

The subsoils consist of a light brown firm CLAY with a massive structure and intermediate plasticity. The native subsoils have an extremely high CLAY content and low permeability. These soils have the potential to form an effective barrier to prevent leachate migrating to the underlying aquifer.

The existing capping layer in the eastern section of the site contains a large fraction of fractured shale stone with very little cohesive material. A sample was taken from the capping layer at TH04 and analysed for particle size distribution in accordance with IS EN 933-1 .

The analysis indicates that 95% of the sample consists of gravel.

4.5 Historic Leachate Monitoring by Limerick Co Council

In 1990, Limerick County Council constructed a sump and a pumping station in the south-west corner of the site. Surface water from the site was discharged via a rising main to the foul public main.

In the period 2001-2003 Limerick County Council Environmental Laboratory analysed samples from the pumping station. The analysis results are contained in **Appendix 10.** A comparison if the median results with the 'Median Values for Methanogenic Leachates Sampled from Large Landfills with a Relatively Dry High Waste Input Rate' (Table 7.2, EPA Landfill Manual – '*Landfill Site Design'* 2000) is given below, with elevated concentrations highlighted in yellow.

Table 11 Leachate Samples from Pumping Station

Determinant (mg/l unless otherwise stated)	Units	Limerick County Council Pumping Station Results 2001 to 2003 - Median	BHP Trail Hole Results 2012 Median
pH-value		7.6	6.54
conductivity	(µS/cm)	718.5	1542
alkalinity ($CaCO_3$)		350.5	
COD	mg/l	60.5	297
BOD_5	mg/l	12.34	18
TOC	mg/l	17	
ammmoniacal-N	mg/l	5.24	67
nitrate-N	mg/l	1.27	1.225
sulphate (as SO_4)	mg/l	11.04	7.865
Chloride	mg/l	31.54	47.7
Sodium	mg/l	25.51	35.55
Magnesium	mg/l	23.25	19.51
Potassium	mg/l	28.08	36.96

Determinant (mg/l unless otherwise stated)	Units	Limerick County Council Pumping Station Results 2001 to 2003 - Median	BHP Trail Hole Results 2012 Median
Calcium	mg/l	66.3	70.6
Chromium	mg/l	0.0102	1
Manganese	mg/l	0.154	115
Iron	mg/l	1.3	606
Nickel	mg/l	0.02	<1
Copper	mg/l	0.01004	<1
Zinc	mg/l	0.04	12.5
Cadmium	mg/l		<0.1
Mercury	mg/l		<0.2
Lead	mg/l		2

The analysis indicates that the water samples taken from the pumping station in 2002-2003 showed very slight levels of contamination.

5 Site Information

5.1 Exiting LFG Collection and Treatment System

There is no LFG collection or treatment system at Churchtown site.

5.2 Existing Leachate Collection and Treatment System

The site is unusual in that there is no surface water outfall or perimeter drainage ditches. All surface water drains towards the south-west corner of the site. Shortly after the closure of the site in the late 1980's, there was considerable ponding of contaminated water in the south-west corner of the site. Some the water overflowed onto the adjoining property. To prevent further surface water ponding, a concrete sump and pumping station was installed at the lowest part of the site and connected to the public foul main via a 100 mm rising main.

The pumping station operated from the late 1990's until approximately 2004. The pumping station was re-commissioned during the main site investigation in 2012 and is now operational. The pumping station effectively removes slightly contaminated water from the site.

5.3 Gas Sim Model By Tobin Consulting Engineers

Tobin Consulting Engineers carried out a Gas Sim Model to estimate the volume of LFG now being produced at the site.

The report is contained in Volume 2 Appendix 11 and should be consulted for full details of the site.

The main findings of the report are:

The theoretical volume of LFG produced in 2012 is in the order of 21 m^3 / hour. The theoretical volume in 1986 at the time of closure of the site was 54 m^3/hour.

5.4 Type of Waste – EU Decision 2003/33/EU

Council Decision 2003/33/EU specifies the uniform classification and acceptance procedure for the landfill of waste in the EU (including Ireland). The Decision provides criteria for the classification of waste into three categories - inert, non-hazardous and hazardous.

During the Tier 2 Preliminary Site Investigation, *BHP Laboratories Ltd.* took solid waste and leachate samples from Trial Holes - TH02, TH03 and TH04. A further leachate sample was taken from Trial Hole - TH05. A summary of the analyses results are contained in Chapter 4.2 with the full analyses results sheets contained in Volume 2 **Appendix 9**.

The analyses results indicate that the waste material at Churchtown complies with the criteria for non hazardous waste and is very close to complying with the criteria for inert waste (with the exception of TOC limit).

5.5 Composition of Waste

The waste at Churchtown landfill site consists predominately of domestic and commercial waste with some pockets of industrial and inert waste. The commercial and domestic waste types are largely co-mingled throughout the site. The inert waste occurs in high concentrations at the south-west of the site in the vicinity of TH06 and TH11. Some industrial waste consisting of plastic moulds were uncovered at the northern extent of the site in TH01.

No hazardous waste was uncovered during the site investigations. Records held by Limerick County Council show that the site generated numerous odour and vermin complaints from local residents. If an effort to mitigate the problem, Limerick Co Council employed a full time gateman with instructions to exclude hazardous and malodourous waste from the site. In addition, the County Engineer in the 1970's instructed that the waste be covered with equal volumes of inert backfill.

The trial holes indicate that the waste throughout the site was mixed with a very high fraction of inert material, predominately fractured shale sourced locally but also with subsoil and occasionally C&D material. The high stone content provides numerous drainage pathways for the downward migration of surface water and the upward migration of LFG.

The waste body exposed in the trial holes, with the exception of TH05 is dry and contains very little perched leachate. The waste body at TH05 is noticeably wetter that elsewhere and contains leachate at 1.5 metres below ground level. TH05 is located at the lowest part of the site and the waste body is underlain by CLAY subsoils rather that bedrock. The waste at TH05 does not contain the large fraction of inert backfill that occurs elsewhere on site.

The European Waste Codes provide a system for cataloging and assigning waste codes to different types of waste. The following types of waste were uncovered in trial holes:

Table 12 Waste Types Found at Churchtown Landfill Site

EWC Code	Category	Description
02	Waste from Food Preparation	Fatty waste discovered in Slit Trench - SL01 likely to have originated from a former commercial cheese manufacturer in the area.
15	Waste Packaging	Paper and cardboard packaging in Trial holes - TH01, TH02, TH05 Plastic packaging in Trail Holes - TH01,TH02,TH05,TH10 Textile packaging in Trial Holes - TH01,TH05
16	End of life vehicles	Car tyre in Trial Holes - TH03,TH10 Car exhaust in Trial Hole - TH02
17	Construction and Demolition	Concrete, bricks in Trial Hole - TH06

EWC Code	Category	Description
	waste	Soil and stones in Trial Hole - TH06
20	Municipal wastes including household waste and similar commercial and industrial waste	Paper and cardboard in all Trial Holes except Trail Hole - TH09 Glass in all Trial Holes. Biodegradable kitchen waste in all Trial Holes except Trial HoleTH09 Clothes in very small quantities in all Trial Holes except Trial Hole - TH09 Nappies in Trial Holes - TH01, TH05 and TH09 Textiles high decomposed found in very small quantities in all Trial Holes except Trial Hole - TH09 Batteries – 2 small batteries in Trial Hole - TH07. Discarded electrical equipment –washing machine in Trial Hole - TH05. Wood – small quantities in Trial Hole - TH03 Plastic – in all Trial Holes except Trial Hole - TH09. Metals – in all Trial Holes except Trial Hole - TH09. Bulky waste-milk churn and washing machine in Trial Hole - TH06, 50 gallon drum in Trial Hole TH08.

5.6 Waste Age

The waste body at Churchtown ranges from 27 to 78 years old.

Waste disposal started at the site in the mid 1930's when the site was in private ownership. Limerick County Council acquired the site in the late 1940's and operated a landfill site until the site closed in 1986. Waste disposal intensified in the early 1970's when Limerick Co Council started a commercial waste collection service.

The waste at the site appears to have been placed in two phases. The earliest waste, predating the 1960's was placed at the front of the site adjacent to the public road and existing site entrance. The waste is totally decomposed and contains no plastic, timber or metals. The main waste body was placed progressively across the entire site. Plastic was found in all trial holes and newspapers dated from September 1977 to May 1986 were found in eight trial holes

5.7 Volume of Waste

The Minerex Geophysics report estimates that the volume of the waste body, including inert backfill is 186,000 $m^{3.}$

There was no weigh bridge in operation during the operation phase of Churchtown landfill. However, the volume of waste can be estimated from the An Foras Forbatha Report – *'National Database on Waste 1986'* indicates that the site accepted 10,000 tonnes of waste per annum.

There are no figures available from 1935 to 1970, but the volumes of waste deposited would have been relatively low. Local knowledge says that commercial waste was collected on a daily basis from the town of Newcastle West using a horse and cart until the early 1960's.

The ERSI Report - [1]*'Estimating Historical Landfill Quantities to Predict Methane Emissions'* provides some guidance on the volumes of waste that were landfilled in the period 1960 to 2008. The report estimates that 1.98 million tonnes of waste was landfilled in 1960. Combining this with the 1961 census figures indicates that approximately 700 kg of waste was landfilled per head of population per annum. Churchtown landfill site was used mainly for Newcastle West town and environs which had a combined population of around 3,500. Therefore an approximation for the annual tonnage of waste in 1960 was:

3,500 x 0.7 = 2450 tonnes.

Assuming a figure of 2,500 tonnes per annum for the period 1935 to 1970, the total volume of waste at Churchtown landfill becomes:

Table 13 Amount of Waste Deposited

Period	Waste (Tonnes / Annum)	Total (Tonnes)
1935 to 1969	2,500	87,500
1970 to 1979	5,000	50,000
1980 to 1986	10,000	70,000
	Total	**207,500**

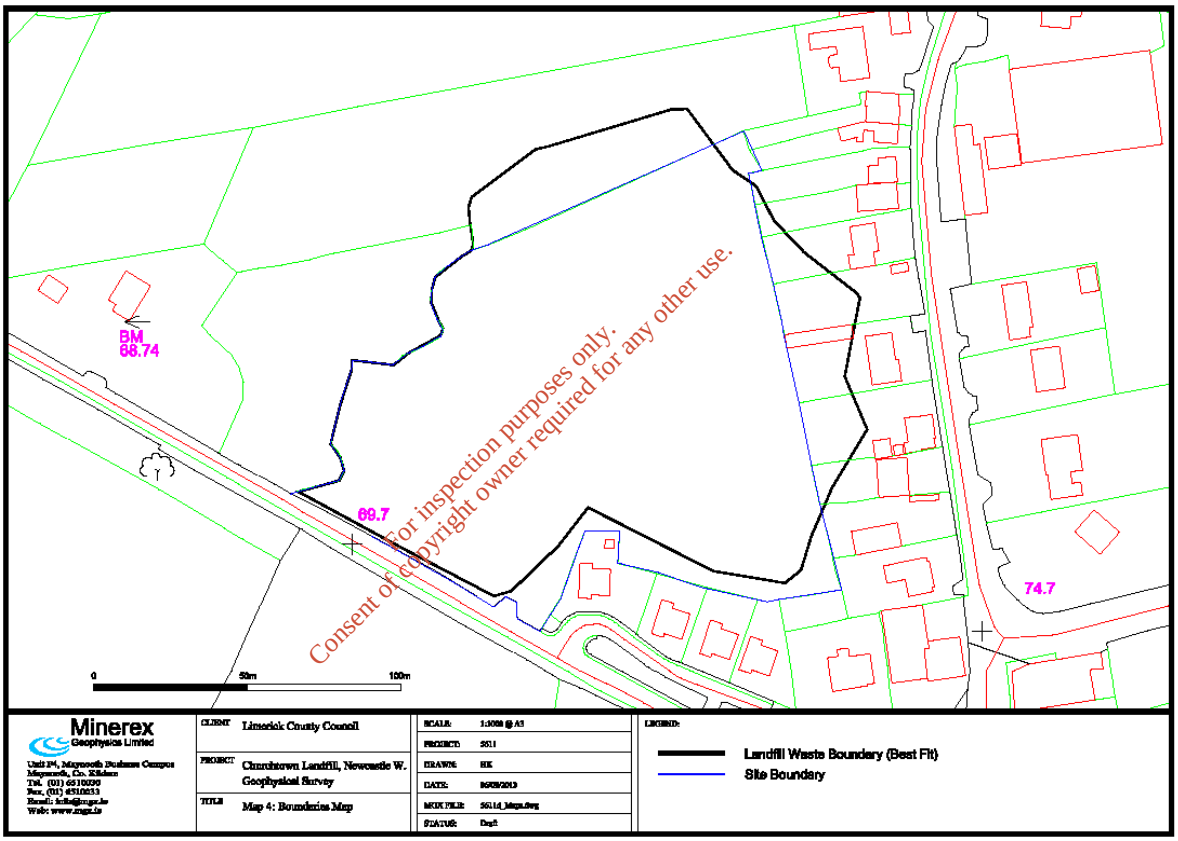
Assuming a relatively low waste density of 1.5 tonnes/m^3, this equates to a waste volume of 138,000 m^3. This figure does not include for inert backfill material which was placed in unusually large amounts at the site in order to reduce odour complaints.

[1] Working Paper 333 December 2009

5.8 Extent of the Waste

The waste body at Churchtown is 1.86 Hectares in extent. The waste body extends beyond the current site boundary to the north and east of the site. The extent of the waste body is shown on Drg 5 in the Minerex Geophysics report and shown in outline below.

Figure 4: Extent of Waste Body



The extent of the waste body has been defined using the following data:

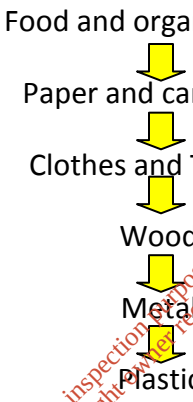
- Cobra probes from Tobin Report 2007 — See Tier 1 Report
- Slit trenches carried out Limerick Co Council 2012-13 — See Appendix 2
- Geophysical survey 2012 — See Appendix 3
- Additional seismic survey 2013 — See Appendix 3

5.9 Decomposition of the Waste

The waste body is highly decomposed throughout the site and consists largely of plastic packaging with occasional fragments of glass, timber, textiles and metal. Organic waste and paper are largely absent throughout the site.

There are pockets of less decomposed waste in the vicinity of TH03, TH05 and TH10.

The state of decomposition can be gauged from the presence or absence of different waste materials. The typical decomposition sequence for the waste streams, starting with the fastest decomposition rate is:



There was no organic food waste in the Trial Holes or Silt Trenches, with the exception of Slit Trench - SL01 and a preserved fragment of orange peel in Trial Hole - TH03. Most papers, cardboard, textiles and timber have fully decomposed although there are occasional small fragments surviving of each waste type in each trial hole. The localised variations in waste decomposition may be due to the formation of micro environments created by the entombing of sections of waste in intact plastic bags.

The Ground Conductivity Geophysical Survey indicates that there are large amounts of metal in the waste body along the eastern perimeter of the site and at one location in the south-west section of the site. TH11 was excavated at the hotspot in the south-west of the site. A large fraction of metal objects including a fridge, milking churn and wire meshing was uncovered.

Most large metal objects exposed in the trial holes showed low levels of corrosion which may indicate that large sections of the waste body are very dry.

The waste in TH09 is completely decomposed with the exception of glass bottles. There is no plastic at this location.

All the Trial Holes were monitored during excavation for LFG with a hand held gas meter. No methane was detected in any Trial Hole. However, the disturbance of the waste produced detectable transient odours at TH03, TH05, TH10 and TH11.

5.10 Depth and Composition of the Capping Layer.

There is no engineered capping layer at Churchtown landfill site. The existing cap is highly permeable and allows the free ingress of surface water and migration of LFG to the atmosphere.

Following closure of the site in the mid 1980's, the waste body was capped off with variable depths of fractured shale, topsoil and C&D material. There is no CLAY subsoil layer at the site.

The existing capping layer can be considered in three areas. The cap in the eastern section of the site consists mainly of fractured shale stone covered with a very shallow layer of topsoil/vegetation. The western part of the site consists mainly of a loose topsoil layer lying directly on the waste. The third area is centered on TH06 and TH011 and consists of coarse C&D material lying directly on the waste.

Within each area there is a high degree of variability in the depth and composition of the capping layer. The capping layer was recorded at 11 trial holes and 12 slit trenches. The thickness of the capping layer varies from 0.1 to 1.0 metres but is typically just 0.3 metres – refer to Table 14 for details.

Table 14: Composition of Existing Capping Layer

Trial Hole / Slit Trench	Depth of Capping Layer (m)	Composition of Capping Layer
TH01	0.6	0.1 metres of topsoil overlying 0.5 metres of coarse gravel.
TH02	0.9	0.3 metres of topsoil overlying 0.6 metres of fractured shale stone.
TH03	0.1	Topsoil
TH04	1.8	0.1 metres of topsoil overlying 1.7 metres of fractured stone backfill.
TH05	0.3	Topsoil
TH06	0.8	Construction and Demolition material
TH07	0.2	Topsoil
TH08	0.2	Topsoil
TH09	0.3	Topsoil
TH10	0.3	Topsoil
TH11	0.7	Construction and Demolition material
SL01	0.2	Coarse gravel
SL02	0.4	0.3 metres of topsoil overlying 0.1 metres of coarse gravel.
SL03	1.0	0.3 metres of topsoil overlying 0.7 metres of fracture stone backfill.
SL04	0.4	Topsoil
SL05	0.4	Coarse gravel.

Trial Hole / Slit Trench	Depth of Capping Layer (m)	Composition of Capping Layer
SL06	0.5	Topsoil
SL07	0.7	Topsoil
SL08	0.5	Topsoil
SL10	0.3	Topsoil
SL11	0.3	0.2 metres of Topsoil overlying 0.1 metres of coarse gravel.
SL12	0.2	0.4 metres of topsoil overlying 0.2 metres of gravel.

BHP Laboratories Ltd. carried out a particle size distribution analysis on the stone capping material in the eastern section of the site which shows that the material complies with 6F1/6F2 capping material as defined in the Specification for Road Works. This material is free draining and will permit surface water to penetrate into the waste body. It will also provide a flow path for LFG to vent to the atmosphere.

The capping layer in the western part of the site consists of a shallow layer of topsoil which sits directly on the waste body. There is also an extensive area capped with C&D material in the vicinity of Trial Hole - TH06. The shallow top soil layer does not provide a permeable barrier to prevent the ingress of surface water.

6 Appropriate Assessment

Limerick Co Council carried out a screening report in accordance with the requirements of Article 6(3) of the EU Habitats Directive (92/43/EEC) to determine if a full Appropriate Assessment was required at the site.

The report is contained in **Volume 2 Appendix 12** and should be consulted for full details of the site.

The key findings of the report are that a full Appropriate Assessment is not required for the site.

Signed:

_____

Barry Murphy EE
Environment Section
Limerick County Council

Comhairle Chontae Luimnigh

Tier 2 –Site Investigation Reports

VOLUME 2

For

Churchtown Landfill Site

Newcastle West

Co. Limerick

EPA Ref: S22-02465

19 October 2013

Prepared by:

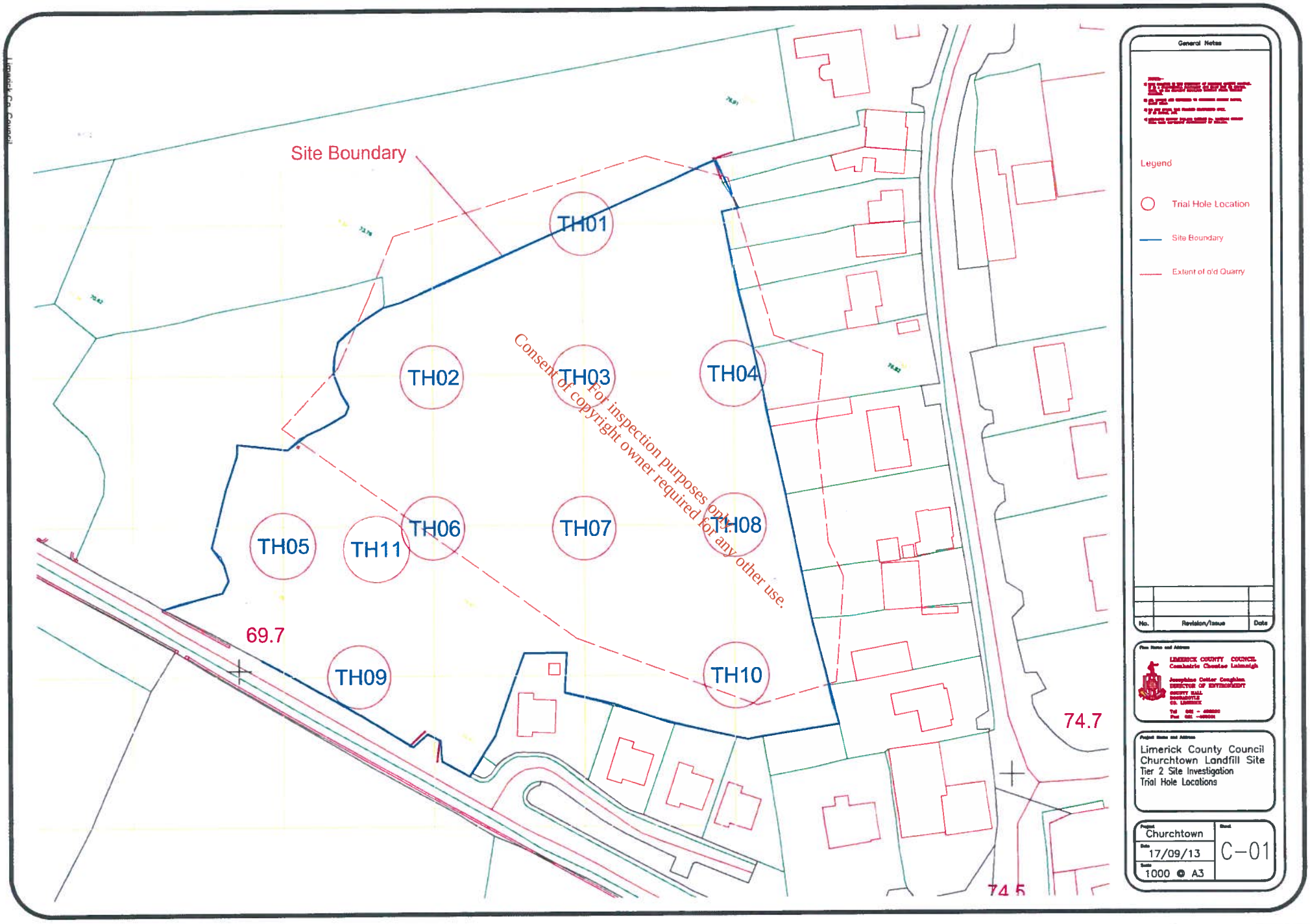
Barry Murphy EE

Environment Section

Limerick County Council

Table of Contents

Appendix 1
Trial Hole Report



Summary of Trail Holes taken at Churchtown Historic Landfill Site

Trial Hole	Excavated	Depth of Trial	Base of Trial Hole	Comment
1	17/02/2012	4.7	72.222	Domestic waste, highly decomposed mixed with stone/clay backfill.
2	14/02/2012	5.2	70.067	Domestic and commercial waste, highly decomposed mixed with stone/clay backfill.
3	14/02/2012	5.2	71.629	Domestic waste, upper 0.8 metre not decomposed, mixed with stone/clay backfill. Mainly clay backfill below 3.5 metres.
4	14/02/2012	5.0	71.980	Domestic waste, highly decomposed mixed with stone/clay backfill.
5	16/02/2012	5.0	65.113	Domestic waste with high metal content, upper 1.5 metres of waste is not decomposed. No waste below 4.0 metres.
6	16/02/2012	6.5	68.145	Domestic and commercial waste with high metal content, highly decomposed, mixed with stone/clay backfill.
7	13/02/2012	6.2	69.942	Domestic waste, highly decomposed mixed with stone/clay backfill down to 4.8 metres. Clay backfill with very low waste content below
8	16/02/2012	5.6	71.237	Commercial and domestic waste, highly decomposed, mixed with stone/clay backfill.
9	16/02/2012	6.0	65.046	Domestic waste, completely decomposed to form uniform granular soil matrix.
10	17/02/2012	5.0	70.160	Domestic and commercial waste down to 2 metres overlying clay layer with no waste.
11	15/04/2013	5.0	68.700	Domestic and commercial waste with a very high content of metal in the top meter.

Limerick Co. Council						TRIAL PIT NO. TP01
Location: Churchtown, NCW		Co-ordinates: E127460 N134660 Level: 76.922				Date: 17/02/2012
Dimensions 5 x 1 x 4.7		Method: 20 T excavator				Logged by: B. Murphy LCC
Depth (M)	**Sample**	**Field Record**	**Reduced Level**	**Depth (m) Thickness**	**Legend**	**Stratum Description**
0.0			76.92			Top Soil, very gravelly.
		no odours		(0.6) 0.5		MADE GROUND comprising very fine granular gravel with no waste
1.0		no organic waste in this layer		(0.7) 1.2		MADE GROUND comprising coarse angular backfill with a high concentration of commercial waste. The waste contains small plastic filters and small offcuts.
2.0		no odours very dry Paper dated 17 July 1983		(1.0) 2.2		MADE GROUND comprising domestic waste mixed through coarse granular backfill with occassional small amounts of clay. Waste contains plastic bags, bottles, metal frame, nappies and paper. The waste is largely
				(0.5) 2.7		MADE GROUND comprising coarse angular stone layer with no waste.
3.0		Very dry throughout				MADE GROUND comprising domestic waste mixed through with course angular stone backfill. Waste is largely decomposed with no odours.
4.0				(2.0)		
4.7		End	72.22	4.7		

General Remarks:

This trial is located on the northern boundary of the site. The waste body extends beyond the perimeter fence into the adjoining field.

This trial hole contains both commercial and domestic waste. The commerical waste consists of plastic objects and dates from post 1984.

The exposed waste was very dry throughout and contains a very highpercentage of stone backfill.

The waste is largely decomposed with no odours or gas detected.

Trial Hole No. 1

Photo 1: Commercial Waste at 1 metre

Photo 2: Plastic objects - small dimater pipes, filters and mesh

Photo 3: Spoil Heap adjacent to site boundary

Photo 4: Spoil Heap

Photo 5: Metal frame

Photo 6: Domestic waste below 1.2 metres

Photo 7: Trial Hole 01
Limerick Co. Council

Limerick Co. Council						TRIAL PIT NO. TP02
Location: Churchtown, NCW		Co-ordinates: E127420 N134620 Level: 75.267				Date: 14/02/2012
Dimensions 5 x 1 x 5.2		Method: 20 T excavator				Logged by: B. Murphy LCC
Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0		No odour or gas	75.26	(0.3)		topsoil, brown, friable
		Sample taken PSD	74.36	(0.6) 0.9		MADE GROUND compirsing coarse angular stone backfill with very occassional plastic bags. Material complies with 6F1/6F2 of Specification for Road Works
1.0		no odour or gas	73.06	(1.1) 2.2		MADE GROUND comprising low fraction of domestic waste mixed with angular stone backfill. Waste contains mainly bottles and plastic. There is some clay interspersed with the stone. The waste is highly decomposed. The waste appears slighly wet at 2.0 metres and is black in colour. **Newspaper dated June 1983 found.**
2.0	Waste sample taken.		72.06	(0.5) (1.0) 3.2		MADE GROUND with increase in waste fraction with large amounts of plastic sheeting and some cardboard. Waste is slightly wet throught out this layer.
3.0		leachate at 4.0 metres.		(3.0)		MADE GROUND comprising low fraction of waste mixed with coarse granular stone with appreciable amount of clay. Waste continues below trial hole Waste is largely decomposed and consists of plastic and glass. Car tyre and exhaust at 3.6 metres
4.0	leachate sample					
5.0						Leachate at base of trial hole
5.2		End	70.06	5.2		

General Remarks:
This trial is located in the western section of the site which was largely overgrown. The top soil is marginally deeper at this location. The granular backfill in the upper metre is very porous.
The backfill below 3 metres contains more clay than any other of the trial holes. Leachte flowed into the excavation at 4.0 metres below ground level. The flow reduced gradually over a 20 minute period. The waste in the bottom metre was wetter that any where else on the site.

Trial Hole 02

Photo 1: granular backfill with very little waste

Photo 2: High plastic content in waste

Photo 3: Top 2 metres of trial hole very dry

Photo 4: High plastic content with waste becomming wetter with depth

Photo 5: Newpaper dated June 1983.

Limerick Co. Council

Photo 7: Trial Hole 2 with leachate at base

Limerick Co. Council						TRIAL PIT NO. TP03
Location: Churchtown, NCW		Co-ordinates: E127460 N134620 Level: 76.83				Date: 14/02/2012
Dimensions 5 x 1 x 5.2		Method: 20 T excavator				Logged by: B. Murphy LCC
Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0			76.73	0.1		Top soil
1.0		Offensive, rancid odour which dissipated after 20 minutes. Methane at 0.5%	75.33	(1.4) 1.5		MADE GROUND comprising very high waste content mixed with coarse angular stone backfill. The waste is contained in black plastic bags which are largely intact. The waste is domestic in nature and contains plastic, bottles, cardboard and organic waste. The waste has not decomposed. **Newspaper dated January 1986**
		no odour	75.03	(0.3)		MADE GROUND comprising coarse granular backfill with no waste
2.0	Compostite waste sample	Inflow of leachate from the south at 2.5 metres.	74.33	(0.7) 2.5		MADE GROUND comprising domestic waste mixed with granular stone backfill. The waste is largely decomposed. Waste contains plastic, bottles, tin cans. Ingress of leachate at 2.5 metres.
3.0			73.83	(0.5) 3.0		MADE GROUND comprising coarse granular backfill with no waste
4.0	leachate sample	no odour ingress of leachate at 4.0 metres.	72.13	(1.7) 4.7		MADE GROUND comprising domestic waste mixed with granular stone backfill. The waste is largely decomposed with no odours detected. The waste contains small amounts of timber, plastic, bottles, tin cans. The clay content of the backfill increases with depth below 3.5 metres and is red in colour. Waste continues below the base of the trial hole.

General Remarks:

The capping layer is non existant at this location. The top 1.5 metres of the trial hole contains a high concentration of domestic waste which has not fully decomposed. This waste is likley to be the final waste placed at the landfill site in 1986.

This waste produced an offensive odour which lasted for approximaltey 20 minutes. However, elevated gas levels of methane and hydrogen sulphide were not detected.

The trial hole indicates that unusually large volumes of stone backfill were used to form cover layers.

Photo 1: No capping layer, minimal topsoil

Photo 2: Waste in plastic bags, not fully decomposed

Photo 3: orange peel not decomposed

Photo 4: red coloured saw dust at 3.2 metres

Photo 5: Ingress of leachate at 2.5 metres.

Photo 6: Spoil heap with large volume of stone backfill

Photo 7: Trial Hole 03

Limerick Co. Council

Limerick Co. Council						TRIAL PIT NO. TP04
Location: Churchtown, NCW	Co-ordinates: E127500 N134620 Level: 76.98					Date: 14/02/2012
Dimensions 5 x 1 x 5.0	Method: 20 T excavator					Logged by: B. Murphy LCC
Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0			76.88	0.1		Top soil
1.0	Sample taken of stone backfill	No odour	75.18	(1.7) 1.8		MADE GROUND comprising angular stone backfill with very occassional fragments of plastic.
2.0						MADE GROUND comprising domestic waste mixed with angular stone backfill and small amount of clay. The waste is highly decomposed. The waste consists of plastic, bottles, metal cans, cardboard and some paper. The waste is very dry throughout. The was some seepage of leachate into the excavation at 3.8 metres. **Newspaper dated 26 May 1984** recovered at 2.3 metres.
3.0						
4.0	leachate sample	no odour ingress of leachate at 3.8 metres.		(3.2)		
5.0			71.98	5.0		

General Remarks:

This trial hole is located close to the eastern boundary of the site. The waste is highly decomposed with no odours or gas detected during the excavation. The upper 1.8 metres consists of free draining angular stone which contains very small amounts of waste.

The waste body from 1.8 to 5.0 metres is very consistent and consists of plastic, metal cans, and some paper. The waste fraction is low and mixed evenly through the stone backfill layer. The waste is very dry down to 3.8 metres. There was an inflow of leachate at 3.8 metres.

Trial Hole 04

Photo 1: Minimal depth of topsoil

Photo 3: Newspaper dated 26th May 1984

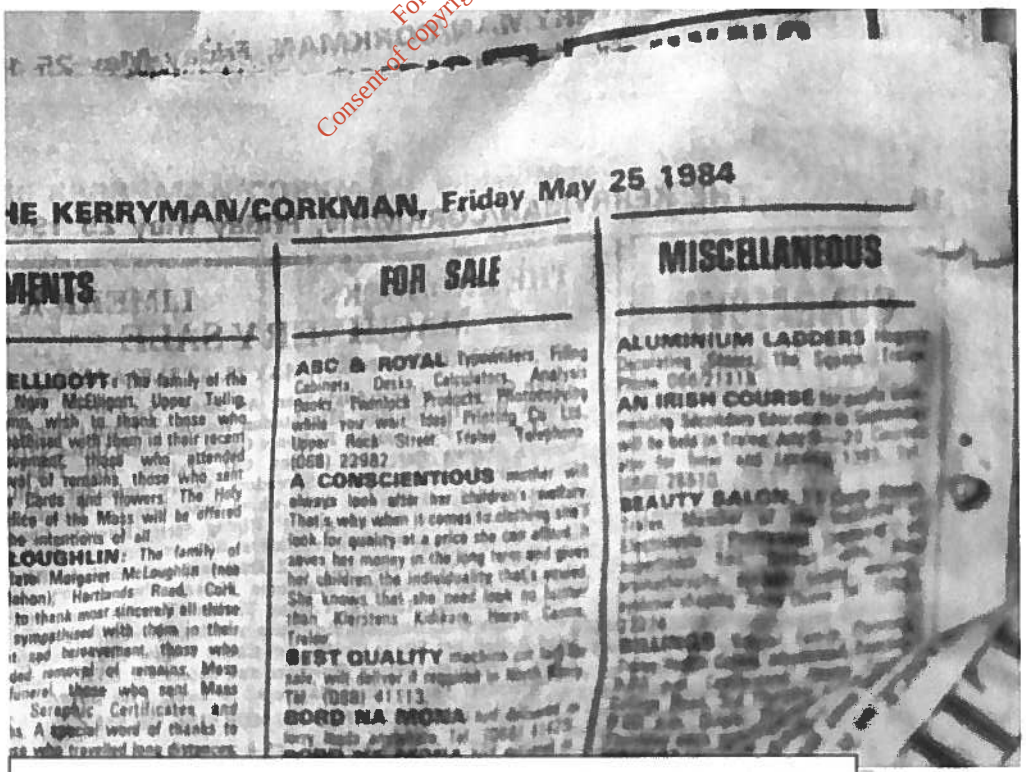


Photo 4: Newspaper dated 25 May 1984 retrieved at 5 metres below ground level

Photo 5: Ingress of leachate at 3.8 metres

Photo 6: Spoil heap from TH 04

Limerick Co. Council
Photo 7: Trial Hole 04

Limerick Co. Council						TRIAL PIT NO. TP05
Location: Churchtown, NCW		Co-ordinates: E127380 N134575 Level: 70.11				Date: 16/02/2012
Dimensions 5 x 1 x 5.0		Method: 20 T excavator				Logged by: B. Murphy LCC
Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0			69.81	(0.3)		topsoil
1.0	Waste sample Leachate sample	transient odour, no gas detected	68.61	(1.2) 1.5		MADE GROUND with very high waste fraction. The waste consists of plastic, paper, nappies, metal cans. There were some animal bones at 0.4 metres. The waste is very wet and black in colour. There was a very slight and transient burnt odour. There was a strong flow of leachate into the excavation from the east. The flow rate was approximatley 100 litres per minute and continued for approximately 40 minutes.
2.0 3.0		transient odour, no gas detected	66.11	(2.5) 4.0		MADE GROUND. The waste below 1.5 metres is largely decomposed but very wet. The waste contains plastic, bottles and timber planks and partially decomposed metal sheets. **Newspaper dated September 1977 at 1.8 metres.** There was large plastic sheeting at 2.8 metres, sheets of partially decomposed metal sheets at 3.4 and a car exhaust at 3.6 metres.
4.0 5.0	Subsoil sample LL 40 PL 19 PI 21 MC 22		65.11			Light brown firm CLAY with massive structure and intermediate plasticity. There is no waste in this layer and this may be the native subsoils.

General Remarks:

This trial hole is located in the south-west corner of the site. This is the lowest part of the site. The site is very wet and partially water logged. Surface water run off and leachate from across the entire site is likely to flow towards this trial hole.

The upper 1.5 metres of waste is largely undecomposed and contains very little backfill. This waste may have been placed shortly before the site closed in 1988. The waste below 1.5 metres appears to be commerical with a high fraction of metal sheets and large plastic wrapping.

The trial hole is located within 20 metres of the borehle LW03.

This trial hole extended below the waste body into a CLAY subsoil. This subsoil may be an imported backfill dating back to

Trial Hole 05

Photo 1: Top soil

Photo 2: domestic waste with animal jaw bone

Photo 3: large concentration of domestic waste

Photo 4: Spoil heap for TH05

Photo 5: ingress of leachate at 1.5 metres

Photo 6: excavated waste very wet

Photo 7: large white plastic at 2.8 metres

Photo 8: soil beneath waste

Photo 9: Trial Hole 05

Limerick Co. Council

Limerick Co. Council			TRIAL PIT NO. TP06
Location: Churchtown, NCW	Co-ordinates: E127420 N134580 Level: 74.65		Date: 16/02/2012
Dimensions 6.5 x 1 x 5.0	Method: 20 T excavator		Logged by: B. Murphy LCC

Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0		no odour	74.65	(0.8)		MADE GROUND comprising C&D waste consisting of broken bricks, concrete, crushed stone. Very little waste in this layer.
			73.85	0.8		
1.0		no odour				MADE GROUND comprising highly decomposed waste consisting mainly of plastic, glass bottles, occassional textiles and paper. The waste is very dry and mixed with a stone granular / clay backfill. The waste fraction is low throughout the trial hole. The clay content of the backfill is low down to 3.7 metres and increases slightly below this but the stratum appears to be free draining. There was a small amount of seepage at 3.5 metres.
2.0						
3.0		small amount of seepage at 3.5		(5.7)		**Newpaper dated May 1986 at 1.8 metres**
4.0						A largely intact milk churn was found at 1.8 metres.
						Washing machine was found at 3.0 metres.
5.0		very faint and transient odour at 4.7				Waste continues below base of trial hole
6.0						
6.5			68.15	6.5		

General Remarks:
This trial hole is located in an overgrown area towards the centre of the site. The capping layer consists of 0.8 metres of C&D type material. The waste material is very decomposed at this location with no organic material present. The waste material is also very uniform with depth.
The waste material is very dry through out the trial hole.

Trial Hole 06

Photo 1: C&D layer on surface

Photo 2: waste very dry and decomposed

Photo 3: waste at 3 metres

Photo 4 : milk churn at 1.8 metres

Photo 5: TH 06 Spoil Heap

Photo 6: Milk churn, washing machine and paper dated May 1986

Photo 7: Trial hole 06

Limerick Co. Council

Limerick Co. Council						TRIAL PIT NO. TP07
Location: Churchtown, NCW		Co-ordinates: E127460 N134580 Level: 76.142				Date: 16/02/2012
Dimensions 6.2 x 1 x 5.0		Method: 20 T excavator				Logged by: B. Murphy LCC
Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0				0.2		Top soil with some waste - 2 small corroded batteries.
1.0		no odour	74.64	(1.2) 1.5		MADE GROUND comprising high waste content with very high plastic content. Waste is largely decomposed and consists of plastic bags,glass bottles, textile fragments, samll amount of paper, metal tins.
2.0						MADE GROUND comprising decomposed waste mixed with angular stone backfill and soil. Waste consists of plastic, glass and a small amount of paper. The clay fraction in the backfill increases below 3.0 metres.
3.0		no odour		(2.3)		Magazine dated **October 1984 at 1.8 metres**
4.0		small amount of seepage				
5.0			71.34	4.8		MADE GROUND comprising clay backfill containing very small amounts of waste.
6.0			69.94	6.2		

General Remarks:
The capping layer consists of 0.2 metres of topsoil.
The waste body is largely decomposed at this location. The waste is combined with an angular stone backfill down to 4.8 metres. The backfill below 4.8 metres is predominately clay and contains very little waste.
The waste in the trial hole is very dry.

Trial Hole 07

Photo 1: sandy topsoil with 2 batteries

Photo 2: Waste at 0.2 metres

Photo 3: decomposed waste mixed with stone backfill

Photo 4: waste at 2 metres

Photo 5: large fraction of plastic in waste

Photo 6: magazine dated October 1984

Photo 7: Spoil heap

Photo 8: Spoil Heap

õõ

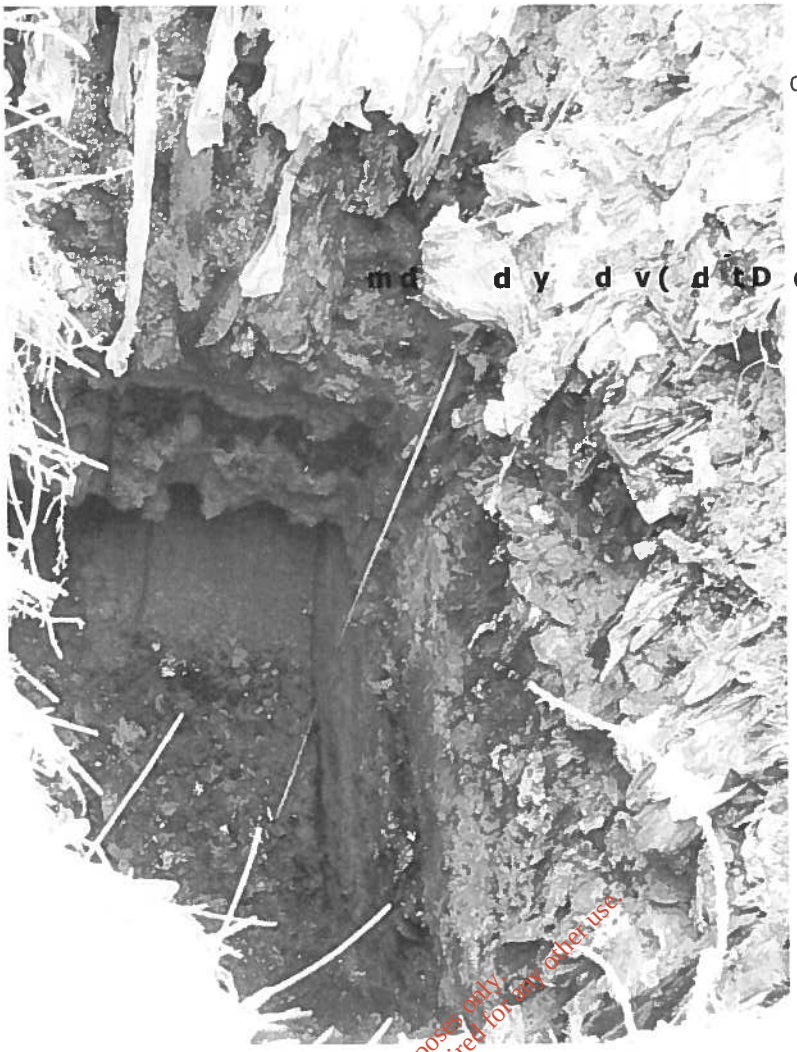


Photo 9: Trial Hole 07

Limerick Co. Council

Limerick Co. Council						TRIAL PIT NO. TP08
Location: Churchtown, NCW		Co-ordinates: E127500 N134580 Level: 76.837				Date: 16/02/2012
Dimensions 5.6 x 1 x 5.2		Method: 20 T excavator				Logged by: B. Murphy LCC
Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0			76.637	0.2		Topsoil
		No odour or gas		(1.5)		MADE GROUND comprising decomposed waste with a very high metal content - 50 gallon drum, metal frame and small diamter metal pipes mixed with stone backfill.
1.0			75.137	1.7		
		no odour or gas	74.837	(0.3) 2.0		Layer of domestic waste, burning evident, nappies, paper, plastic.
2.0		Seepage at 2.5 metres		(3.6)		MADE GROUND comprising commerical and domestic waste mixed with stone and clay backfill. The clay content of the backfill increased below 3.0 metres. The waste is largely decomposed with no gas or odours detected. The waste is very dry. Large amont of white plastic packaging between 1.8 and 2.0 metres. **Newspaper dated August 1984 at 2.4 metres**
3.0						
4.0						
5.0						
5.6		End	71.237	5.6		

General Remarks:
The capping layer consists of 0.2 metres of topsoil.
The waste is largely decomposed throughout the trial holes with no odours or gas detected. There is a mixture of commercial and domestic waste in the trial hole.

Trial Hole 08

Photo 1: 0.2 metres of topsoil

Photo 2: 50 gallon drum

Photo 3: domestic waste with evidence of burning

Photo 4: small amount of seepage at 2.5 metres

Photo 5: waste in trial hole

Photo 6: white plastic material

Photo 7: Trial Hole 08
Limerick Co. Council

Limerick Co. Council			TRIAL PIT NO. TP09
Location: « Churchtown, NCW	Co-ordinates: E127405 N134580 Level: 71.046		Date: 16/02/2012
Dimensions 6.0 x 1 x 5.0	Method: 20 T excavator		Logged by: B. Murphy LCC

Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0			71.05	(0.3)		Topsoil
1.0				(5.4)		Waste which is completely decomposed. The waste consists of glass bottles embedded in a clinker, granular material. There is no plastic, textiles, timber or organic waste throuhgout the trial holes. The waste is very dry.
2.0						
3.0						
4.0						
5.0			65.65	5.4		
6.0			65.05	6.0		Light brown firm CLAY with massive structure. There is no waste in this strata.

General Remarks:
This trial hole is located at the southern perimeter of the site adjacent to the site entrance. The waste at this location is considerable older that any other location on site. The 1840 historic map suggests that an older quarry located to the south of the public road encroached onto this part of the site.

Trial Hole 09

Photo 1: Topsoil

Photo 2: spoil heap

¢
¥
¥df ½ÁÅÇæ# · ·C
«
«D[bEXPn$ZD<$z(F$2f$ µ ½
«
«[b

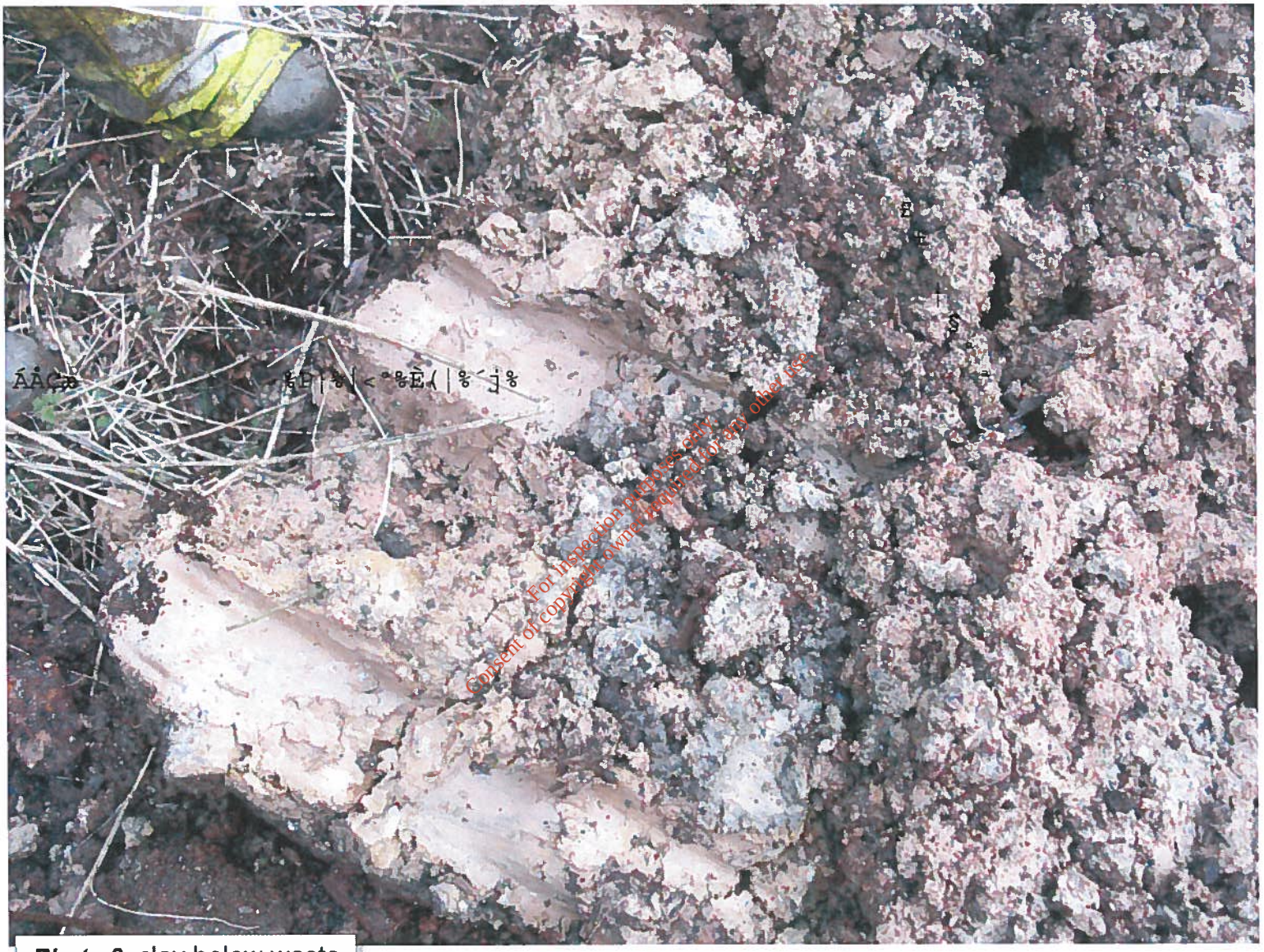


Photo 3: clay below waste

Photo 4: Trial Hole 09
Limerick Co. Council

Limerick Co. Council

TRIAL PIT NO. TP10

Location: Churchtown, NCW	**Co-ordinates:** E127580 N134540 **Level:** 75.16	**Date:** 17/02/2012
Dimensions 7.5 x 1 x 5.0	**Method:** 20 T excavator	**Logged by:** B. Murphy LCC

Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0			74.86	(0.3)		topsoil
			74.36	(0.5) 0.8		MADE GROUND comprising commercial waste with long strips of plastic,
1.0		transient rancid odour, no gas		(1.7)		MADE GROUND comprising domestic and commercial waste mixed with stone/clay backfill. The layer contains partially decomposed domestic waste with a transient rancid odour. Partially corroded metal sheeting and car tyre at 1.3 metres, white plastic packaging at 1.6 metres. **Newspaper dated December 1983** at 1.5 metres. Ingress of leachate at 1.8 metres. large concrete pillar at 1.8 to 2.0 metres removed with excavator.
2.0		Seepage of leachate from north	73.16	2.0		
3.0				(3.0)		Light brown firm CLAY with massive structure. No waste in this strata.
4.0						
5.0			70.16	5.0		

General Remarks:

This trial hole is located in the south-east corner of the site to the rear of the houses in Evergreen Close.
The trial hole contains a mixture of commercial and domestic waste. The domestic waste is not fully decomposed.
The waste is just 2.0 metres deep at this location and overlies a firm light brown sany CLAY. There is no waste throuhg the 3 metre CLAY stratum. The clay may be the natural subsoil which overlies the bedrock in the area. The clay is similar to that found at the base of TH05 and TH09.

Trial Hole 10

Photo 1: Topsoil and waste

Photo 2: domestic waste at 1.3 metres

Photo 3: Spoil heap

Photo 4: ingress of leachate at 1.6 metres

Photo 5: Large concrete pillar at 1.8 metres

Photo 6: concrete pillar removed

Photo 7: Trial Hole 10
Limerick Co. Council

Photo 8: Clay beneath waste

Limerick Co. Council						TRIAL PIT NO. TP11
Location: Churchtown, NCW		Co-ordinates: E127406, N134575 Level: 73.5				Date: 03/12/2012
Dimensions 4.0x1.0 x 5.0		Method: 13.5 T				Logged by: B. Murphy LCC
Depth (M)	Sample	Field Record	Reduced Level	Depth (m) Thickness	Legend	Stratum Description
0.0			73.3	(0.2)		No topsoil, C&D material consisting of crushed rock and subsoil
1.0		strong offensive odour detected at 0.7 metres, persisted as trial hole was excavated.	72.5	(0.8) 1.0		MADE GROUND comprising commercial waste with very high metal content including metal frame and wire mesh. No organics, textiles or paper Fridge recovered 1 metre below ground
2.0			71.6	(0.9) 1.9		MADE GROUND consisting mainly of granular stone backfill with a small fraction of waste. Small fraction of white organic material
			71.3	(0.3) 2.2		High content of industrial type waste, plastic offcuts and washers, some organic material
3.0			69.9	(1.4) 3.6		MADE GROUND highly decomposed domestic waste mixed with granular stone backfill. Some evidence of burning throughout this layer.
4.0				(1.2)		MADE GROUND small fraction of highly domestic waste mixed with grey granular backfill and clay. Large sheets of plastic towards the bottom of this layer.
4.8		Seepage of black liquid at 4.5 metres	68.7	4.8		Bedrock not encountered

General Remarks:
This trial was excavated to investigate the very high magnestic response found during the geophysical survey carried out in March 2012.
The trial hole indicates that the upper sections of the waste contain a high fraction of metal.

Photo 1: Start of excavation

Photo 2: Waste with high metal and plastic content

$$$$$$22222$¤$üü!8#öü$Ôüüüüü$b$hüüüüüüü$bh°ü$Âüüü$bh°ü$Âüüü$bh°ü$Â$t%4$$Þ
(2

Photo 3: metal frame

Photo 4: wire meshing

Photo 5: Spoil heap

Photo 6: Intact buried fridge

Ä*°Ò

Appendix 2
Slit Trench Report

Tier 2 Investigation Churchtown Landfill NCW

Slit Trench 1 to 12 15th February 2012
Slit Trench 13 to 15 20th April 2013

Slit Trench No. 1:
GPS Co-Ordinates: E -127 422 & N -134 641
Location: Adjacent to bare batch in adjoining field – 0.3m from boundary fence
Start Time: 09.15
Finish Time: 09.40

Findings:

Depth (m)	Findings
0-0.2	Loose gravel
0.2	Black bag of waste visible
0.4	Off-white fatty substance visible. Strong 'fatty' type odour A lot of plastics visible Some cardboard

Note:
- Waste was visible adjacent to the boundary ditch at 0.4m
- Times on photographs are incorrect.

Picture 1: Slit Trench 01

Slit Trench No. 2:
GPS Co-Ordinates: E -127 413 & N -134 635
Location: Started trench adjacent to dry surface water drain
Start Time: 09.45
Finish Time: 09.55

Findings:

Depth (m)	Findings
0-0.3	Loose well drained clay soil
0.3-0.4	Layer of gravel
0.55	Small quantities of textiles & plastic visible
0.8	Plastics visible with some glass inter-dispersed

Note:
- Waste was visible at approx. 1.6m from the surface water drain
- Times on photographs are incorrect up to 11.09 correct time of 09.50 then entered.

Picture 2: Slit trench 2

Slit Trench No.3:
GPS Co-Ordinates: E -127 404 & N -134 626
Location: Started trench approx 0.5m from dry surface water drain
Start Time: 10.00
Finish Time: 10.15

Findings:

Depth (m)	Findings
0-0.3	Loose well drained clay soil with gravel inter-dispersed
0.3	Broken shale
1.0	Waste visible mostly plastic with some glass. Black decayed waste inter-dispersed with the clay – no odour Large concrete boulder (approx. $1m^2$)

Note:

- Waste was visible at face of the silt trench

Picture 3: Slit trench 3

Slit Trench No.4:
GPS Co-Ordinates: E -127 395 & N -134 606
Location: Started trench approx 0.5m from dry surface water drain – on a steep incline just to N of the field gate.
Start Time: 10.45
Finish Time: 11.00

Findings:

Depth (m)	Findings
0-0.4	Loose well drained clay soil
0.5	Plastics & glass visible

Note:
- Waste was visible approx. 1.5m from dry surface water drain

Picture 4: Slit trench 4

Slit Trench No.5:

GPS Co-Ordinates: E -127 440 & N -134 650

Location: To the E of slit trench No. 1 & W of TH1. Started trench approx 0.5m from boundary ditch

Start Time: 11.20

Finish Time: 11.30

Findings:

Depth (m)	Findings
0.1	Gravel layer
0.4	Waste visible – mostly plastics with some textiles

Note:

- Waste was visible at face of the silt trench

Picture 5: Slit trench 5

Slit Trench No.6
GPS Co-Ordinates: E -127 479 N -134 668
Location: To the E of TH1. Started trench approx 0.6 from boundary ditch
Start Time: 11.40
Finish Time: 11.55

Findings:

Depth (m)	Findings
0-0.5	Loose well drained clay soil
0.5	Waste visible – mostly plastics with some glass. No odour

Note:
- Waste was visible at face of the silt trench

Picture 6: Slit trench 6

Slit Trench No.7

GPS Co-Ordinates: E -127 392 N-134 543

Location: Along the southern boundary of site, W of entrance gate. Started trench approx 5.6m from boundary ditch due to overhead wire.

Start Time: 12.05

Finish Time: 12.30

Findings:

Depth (m)	Findings
0-0.7	Loose well drained clay soil
0.7	Small quantities of waste mostly glass. No plastic
1	Small quantities of plastic. Cover of milk churn & spring of mattress.
1.3 -1.7	Glass visible. Fine sandy reddish ashy material present with pieces of broken glass mixed through it

Note:

- Waste was visible approx. 0.7m from face of the silt trench.
- Beer bottle removed from trench inscribed with 'O'Connor & Son Kanturk Castle'
- Free draining soil throughout the 1.7m trial hole.

Picture 7: Slit trench 7

Slit Trench No.8

GPS Co-Ordinates: E -127 404 N-134 532

Location: Just to the W of entrance gate. Started trench approx 2.1m from boundary ditch.

Start Time: 12.45

Finish Time: 13.00

Findings:

Depth (m)	Findings
0-0.5	Loose well drained clay soil
0.5	Small quantities of waste mostly glass and small quantities of plastic
0.7	Glass evident (older type bottles)
1.1	A lot of broken glass evident at base of slit trench

Note:

- Glass was visible at face of the silt trench.
- Free draining soil throughout the 1.1m trial hole.

Picture 8: Slit trench 8

Slit Trench No.9

GPS Co-Ordinates: E -127 442 N-134 550
Location: Just to the E of entrance gate to the rear of House No1 Evergreen Crescent.
Started trench approx 1.1m from boundary ditch.
Start Time: 14.00
Finish Time: 14.35

Findings:

Up to a distance of 7.4m from boundary fence

Depth (m)	Findings
0.2	Poorly draining clay soil
0.9	Heavy wet clay soil – small quantity of water evident 6" black open-ended plastic pipe evident approx. 3.8m from boundary
2.1	No evidence of waste

Note: Slit trench adjacent to concret slab (2.5m*1.5m) overlying a fine gravel base

From 7.4m from boundary fence

Depth (m)	Findings
0-0.15	Gravel layer
0.15	Waste visible – plastics, glass & some textiles & metal – no odour
0.6	Seepage evident

Picture 9: Slit trench 9

Slit Trench No.10

GPS Co-Ordinates: E -127 473 N-134 548

Location: Adjacent to container between House No1 & No2 Evergreen Crescent. Started trench approx 15m from boundary ditch (unable to get closer due to trees).

Start Time: 14.55

Finish Time: 15.10

Findings:

Depth (m)	Findings
0-0.3	Freely draining sandy clay
0.3	Waste visible – plastics, glass & woven bags

Picture 10: Slit trench 10

Slit Trench No.11
GPS Co-Ordinates: E -127 485 N-134 541
Location: Between House No2 & No3. Started trench approx 4m from boundary ditch
Start Time: 15.20
Finish Time: 15.35

Findings:

Depth (m)	Findings
0-0.2	Loose well drained clay
0.2	Gravel layer
0.3	Small quantities of waste visible
0.5	Waste visible – alot of plastics, glass & textiles. Healtlogs 25kg plastic bag which when opened appeared to have decayed household waste – no odour

Picture 11: Slit trench 11

Slit Trench No.12
GPS Co-Ordinates: E -127 515 N-134 538
Location: Rear of House No4. Started trench approx 4m from boundary ditch
Start Time: 15.45
Finish Time: 16.00

Findings:

Depth (m)	Findings
0-0.4	Loose well drained clay
0.4	Gravel layer
0.5-0.7	Waste visible - plastics, glass, metal, paint brush

Slit Trench No. 13:
GPS Co-Ordinates: 127510E, 134526.8N
Location: Adjacent to southern boundary of site adjacent to Evergreen Close
Start Time: 11:10
Finish Time: 11:30

Findings:

Depth (m)	Findings
0-0.2	Loose friable topsoil.
0.2 -0.8	Domestic waste, no organics, highly decomposed, predominately plastic and glass with some metal.. High Concentration of coarse angular stone. The waste is very dry.

Note:
The southern extent of the waste was not established due to the presence of large conifer trees on the boundary.

Picture 12: Slit Trench 13

Slit Trench No. 14:
GPS Co-Ordinates: E -127485 & N -134530
Location: southern boundary adjacent to Evergreen Close
Start Time: 11:45
Finish Time: 12:00

Findings:

Depth (m)	Findings
0-0.2	loose top soil
0.2-0.6	Domestic waste, highly decomposed, no organics, mainly plastic with some glass.

Picture 13: Southern boundary

Note:
The southern end of the waste was not reached due to the line of mature tress adjacent to the southern boundary.

Slit Trench No. 15:

GPS Co-Ordinates:127447E, 134553N
Location: Southern boundary adjacent to Evergreen Close
Start Time: 12:30
Finish Time: 12:45

Findings:

Depth (m)	Findings
0-0.2	loose friable topsoil
0.2 to 0.4	granular subsoil with no waste.
0.4 to 0.8	brown stiff clay

Note:

Picture 14: Slit trench 3

Appendix 3
Geophysical Survey

Churchtown Landfill Site

Newcastle West

Geophysical Survey

Report Status: Draft

MGX Project Number:5711

MGX File Ref: 5711f-005.doc

3rd October 2013

Confidential Report To:

Limerick County Council
Environment Section
County Hall
Dooradoyle
Co. Limerick

Report submitted by :
Minerex Geophysics Limited

Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare

Ireland
Tel.: 01-6510030
Fax.: 01-6510033
Email: info@mgx.ie

Issued by:

Hartmut Krahn (Senior Geophysicist)

Minerex
Geophysics Limited

Subsurface Geophysical Investigations

EXECUTIVE SUMMARY

1. Minerex Geophysics Ltd. (MGX) carried out a geophysical survey in 2012 consisting of EM31 Ground Conductivity, 2D-Resistivity and seismic refraction for the Tier 2 preliminary Site investigation of the historic Churchtown Landfill Site in Newcastle West, Co. Limerick.
2. The main objectives of the survey were to determine ground conditions in general, the extent, depth, volume and nature of the waste, information on the capping and possible leachate from the site.
3. In June 2013 a seismic survey consisting of 8 short profiles was added in the east of the landfill area in some residential gardens. The aim was to define the landfill boundary as precisely as possible.
4. This report also includes the data from four 2D-Resistivity Profiles that were done in 2007 by BRG Ltd.
5. The draft report in 2012 made some recommendations that were carried out by the client and the results are included in this final report.
6. The boundary of the landfill is well defined when taking all the previous GI, geophysics and historical maps into account. The area within the boundary (Black and magenta line on Map 3) is 1.86 ha.
7. The base of the landfill and floor of the former quarry are at a level of 63 – 65 mOD. Given the ground elevations of 68 – 78 m on the landfill the thickness of the waste body is 5 – 15m. Using the area of 1.86 ha and an average thickness of 10 m there would be a volume of 186000 m^3.
8. There is no evidence of an engineered capping layer though a general trend of higher resistivities at the surface indicates more granular gravelly material and stone or rock fill at the surface. This may provide some capping function.
9. Resistivity data shows that it is likely that some leachate occurs into the rock below the landfill.

CONTENTS

List of Tables, Maps and Figures:

1. INTRODUCTION

1.1 Background

Minerex Geophysics Ltd. (MGX) carried out a geophysical survey for the Tier 2 preliminary site investigation for the historic Churchtown Landfill Site in Newcastle West, Co. Limerick. The survey consisted of EM31 Ground Conductivity, 2D-Resistivity and seismic refraction (p-wave). The survey is part of the ground investigation for the landfill. The survey was commissioned by Limerick County Council. Other work items like trial pits, slit trenches and sampling were done by Limerick Co. Co. in February 2012 at the same time as the geophysical survey. In June 2013 a seismic refraction survey was added to determine the landfill boundary in the residential gardens to the east of the site. Four 2D-Resistivity Profiles done in 2007 were also added to this report.

1.2 Objectives

The main objectives of the first geophysical survey in 2012 were set out by the client in the tender:

- Identify the extent of the former landfill site and quarry
- Provide information on the depth and nature of the waste body
- Quantify the volume of the waste
- Provide information on the depth and extent of the capping layer
- Look for evidence for leachate migration from the site

The detailed objective of the seismic survey in June 2013 was:

- Identify the landfill boundary precisely in the gardens to the east

1.3 Site Description

The landfill site is situated in a former limestone quarry and has a size of approx. 2 ha. A topographical survey was carried out in 2007 and is used as a background map in the maps of this report. The elevations on the site range from 68 to 78 mOD. The site slopes from NE to SW. The surrounding topography generally slopes from East to West. Some parts of the site are overgrown. The site is described in detail in the Tier 1 – Landfill Risk Assessment report.

1.4 Geology

The bedrock geological map of the Shannon Estuary (GSI, 1999) indicates that the survey area is underlain by the Waulsortian limestone formation, described as massive unbedded lime-mudstone. These limestones are typically very clean and liable to karstification.

The Tier 1 and Tier 2 reports detail the site investigations carried out at the Churchtown Landfill Site.

1.5 Report

This report includes the results and interpretation of the geophysical survey. Maps, figures and tables are included to illustrate the results of the survey. More detailed descriptions of geophysical methods and measurements can be found in GSEG (2002), Milsom (1989) and Reynolds (1997).

The client provided maps of the site and the digital version was used as the background map in this report. Elevations were surveyed on site and were incorporated into the data for the vertical sections. The system used in this report is Irish transverse Mercator (ITM).

The interpretative nature and the non-invasive survey methods must be taken into account when considering the results of this survey and Minerex Geophysics Limited, while using appropriate practice to execute, interpret and present the data, give no guarantees in relation to the existing subsurface.

2. GEOPHYSICAL SURVEY

2.1 Methodology

The methodology for the geophysical survey consisted of EM31 Ground Conductivity, 2D-Resistivity and Seismic Refraction Profiles. The survey locations are indicated on Map 1. There are four 2D-Resistivity profiles and eight seismic refraction profiles. The geophysical survey parameters for the profile are listed in Table 1.

All geophysical surveys are acquired, processed and reported in accordance with British Standards BS 5930:1999 + A2:2010 'Code of Practice for Site Investigations'.

Table 1: Data Acquisition Parameters for Geophysical Profiles

Profile Name	Electrode/Geophone Interval/m	Number of Electrodes/Geophones	Profile Length/m
R1 - R4	3	64	189
S1 – S8	3	24	69

2.2 EM31 Ground Conductivity

The EM31 ground conductivity survey was carried out on lines over the landfill and the surrounding area to the west and north where clearance was made or previously available. Along each line a reading of ground conductivity was taken every second while walking along. The locations (small crosses on Map 2) were measured with a sub-meter accuracy SERES DGPS system attached to the EM31 and all data was jointly stored in a data logger. The conductivity meter was a GEONICS EM31 with Allegro data logger and NAV31 data acquisition software. The instrument was checked at a base station, the readings were stable and no drift occurred.

EM31 ground conductivity determines the bulk conductivity of the subsurface over a typical depth between 0 and 6 m bgl. and over a radius of approx. 5m around the instrument. Landfill waste and leachate have higher conductivities than most geological materials and can be located within the depth range of the meter. When looking for clay, silt and water infill within rock occurring at relatively shallow depth the EM31 can find anomalous rock zones with a vertical extent of approx. 3m. The measurements are disturbed by metal and other conductive objects within the range of the instrument and therefore no geological interpretations can be made in the vicinity of such man-made objects. Either readings were not taken near sources of interference in the first place or notes were taken by the operator in order to account for these in the interpretation.

2.3 2D-Resistivity

During 2D-Resistivity surveying data is acquired in the form of linear profiles using a suite of metal electrodes. A current is injected into the ground via a pair of electrodes while a potential difference is measured across a second pair of electrodes. This allows for the recording of the apparent resistivity in a two-dimensional

arrangement below the profile. The data is inverted after the survey to obtain a model of subsurface resistivities. The generated model resistivity values and their spatial distribution can then be related to typical values for different geological materials.

2D-Resistivity profiles with electrode spacing of 3m were surveyed at the locations shown on Map 1. The readings were taken with a Tigre Resistivity Meter and Imager Cables.

2.4 Seismic Refraction

In the seismic refraction survey method a p-wave is generated by a source at the surface resulting in energy travelling through surface layers directly and along boundaries between layers of differing seismic wave velocities. Processing of the seismic data allows geological layer thicknesses and boundaries to be established.

The seismic survey consisted of p-wave seismic refraction profiling. Each of the profiles consisted of 24 geophones with 3 m spacing, resulting in lengths of up to 69m per profile. The recording equipment consisted of a 24 Channel DMT Summit engineering seismograph with 4.5 Hz vertical geophones. The seismic energy source consisted of a hammer and plate. A zero delay trigger was used to start the recording.

Seismic Refraction generally determines the depth to horizontal or near horizontal layers where the compaction/strength/rock quality changes with an accuracy of 10 – 20% of depth to that layer. Where low velocity layers are present or where layers dip with more than 20 degrees angle the accuracy becomes much less. In loose and soft ground like a landfill the seismic energy gets heavily attenuated and usually on 3 – 6 m depth penetration is possible.

2.5 Site Work 2012

The data acquisition was carried out on the 13th and 14th of February 2012. The weather conditions were variable throughout the acquisition period. Health and safety standards were adhered to at all times.

The locations and elevations were surveyed with a TRIMBLE RTK-GPS to accuracy < 0.02m.

2.6 Site Work 2013

The data acquisition for the 2013 seismic refraction survey was carried out on the 25th June 2013. The geophone spacing used was 1 m in order to resolve the seismic velocity of the shallow subsurface with high resolution. Otherwise the seismic refraction method was done as described above. There were 8 seismic refraction profiles done named S11 – S18 and they are indicated on the location maps.

3. RESULTS AND INTERPRETATION

The interpretation of geophysical data was carried out utilising the known response of geophysical measurements, typical physical parameters for subsurface features that may underlay the site, and the experience of the authors.

3.1 EM31 Ground Conductivity

The EM31 ground conductivity values were merged into one data file and contoured and gridded with the SURFER contouring package. The contours are created by gridding and interpolation and care must be taken when using the data. The contour map is overlaid over the location and base map (Map 2) and the values in milliSiemens/metre (mS/m) are indicated on the colour scale bar.

Low conductivities would indicate either shallow bedrock or dry sandy and gravelly overburden while higher conductivities would indicate deeper bedrock and clay-rich overburden. Very high or very low conductivities indicate interference from manmade metal objects or occur over the waste body.

Middle range values (15 – 25 mS/m) indicate gravelly clay outside the landfill in the field to the west or areas where the waste is relatively thin close to that field boundary in the west (and inside the landfill area).

The high values (> 25 mS/m) are concentrated over the highest part of the landfill where they indicate the largest thickness of the waste and leachate within the waste. The transition from high to low values can be seen on the property without a building between the R521 and the landfill. The gradient in the readings indicates the landfill boundary.

A line of high readings occurs in the field to the west close to the road. There is no visible obvious reason for these high readings that must be caused by subsurface metal. The subsequent site investigation showed that this is a buried power cable.

3.2 2D-Resistivity Profiles

The 2D-Resistivity data was positioned and inverted with the RES2DINV inversion package. The programme uses a smoothness constrained least-squares inversion method to produce a 2D model of the subsurface model resistivities from the recorded apparent resistivity values. Three variations of the least squares method are available and for this project the Jacobian Matrix was recalculated for the first three iterations, then a Quasi-Newton approximation was used for subsequent iterations. Each dataset was inverted using seven iterations resulting in a typical RMS error of < 2.1%. The resulting models were colour contoured with the same scale for all profiles and they are displayed as cross sections (Figure 1a and 1b).

The resistivities cover a wide range of values. The high values at depth indicate clean limestone bedrock while low values indicate the presence of the landfill waste body. The lowest values within the landfill are most likely caused by a combination of waste material and water within the landfill body.

The resistivities at depth are generally quite high which is consistent with the clean (non-argillaceous) limestone rock type. It confirms that the undisturbed rock is a clean limestone, which means it has no or very low shale or mud content. The high resistivities indicate that the limestone is liable to karstification but does not have to be karstified.

3.3 Seismic Refraction Data 2012

The seismic refraction data was positioned and processed with the SEISIMAGER software package to give a layered model of the subsurface. The numbers of layers has been determined by analysing the seismic traces and up to 5 layers were used in the individual models. All seismic profiles were subject to a standardised processing sequence which consisted of a topographic correction which was based on integrated elevation data, first break picking, tomographic inversion, travel-time computation via ray-tracing and velocity modelling. Following each processing stage QC procedures were adhered to. The resulting layer boundaries are shown as thick lines overlaid on the 2D-Resistivity cross sections (Figure 1a and 1b). The seismic velocities obtained within the layers are annotated on the sections.

S1 and S8 were done outside the landfill to model the normal geological ground conditions in a down gradient direction. S2, S6 and S7 were done to cross the boundary of the waste body and determine the edge of the former rock quarry. S4 and S5 are over the lower part of the landfill to see if the bottom can be reached. S3 is entirely within the landfill waste body.

S1 and S8 indicate that the succession of ground layers is quite normal going from soft topsoil over firm to stiff gravelly clay and weathered bedrock to strong rock. The layer 4 (Figures 1a and 1b) is a typical transition layer between overburden and strong bedrock and can contain weathered rock but also very consolidated overburden. Notable is a thickening of the overburden and weathered rock layer on S8 (at 60-100m on R8) which is also the lowest point of the ground across the road from the westernmost point of the landfill.

S2, S6 and S7 show the lateral change between landfill waste body and the natural geology quite well and the modelling could prove the edge of the former rock quarry well. The large difference of seismic velocities across the boundary causes a good contrast and the first breaks in the seismic shot records allow an excellent locating of the former quarry edge.

S3 is at the thickest part of the landfill and it is not possible to make any deduction about the depth of the landfill. This was to be expected because of the strong attenuation of the seismic signal in the loose waste body. Some variations of the seismic velocity within the waste body could be modelled and improved the model accuracy. This shows that the waste has a quite narrow band of seismic velocities (0.25 to 0.5 km/s).

S4 and S5 still do not show the base of the landfill although it is thinner than at S3. S5 allows some estimation about the depth to the limestone which is significant close to the site entrance. It shows that the former quarry floor was located deeper than the current site entrance (also found in the slit trenches). S4 shows a curious change from normal condition in the waste body as there is an area with high seismic velocities (modelled with 3 km/s). This is likely an area of backfilled very compact and hard stones or rocks though it could be also

an area of rock that was not excavated in the former quarry. It is noted that the highest resistivities within the landfill occur at this location.

3.4 Interpretation

Abbreviated trial pit and well logs are shown on the sections where ground investigation points are close to the geophysical profiles. For a full description of the logs the report should be used.

Table 2 summarises the interpretation. The interpretation follows the seismic layers and then is extrapolated along the resistivity sections. The interpretation has been made from all available information including the well logs and trial pits. The base of the landfill which is the old quarry floor has been interpreted from the boreholes and the resistivities as no seismic profile has reached the base.

The interpretations are drawn on Figures 2a and 2b. Layers are indicated by the hatch pattern. The magenta dashed line on R 2 and R3 indicates the water table within the landfill as indicated by the sudden increase in resistivities around this level.

Table 2: Summary of Results and Interpretation

Layer	**General Seismic Velocity Range (km/sec)**	**General Resistivity Range (Ohmm)**	**Compaction/Strength/ Rock Quality**	**Interpretation**
1	0.25 – 0.3	< 160	Soft/Loose	Overburden (Soil or Topsoil)
2	0.25 – 0.5	< 320	Loose/soft	Waste - Landfill
3	0.7 – 1.5	< 240	Firm to stiff	Overburden (Clay)
4	2.1	< 480	Weathered or hard	Weathered Rock or Overburden (Clay)
5	3.5 – 4.3	> 240	Strong	Strong Limestone
-	-	< 60	-	Possible Leachate outside Landfill Waste Body
On S4	3.0	> 320	-	Solid Object/Layer within Landfill

Map 3 summarises some of the interpretations made in this report.

3.5 Seismic Refraction Interpretation 2013

The seismic modelling with ray tracing and interpretation was aimed at defining the landfill boundary as precisely as possible. The layers and velocity ranges used previously on this project were used as far as possible, with some modifications visible on the legend of Figure 3. The results and interpretation of profiles S11 – S18 are displayed on Figure 3.

The 8 seismic profiles (S11 – S18) show quite varying results in term of ground model and background geology. The boundary between waste body natural ground is not always sharp and seismic velocities are quote similar at a shallow depth inside and outside the fill.

Profile 18 shows a 'normal' ground layering with rock at depth and no indication for waste and landfill material. There is no landfill material in this back garden.

Profiles 15 – 17 show the boundary by the drop in the faster velocity layers to the west where they are replaced by lower velocity layers representing the landfill. Profile 11 shows the same pattern where the landfill occurs just at the western profile end.

Profiles 12 – 14 show an opposed pattern where the ground gets less compacted and possibly more gas-rich towards the east. Therefore the boundary was placed at the eastern zone where the velocity get less. On Profile 14 the landfill boundary is outside the profile and taken from the previous survey.

Overall confidence about the landfill boundary location is good at profiles 11 and 15 – 17. On profiles 12 and 13 the confidence is less. There is no landfill under profile 18, and along profile 14 and the old profile S2 the boundary is most eastward.

The boundary may not always be 'sharp' with some mixing of landfill and overburden material likely. The boundaries as displayed here show a 'best fit' solution and are useful for the estimation of size and extent of the landfill.

3.6 2D-Resistivity Interpretation 2007

The resistivity profiles carried out in 2007 have been re-processed with elevations and the same inversion and display parameters as in the 2012 survey. The results are similar as in the 2012 survey. The older profiles have been displayed in Figure 1c and are interpreted in Figure 2c.

4. CONCLUSIONS

This chapter summarises the conclusion based on the objectives and topics investigated.

Lateral extent of waste and boundary

The boundary of the landfill is well defined when taking all the previous GI, geophysics and historical maps into account. The edge of the former quarry has been found at S2, S6, and S7 and twice on R1. R1 runs over the edge of the landfill at an oblique angel therefore the boundary appears less focuses than elsewhere. The boundary has been also modelled on S11 – S17 while S18 is outside the landfill. It also shows on the northern end of R3-2007.

The boundary has been drawn on Map 3 as a black line and for S11 – S17 as a magenta line. The area within the boundary is 1.86 ha.

Volume of waste

The base of the landfill and floor of the former quarry are at a level of 63 – 65 mOD. Given the ground elevations of 68 – 78 m on the landfill the thickness of the waste body is 5 – 15m. Towards the field in the west it is likely that the thickness will decrease to 0m as the EM31 values approach the background values. Using the area of 1.86 ha and an average thickness of 10 m there would be a volume of 186000 m^3.

Nature of waste

In this report the whole landfill body was addressed as waste though it is known from the trial pits and slit trenches that there are significant volumes of made ground consisting of clay and sand/gravel with little or no waste material within the landfill. There is no indication in the resistivities or other physical parameters that allow a distinction between these materials. The waste body as described throughout this report is determined by the low resistivities of the waste that is spreading through solution as leachate and therefore equalises the resistivities.

Capping layer

There is a general trend of higher resistivities at the surface (dry waste) with lower resistivities (saturated waste) near the top. At the very top resistivities change mainly between > 80 Ohmm (green) to < 80 Ohmm (yellow – brown). Higher values indicate more granular gravelly material and stone or rock fill while lower values represent clay and waste material.

Deepest part of landfill and possible leachate vertical below landfill

New and old resistivity profiles for the site indicate lower resistivities stretching deeper than the expected final depth of the landfill (as defined from previous boreholes). This area is centred on the highest part of the landfill and mapped on Map 3. The reason is most likely that there is leachate into the subsurface vertically downwards into the rock below the landfill.

Underground Power Cable

An anomaly found by EM31 in the field to the west was identified as an underground power cable coming from the overhead power line and running west to a residential property.

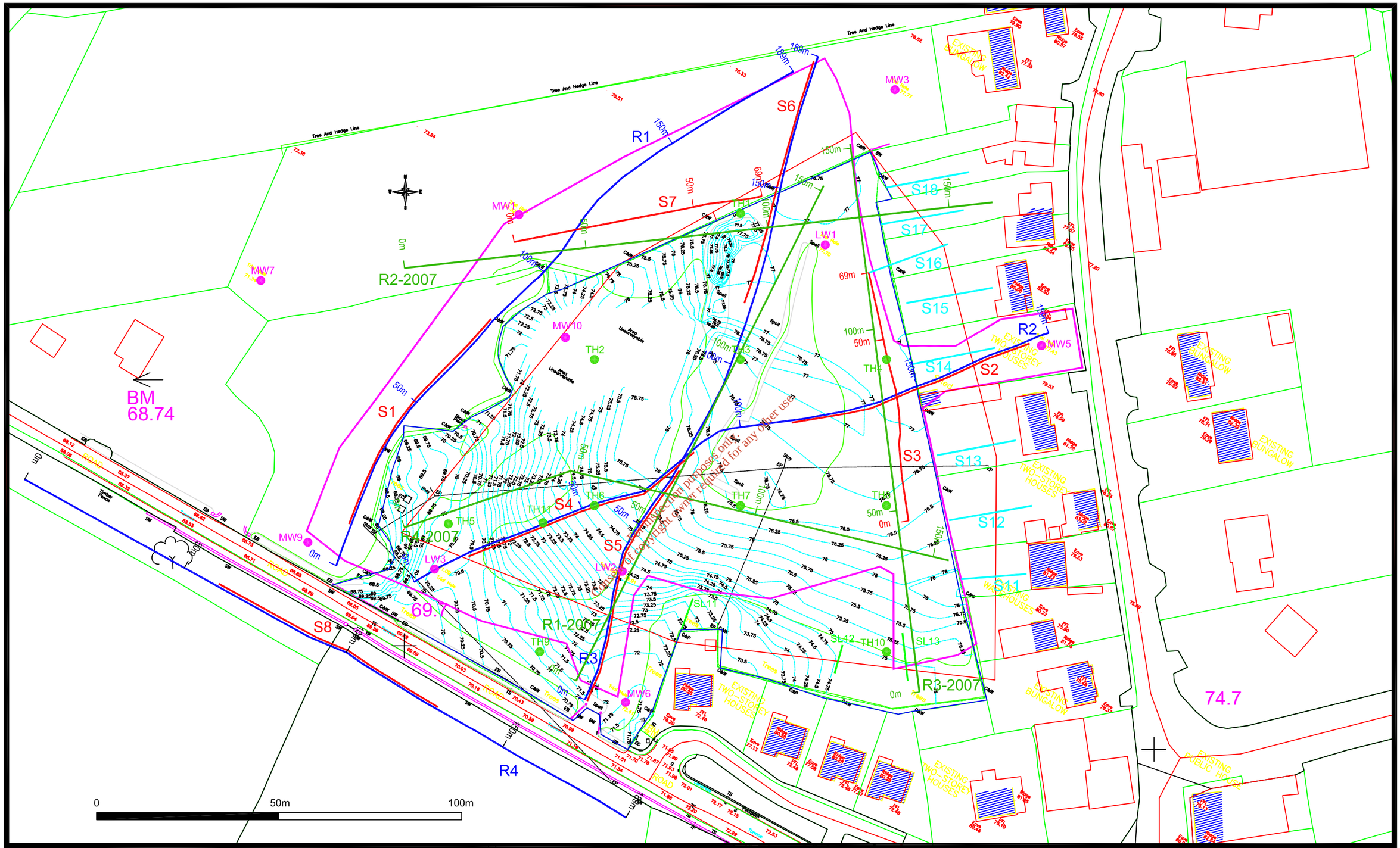
5. REFERENCES

1. **GSEG 2002.** Geophysics in Engineering Investigations. Geological Society Engineering Geology Special Publication 19, London, 2002.

2. **GSI, 1996.** Geology of Tipperary. Geological Survey of Ireland 1996.

3. **Milsom, 1989.** Field Geophysics. John Wiley and Sons.

4. **Reynolds, 1997.** An Introduction to Applied and Environmental Geophysics. John Wiley and Son.



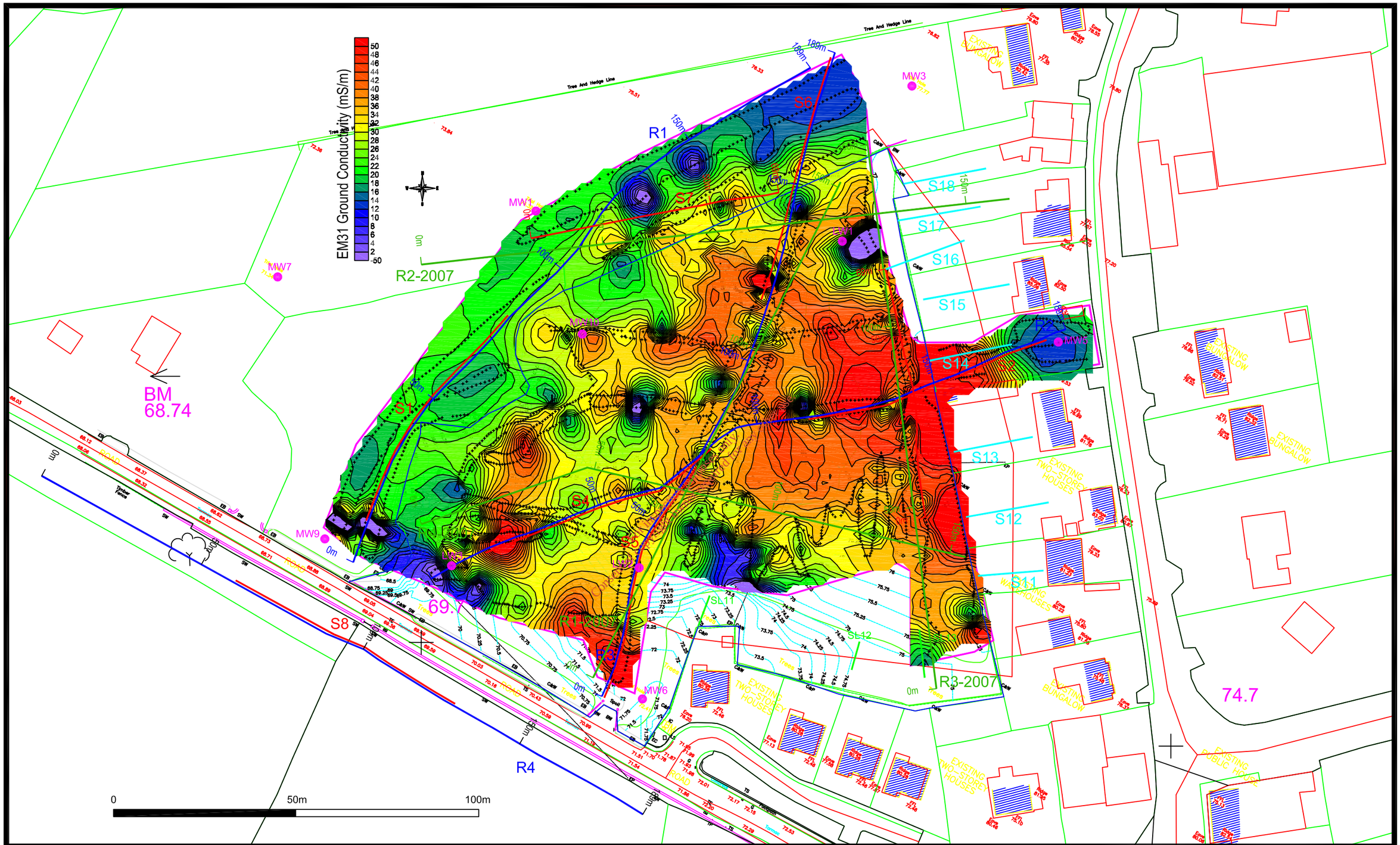
Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Map 1: Geophysical Survey Location Map

SCALE:	1:1000 @ A3
PROJECT:	5611
DRAWN:	DA
DATE:	06/09/2013
MGX FILE:	5611f_Maps.dwg
STATUS:	Final

LEGEND:

- 2D-Resistivity Profile (2012)
- Seismic Refraction Profile (2012)
- 2D-Resistivity Profile (2007)
- Seismic Refraction Profile (2013)
- Trial Holes (Feb 2012)
- Wells (2007)
- EM31 Survey Area



Minerex
Geophysics Limited

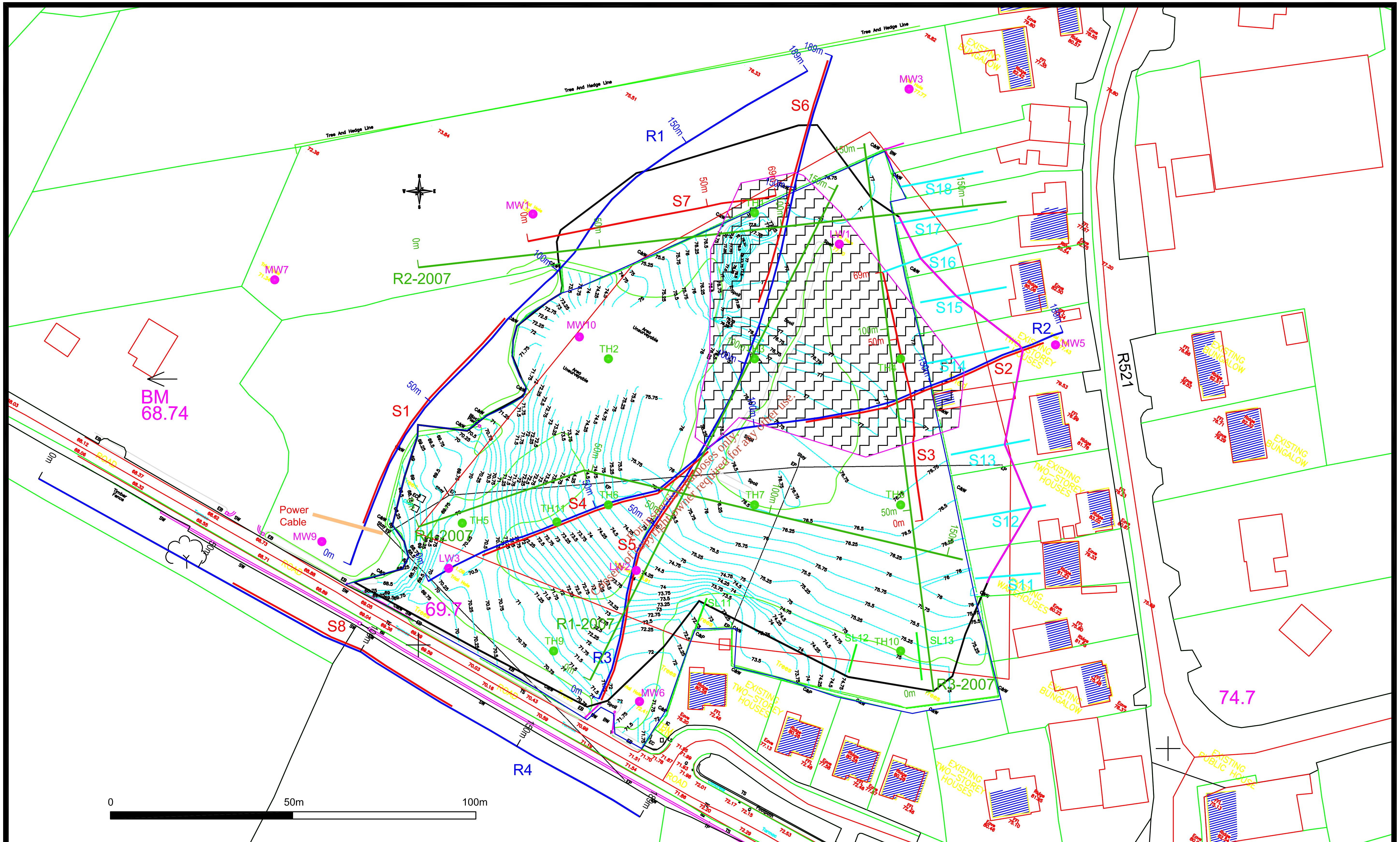
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Map 2: EM31 Ground Conductivity Contour Map

SCALE:	1:1000 @ A3
PROJECT:	5611
DRAWN:	DA
DATE:	06/09/2013
MGX FILE:	5611f_Maps.dwg
STATUS:	Final

LEGEND:

The map shows the EM31 ground conductivity contours mS/m. The lowest (magenta) readings occur when the instrument is close over metal. The low (blue) conductivities indicate relatively shallow limestone outside the landfill body. The middle range (green) values indicate gravelly clay outside the landfill or the part of the landfill body with relatively low thickness of waste. The high (red) values indicate the thickest waste body and the highest amount of leachate within the landfill waste body. Red values can also indicate the influence of metal, either above ground (like fences) or below ground (metal waste within the landfill).



Minerex
Geophysics Limited

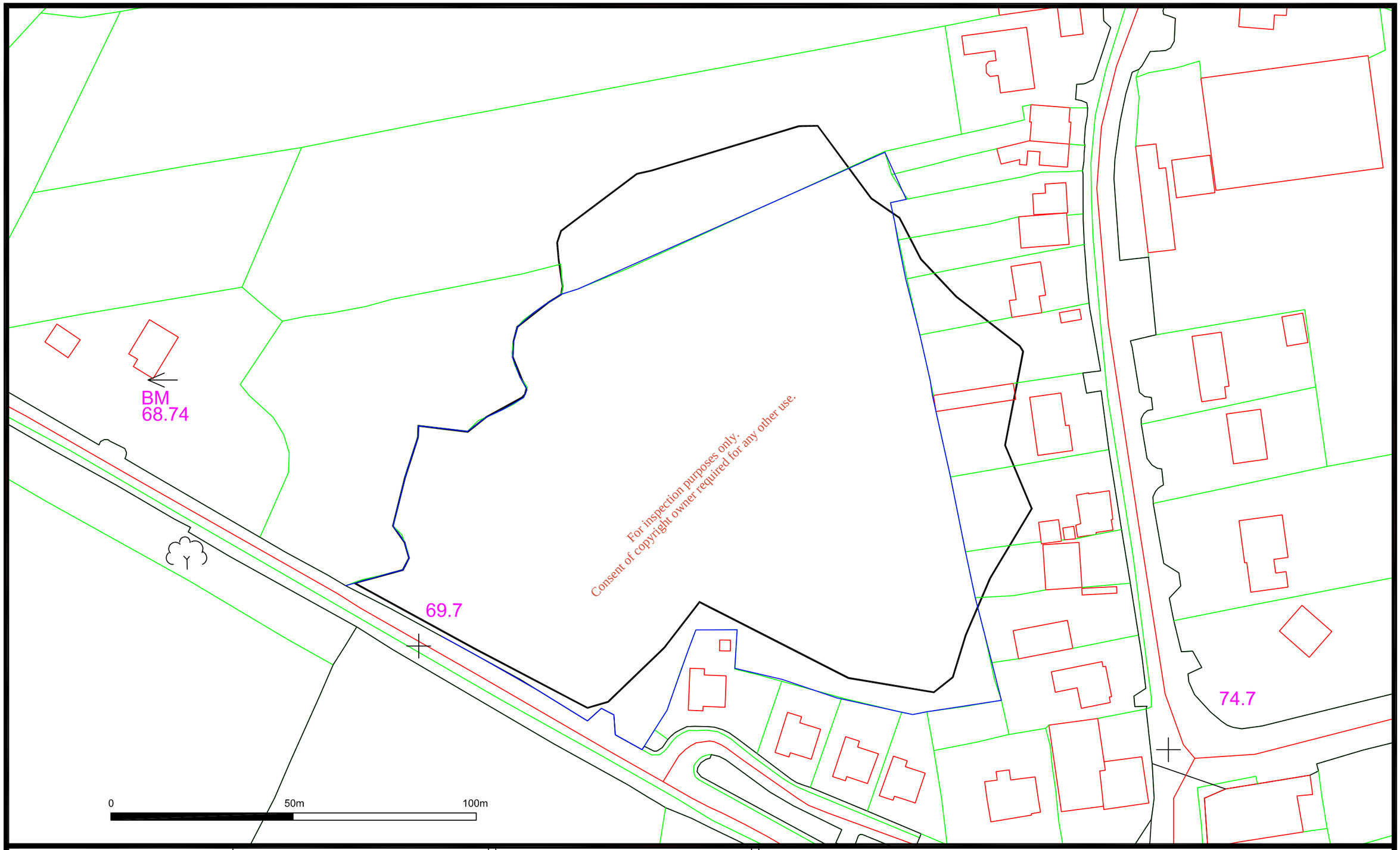
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Map 3: Interpretation Map

SCALE:	1:1000 @ A3
PROJECT:	5611
DRAWN:	HK
DATE:	06/09/2013
MGX FILE:	5611f_Maps.dwg
STATUS:	Final

LEGEND:

- Power Cable
- Landfill Boundary (Best Fit)
- Possible Leachate below Landfill
- Landill Boundary from 2013 Seismic Survey (S11 - S18)



Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

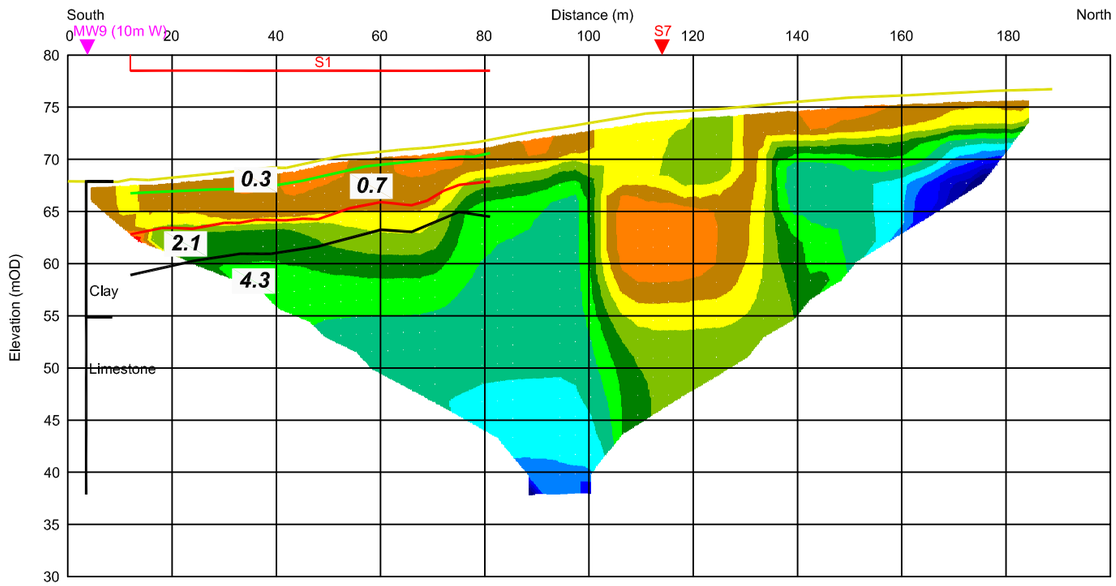
CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Map 4: Boundaries Map

SCALE:	1:1000 @ A3
PROJECT:	5611
DRAWN:	HK
DATE:	06/09/2013
MGX FILE:	5611f_Maps.dwg
STATUS:	Final

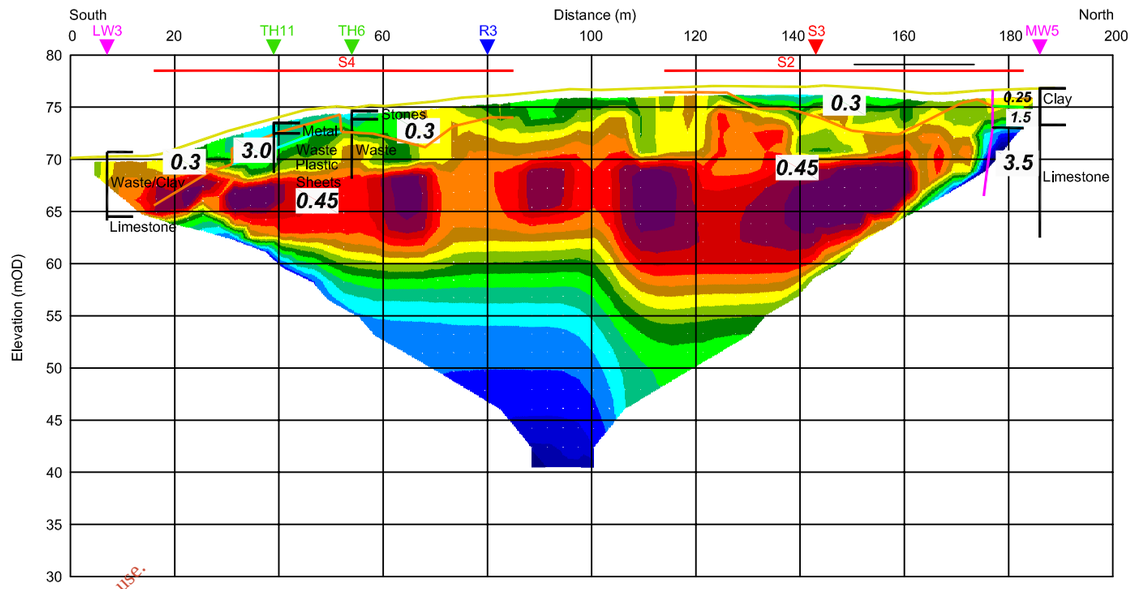
LEGEND:

- Landfill Waste Boundary (Best Fit)
- Site Boundary

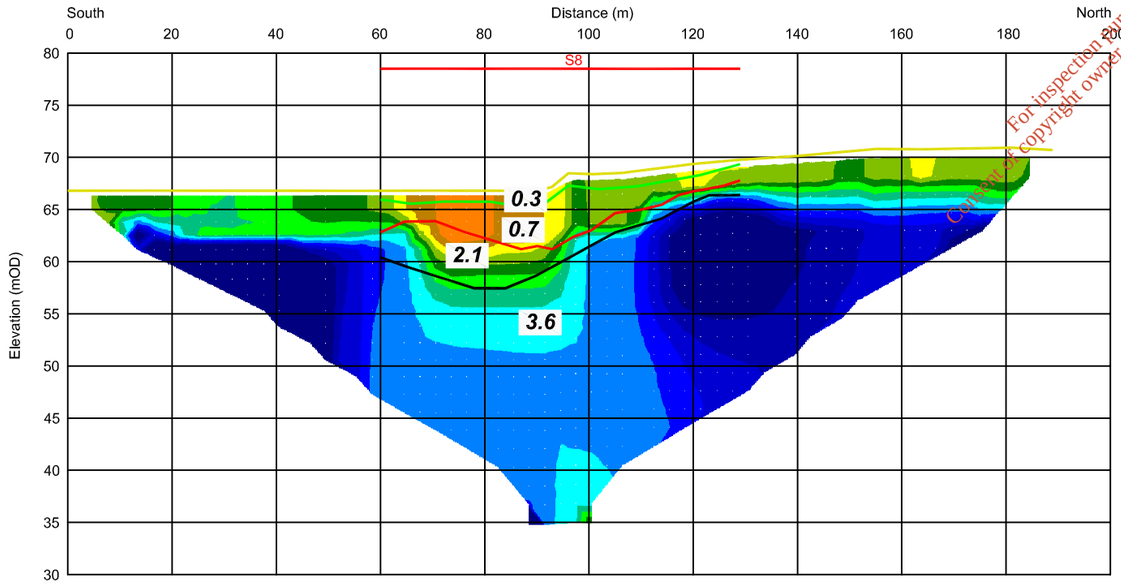
2D-Resistivity Profile R1 and Seismic Refraction Profile S1 Model



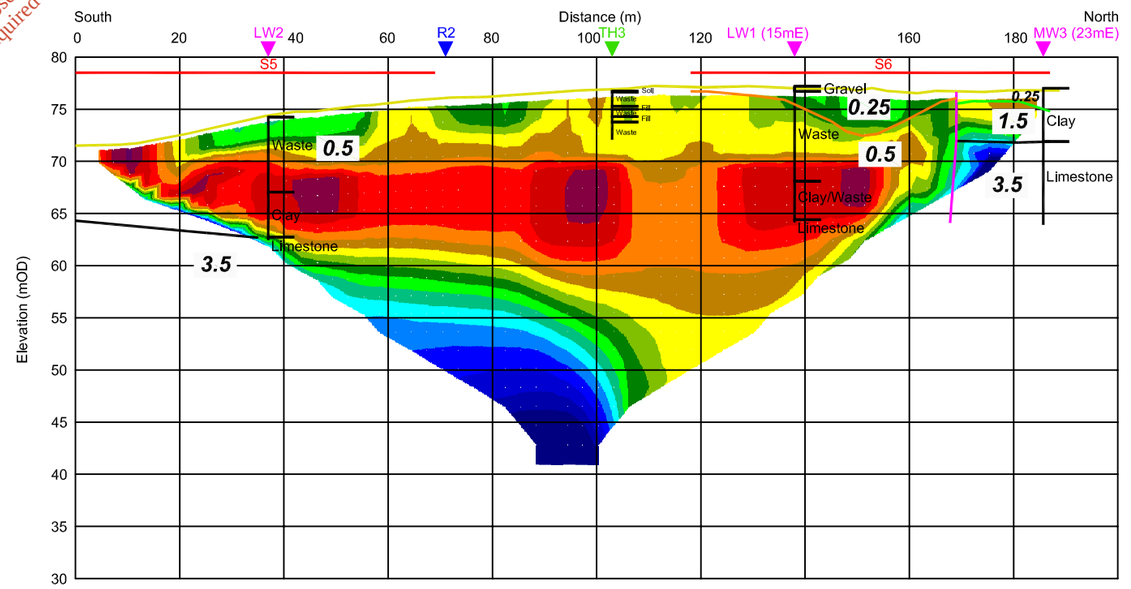
2D-Resistivity Profile R2 and Seismic Refraction Profile S2, S4 Model



2D-Resistivity Profile R4 and Seismic Refraction Profile S8 Model



2D-Resistivity Profile R3 and Seismic Refraction Profile S5, S6 Model



Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Figure 1a: Results of Geophysical Survey

SCALE:	NTS, VE x 2
PROJECT:	5711
DRAWN:	DA
DATE:	06/09/2013
MGX FILE:	5711f_Figs.dwg
STATUS:	Final

LEGEND:

Layers from Seismic Refraction Model:

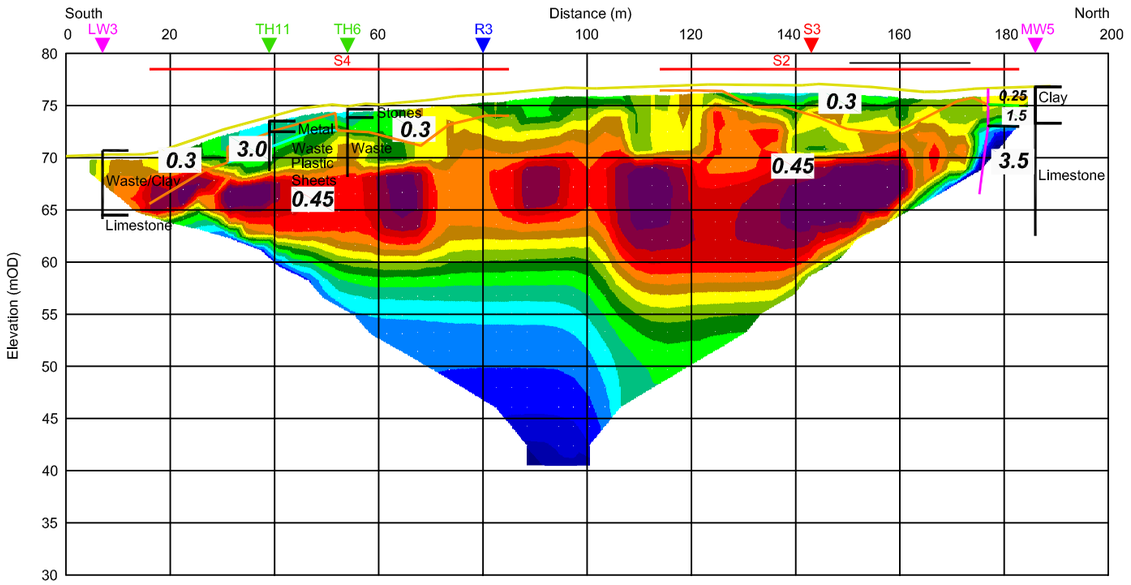
- Ground Surface
- Layer 2 Intra-Waste Boundary (0.25 - 0.5 km/s)
- Boundary between Waste and geological Layer
- Base of solid Object/Layer within Landfill
- Base of Layer 1 (0.25-0.3 km/s) Soil and Top of Layer 3 Firm to stiff Clay (0.7-1.5 km/s)
- Top of Layer 4 weathered Rock or hard Clay (2.1 km/s)
- Top of Layer 5 Strong Limestone (3.5 - 4.3 km/s)

1.5 Seismic Velocity km/s

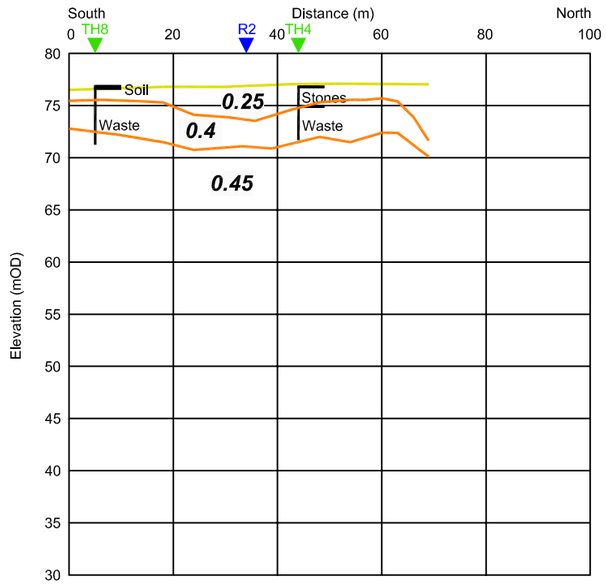
Model Values 2D-Resistivity (Ohmm)

10.0 20.0 40.0 80.0 160 320 640 1280

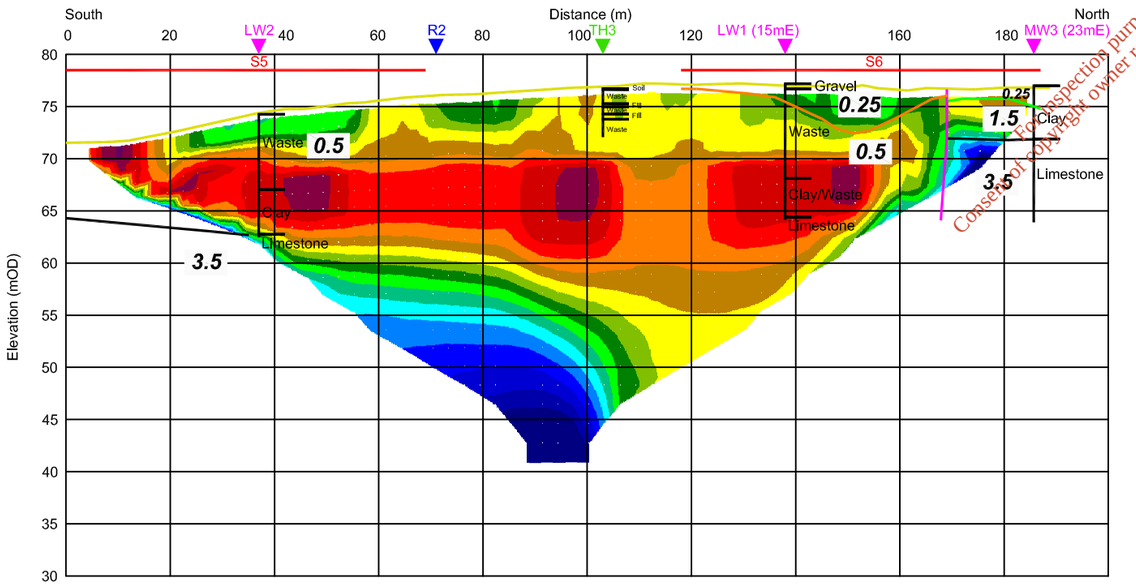
2D-Resistivity Profile R2 and Seismic Refraction Profile S2, S4 Model



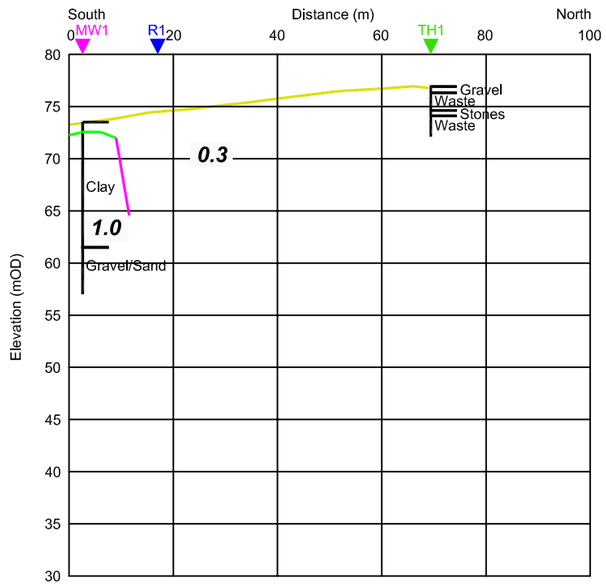
Seismic Refraction Profile S3 Model



2D-Resistivity Profile R3 and Seismic Refraction Profile S5, S6 Model



Seismic Refraction Profile S7 Model



Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Figure 1b: Results of Geophysical Survey

SCALE:	NTS, VE x 2
PROJECT:	5711
DRAWN:	DA
DATE:	06/09/2013
MGX FILE:	5711f_Figs.dwg
STATUS:	Final

LEGEND:

Layers from Seismic Refraction Model:

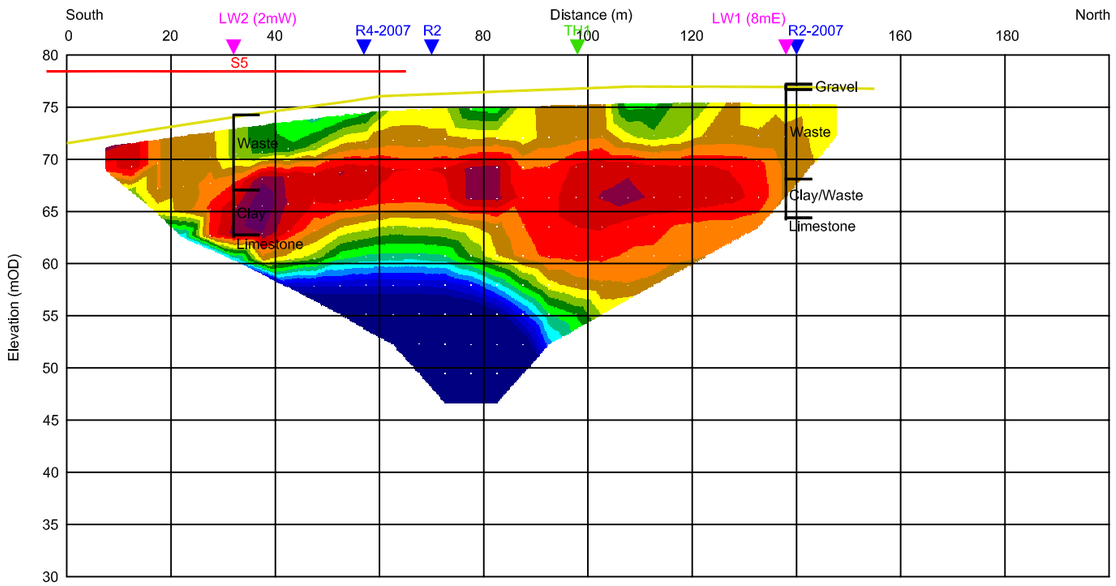
- Ground Surface
- Layer 2 Intra-Waste Boundary (0.25 - 0.5 km/s)
- Boundary between Waste and geological Layer
- Base of solid Object/Layer within Landfill
- Base of Layer 1 (0.25-0.3 km/s) Soil and Top of Layer 3 Firm to stiff Clay (0.7-1.5 km/s)
- Top of Layer 4 weathered Rock or hard Clay (2.1 km/s)
- Top of Layer 5 Strong Limestone (3.5 - 4.3 km/s)

1.5 Seismic Velocity km/s

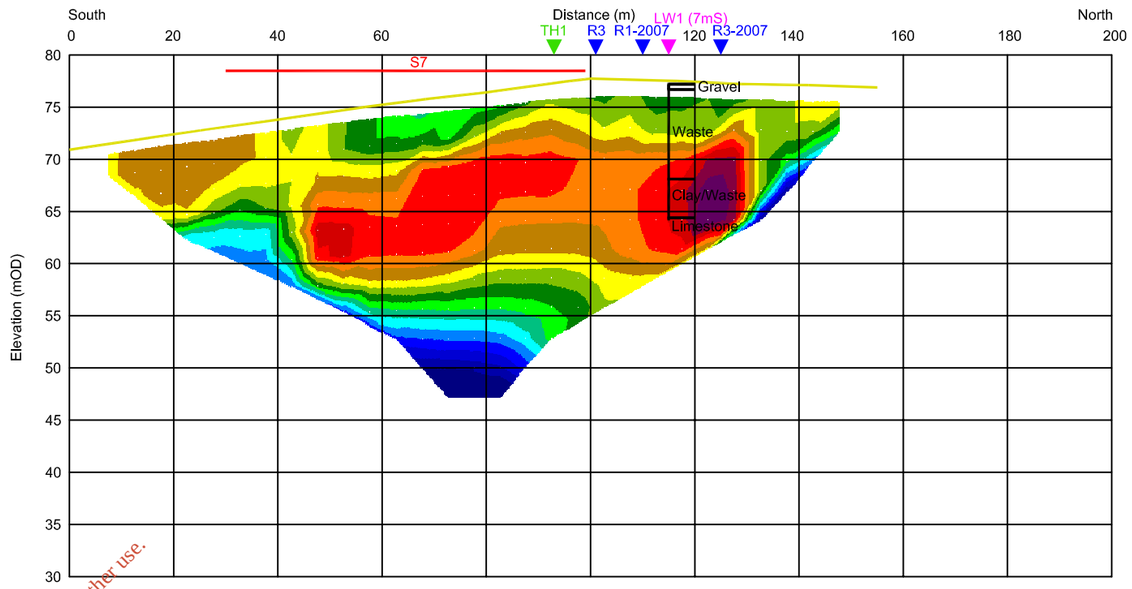
Model Values 2D-Resistivity (Ohmm)

10.0 20.0 40.0 80.0 160 320 640 1280

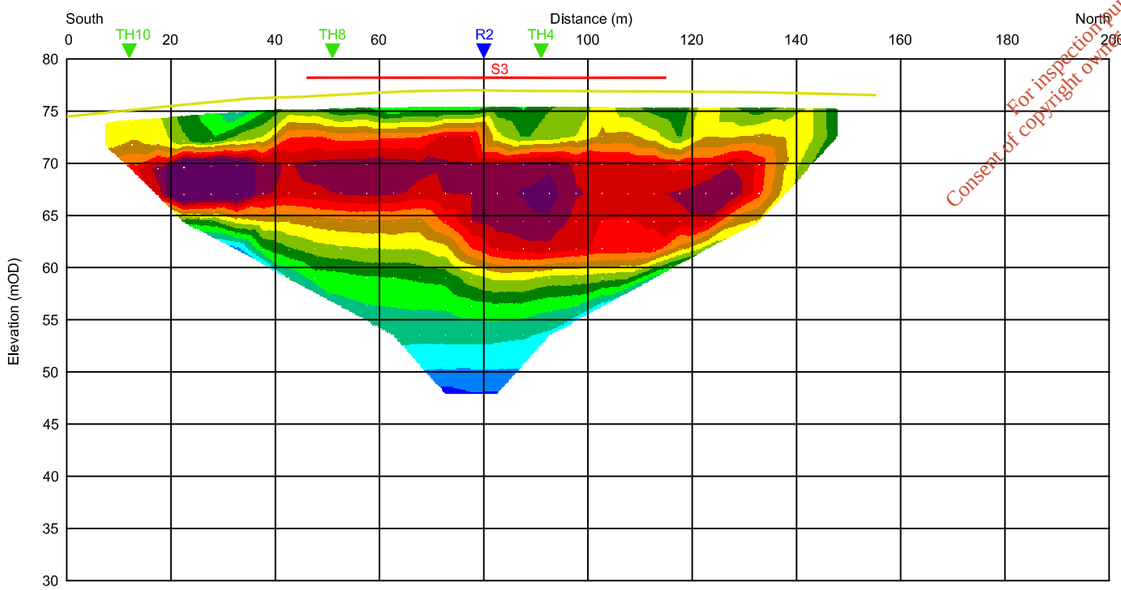
2D-Resistivity Profile R1-2007 Model



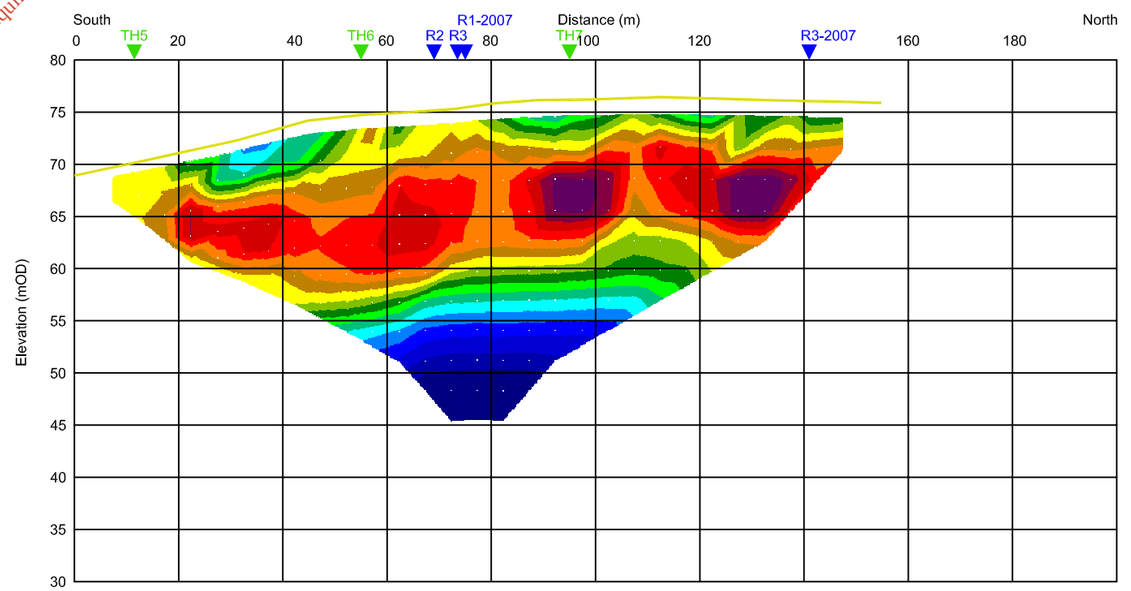
2D-Resistivity Profile R2-2007 Model



2D-Resistivity Profile R3-2007 Model



2D-Resistivity Profile R4-2007 Model



Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Figure 1c: Results of Geophysical Survey 2007

SCALE:	NTS, VE x 2
PROJECT:	5711
DRAWN:	DA
DATE:	06/09/2013
MGX FILE:	5711f_Figs.dwg
STATUS:	Final

LEGEND:

Layers from Seismic Refraction Model:

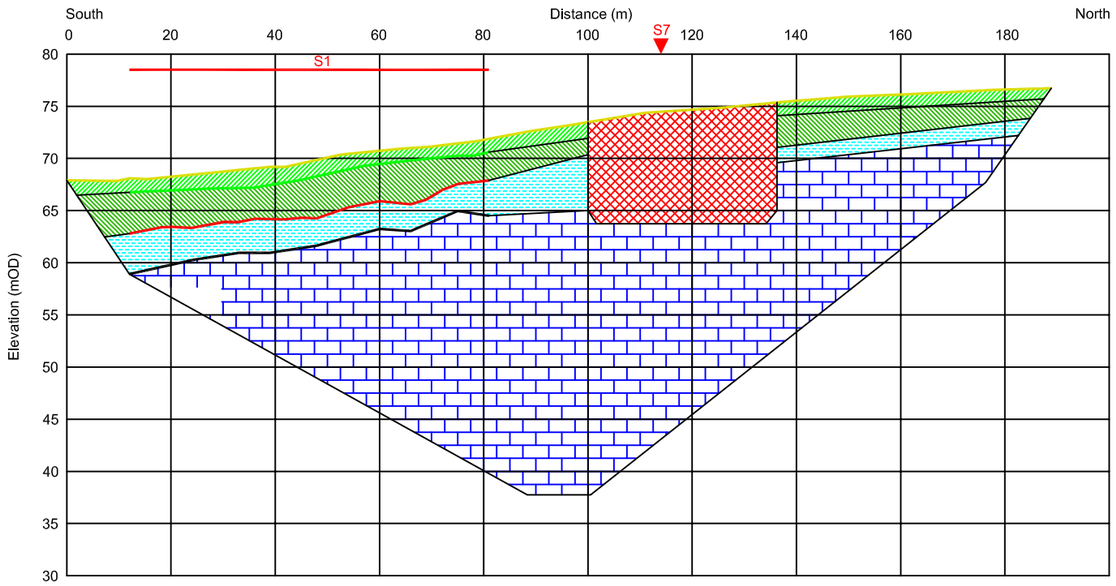
- Ground Surface
- Layer 2 Intra-Waste Boundary (0.25 - 0.5 km/s)
- Boundary between Waste and geological Layer
- Base of solid Object/Layer within Landfill
- Base of Layer 1 (0.25-0.3 km/s) Soil and Top of Layer 3 Firm to stiff Clay (0.7-1.5 km/s)
- Top of Layer 4 weathered Rock or hard Clay (2.1 km/s)
- Top of Layer 5 Strong Limestone (3.5 - 4.3 km/s)

1.5 Seismic Velocity km/s

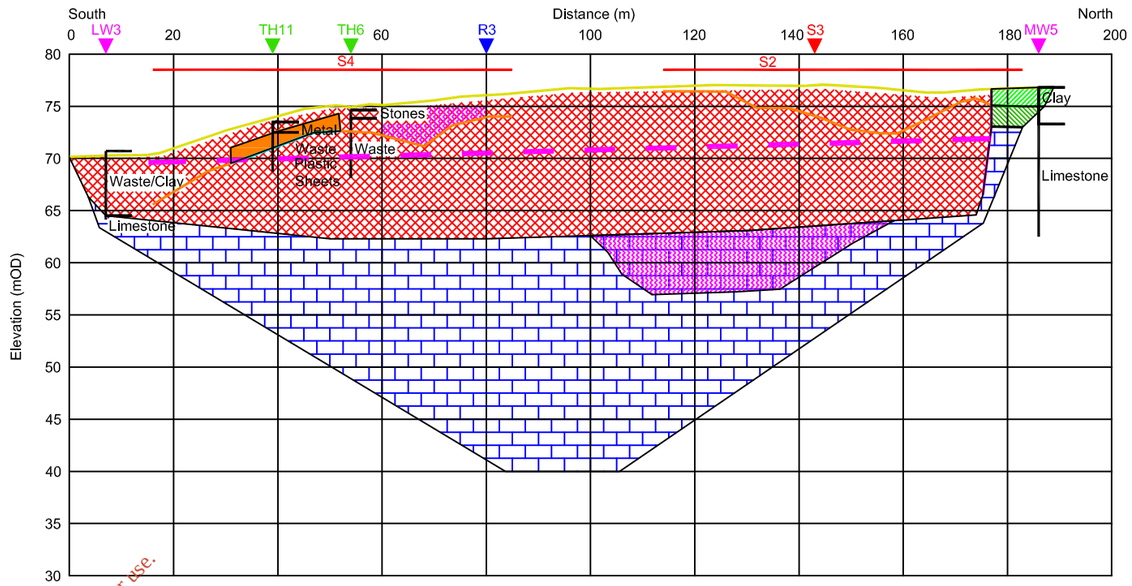
Model Values 2D-Resistivity (Ohmm)

10.0 20.0 40.0 80.0 160 320 640 1280

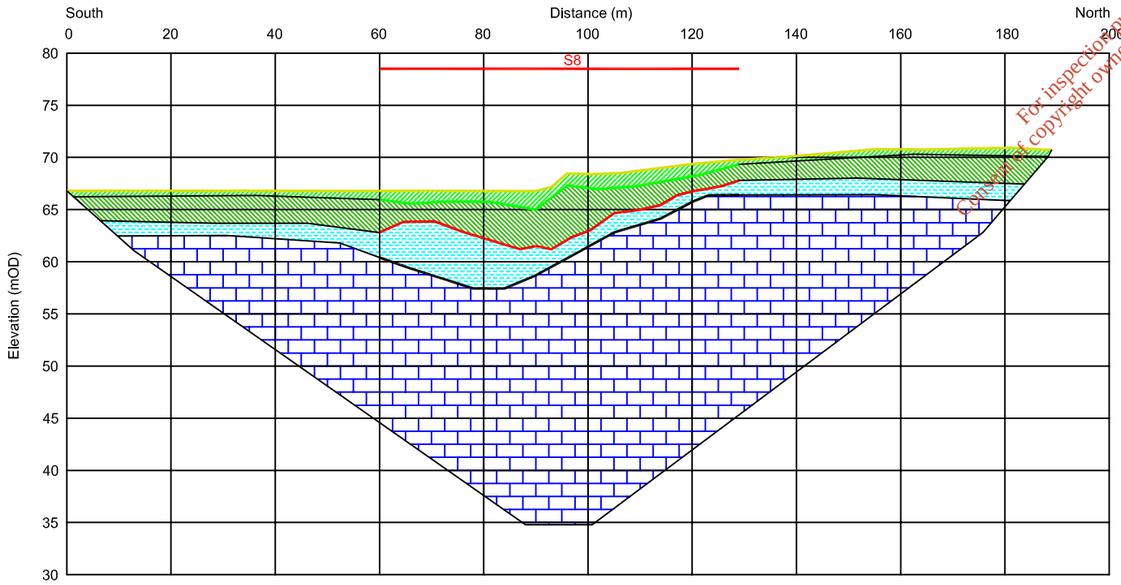
2D-Resistivity Profile R1 and Seismic Refraction Profile S1 Model



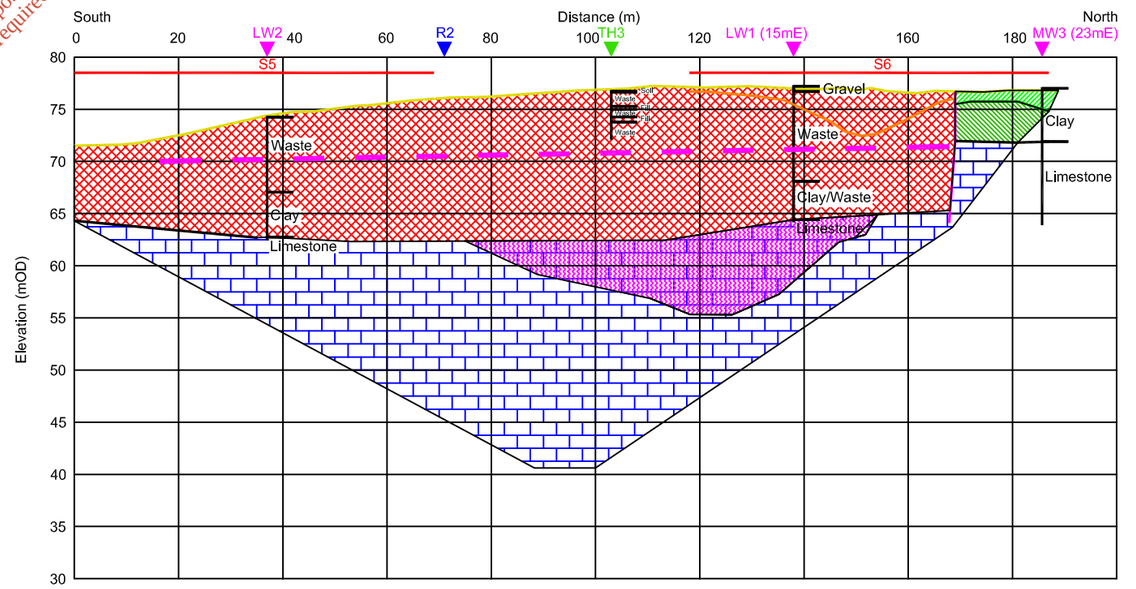
2D-Resistivity Profile R2 and Seismic Refraction Profile S2, S4 Model



2D-Resistivity Profile R4 and Seismic Refraction Profile S8 Model



2D-Resistivity Profile R3 and Seismic Refraction Profile S5, S6 Model



Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Figure 2a: Interpretation of Geophysical Survey

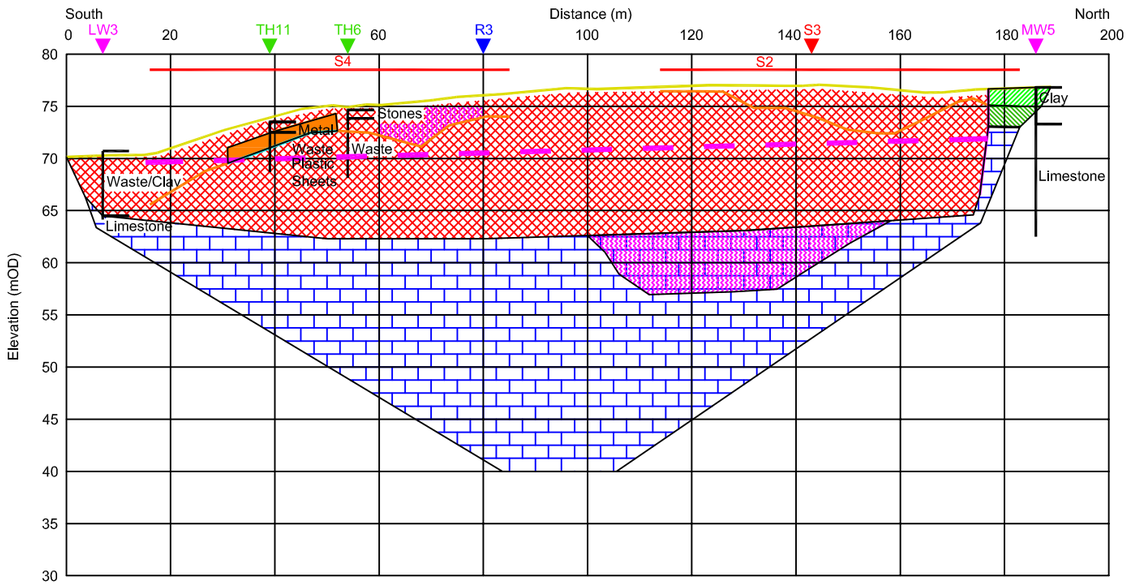
SCALE:	NTS, VE x 2
PROJECT:	5711
DRAWN:	DA
DATE:	06/09/2013
MGX FILE:	5611f_Figs.dwg
STATUS:	Final

LEGEND:

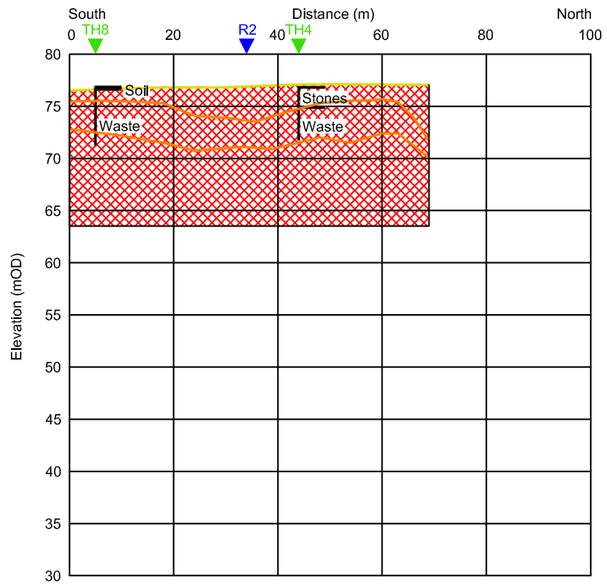
Combined Interpretation:

- 1 Overburden / Soft Soil
- 3 Overburden / Firm - Stiff Clay
- 3 Weathered Rock or Overburden (hard Clay)
- 4 Strong Limestone
- 2 Waste - Landfill
- Solid Object/Layer within Landfill
- Possible Leachate outside Landfill Waste Body
- Approx. Water Level within Landfill

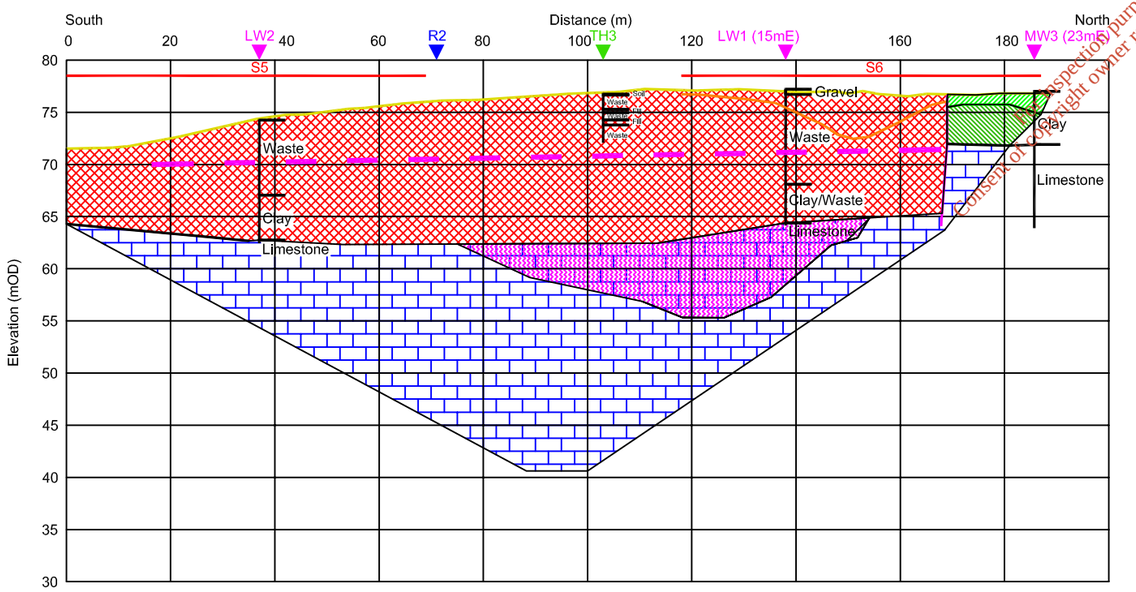
2D-Resistivity Profile R2 and Seismic Refraction Profile S2, S4 Model



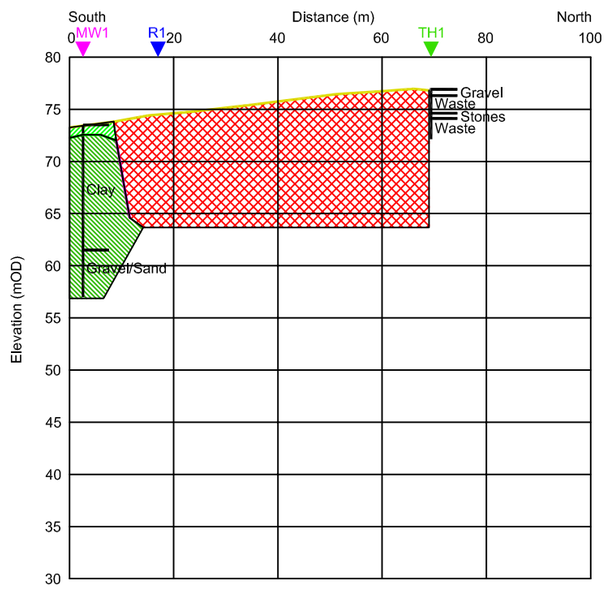
Seismic Refraction Profile S3 Model



2D-Resistivity Profile R3 and Seismic Refraction Profile S5, S6 Model



Seismic Refraction Profile S7 Model



Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Figure 2b: Interpretation of Geophysical Survey

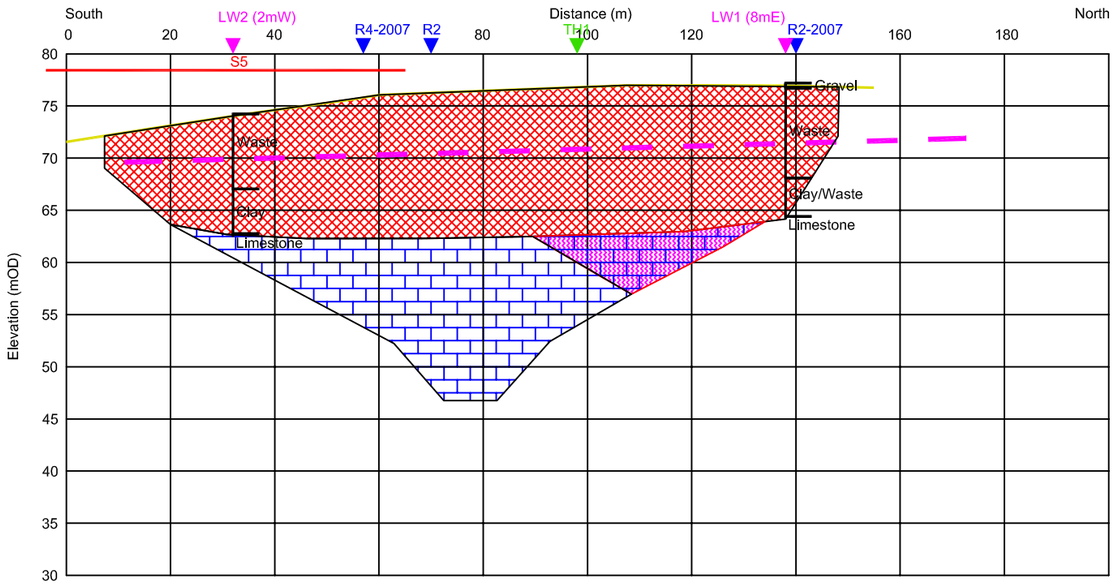
SCALE:	NTS, VE x 2
PROJECT:	5711
DRAWN:	DA
DATE:	06/09/2013
MGX FILE:	5611f_Figs.dwg
STATUS:	Final

LEGEND:

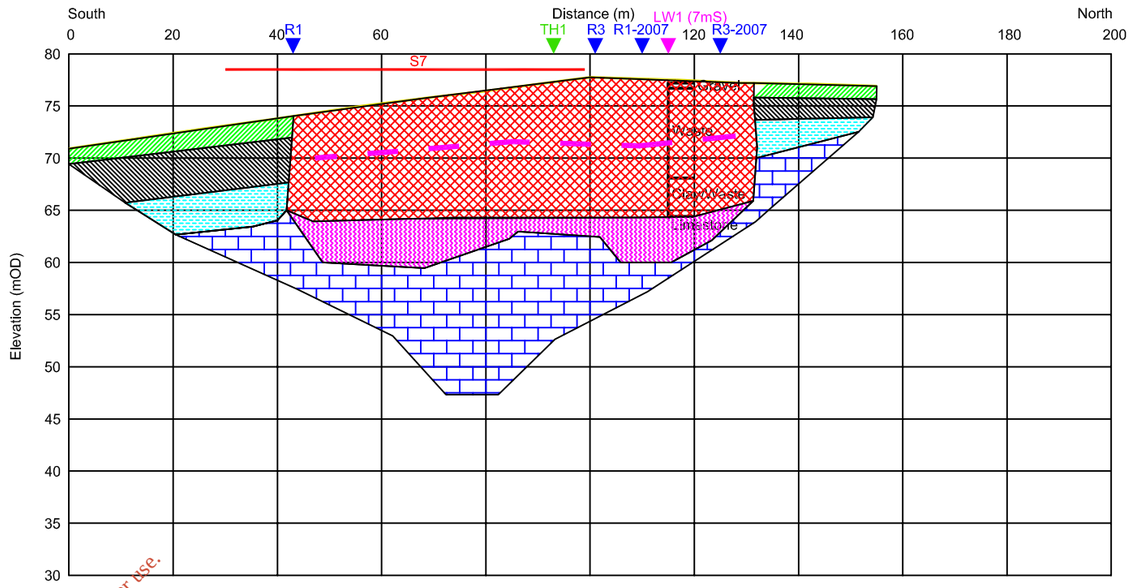
Combined Interpretation:

- 1 Overburden / Soft Soil
- 3 Overburden / Firm - Stiff Clay
- 3 Weathered Rock or Overburden (hard Clay)
- 4 Strong Limestone
- 2 Waste - Landfill
- Solid Object/Layer within Landfill
- Possible Leachate outside Landfill Waste Body
- Approx. Water Level within Landfill

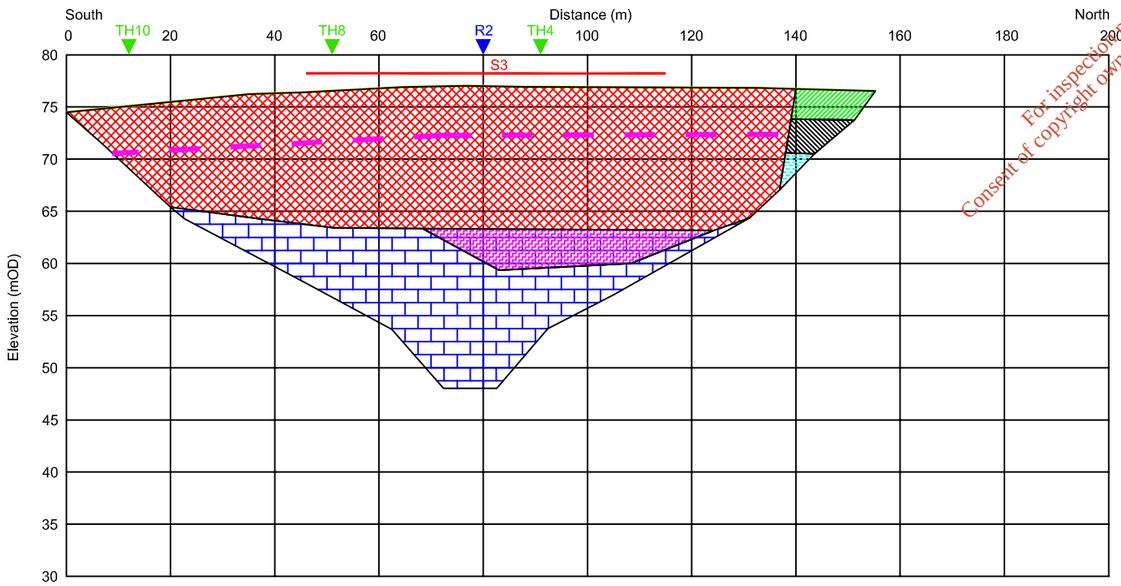
2D-Resistivity Profile R1-2007 Interpretation



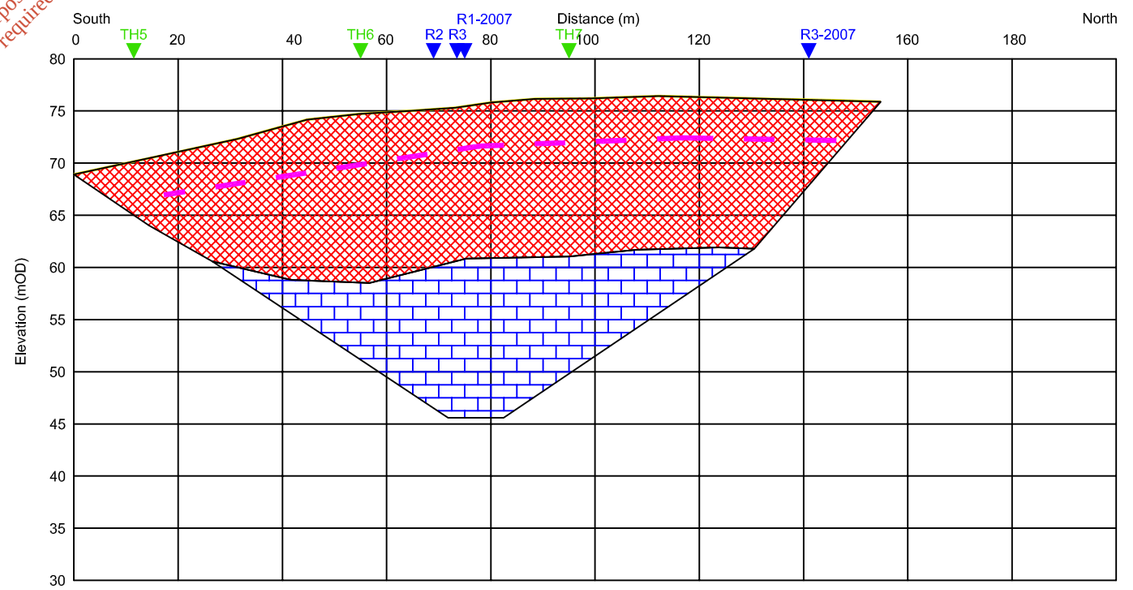
2D-Resistivity Profile R2-2007 Interpretation



2D-Resistivity Profile R3-2007 Interpretation



2D-Resistivity Profile R4-2007 Interpretation



Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Figure 2c: Interpretation of Geophysical Survey 2007

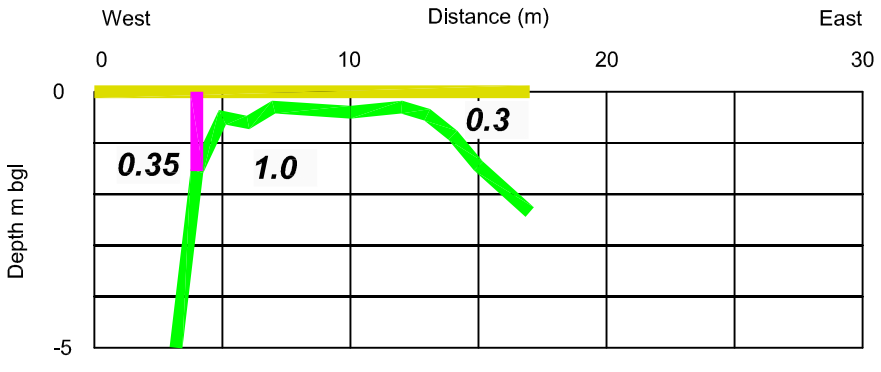
SCALE:	NTS, VE x 2
PROJECT:	5711
DRAWN:	DA
DATE:	06/09/2013
MGX FILE:	5611f_Figs.dwg
STATUS:	Final

LEGEND:

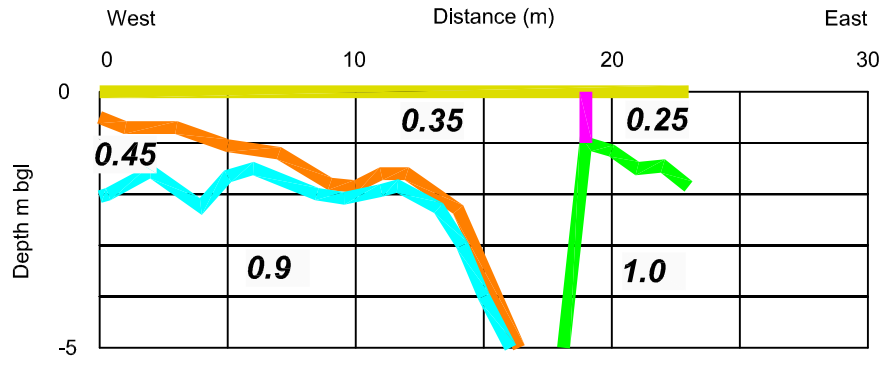
Combined Interpretation:

- 1 Overburden / Soft Soil
- 3 Overburden / Firm - Stiff Clay
- 3 Weathered Rock or Overburden (hard Clay)
- 4 Strong Limestone
- 2 Waste - Landfill
- Solid Object/Layer within Landfill
- Possible Leachate outside Landfill Waste Body
- Approx. Water Level within Landfill

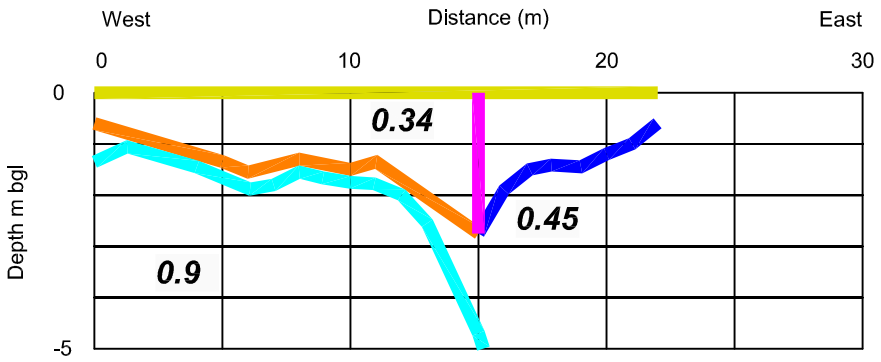
Seismic Refraction Profile S11 Model



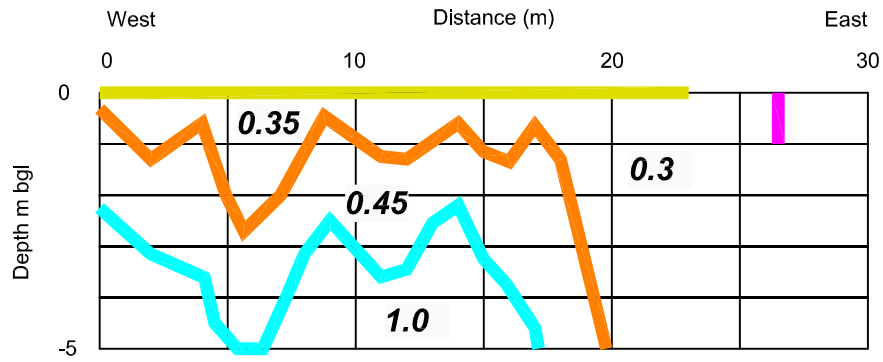
Seismic Refraction Profile S12 Model



Seismic Refraction Profile S13 Model



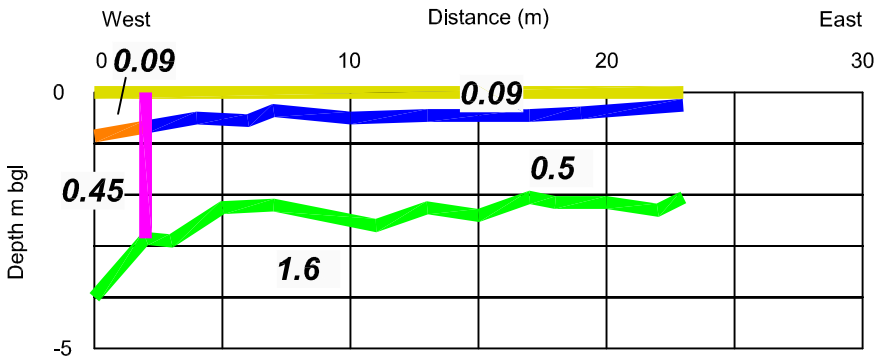
Seismic Refraction Profile S14 Model



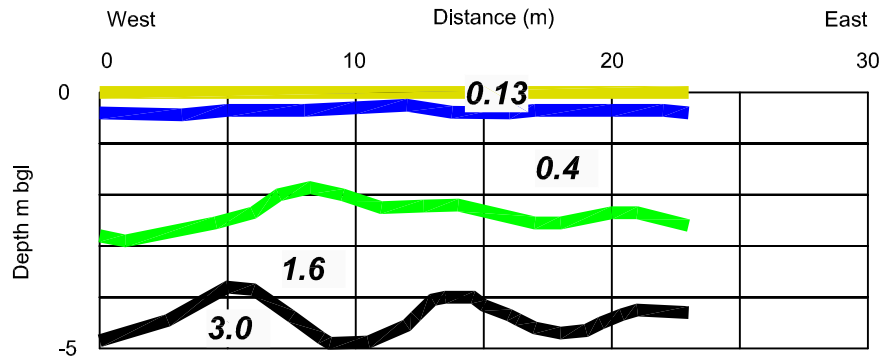
Seismic Refraction Profile S15 Model

Seismic Refraction Profile S16 Model

Seismic Refraction Profile S17 Model



Seismic Refraction Profile S18 Model



Layers with Interpretation from Seismic Refraction Model:

Within Landfill Boundary

- Ground Surface and Top of Waste (0.09 - 0.35 km/s)
- Layer 2 Intra-Waste Boundary (0.25 - 0.5 km/s)
- Top of more compacted Layer within Landfill (0.9 - 1.0 km/s)
- Boundary between Waste and geological Layer

Outside Landfill Boundary

- Ground Surface and Top of Topsoil Layer1 (0.09 - 0.13)
- Base of Layer 2b (0.4-0.5 km/s) Subsoil
- Top of Layer 3 Firm to stiff Clay (1.0 - 1.6 km/s)
- Top of Layer 5 Strong Limestone (3.5 - 4.3 km/s)

Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	Limerick County Council
PROJECT	Churchtown Landfill, Newcastle W. Geophysical Survey
TITLE	Figure 3: Results and Interpretation of Geophysical Survey 2013

SCALE:	NTS, VE x 2
PROJECT:	5711
DRAWN:	HK
DATE:	06/09/2013
MGX FILE:	5611f_Figs.dwg
STATUS:	Final

LEGEND:

1.5 Seismic Velocity km/s

Appendix 4
Pump Test and Boreholes

IRISH DRILLING LIMITED

LOUGHREA, CO. GALWAY, IRELAND

CONTRACT DRILLING
SITE INVESTIGATION

Phone: (091) 841 274
Fax: (091) 880861

email: info@irishdrilling.ie

PROPOSED LANDFILL RESTORATION
AT
NEWCASTLE WEST

SITE INVESTIGATION
FACTUAL REPORT

Limerick County Council,
County Hall,
Dooradoyle,
Co. Limerick.

Tobin Environmental Services Ltd.,
Consulting Engineers,
Block 10-4,
Blanchardstown Corporate Park,
Blanchardstown,
Dublin 15.

January 2013

FOREWORD

The borehole records have been compiled from an examination of the samples by a Geotechnical Engineer and from the Drillers' descriptions. The work was carried out in accordance with BS5930 (1999) and BS1377 (1990).

The report presents an opinion on the configuration of the strata within the site based on the borehole results. The assumptions, though reasonable, are given for guidance only and no liability can be accepted for changes in conditions not revealed by the boreholes.

Contents:

1.0 Introduction.

Irish Drilling Ltd. (IDL) was instructed by Tobin Consulting Engineers., on behalf of Limerick County Council, to carry out a site investigation on the site of the proposed Newcastle West Landfill Restoration.

This site investigation was carried out to allow for the installation of gas and groundwater monitoring standpipes at the disused landfill site.

The fieldwork commenced on November 29th 2012 and was completed on December 4th 2012.

2.0 Site & Geology

The site is located at Churchtown, Newcastle West, County Limerick.

Geological Survey maps of the area indicate that the site is underlain by Carboniferous Limestone Rock Formations.

A Site Plan, prepared by the client's representatives and showing 'as-built' fieldwork locations, is included with this report.

3.0 Fieldwork.

The following plant was mobilised to site to carry out fieldwork operations:

A BBS37 GoTract Rotary Core Drilling Rig.

Fieldwork carried out to date has included the following:

Three rotary boreholes, using openhole drilling techniques, were carried to a depth of 6.00m below ground level.

A 50mm diameter gas standpipe was installed in the boreholes to allow for the monitoring of gas levels over a prolonged period of time.

Two rotary core boreholes were carried out to establish overburden conditions and rockhead and to establish the nature and integrity of the underlying rock.

Wireline drilling techniques, using GeoboreS size drill strings, were carried out to recover 100mm diameter soil and rock core samples at location BH 09.

PQ size (84mm diameter core samples) rotary core drilling was carried out at borehole BH 10.

The samples were stored in wooden boxes and returned to the laboratory where there were logged and photographed by a Geotechnical Engineer.

A 50mm diameter standpipe was installed in borehole BH 10 to allow for the monitoring of groundwater levels over a prolonged period of time.

The rotary core boreholes were carried out using a BBS37 GoTract Rotary Core Drilling Rig to depths ranging from 20.00m to 30.00m below ground level.

Borehole BH 09 was carried out using GeoboreS size drill strings to allow for the completion of a Pump Test using a 100mm diameter submersible pump.

Data loggers were installed in a number of boreholes to act as observation wells during the pump test operations.

A 72-hour Pump Test was carried out on December 10th 2012 by Hydro-Environmental Services Limited and the results of this Pump Test are presented as a 'stand-alone' report and are included in the appendices.

On completion of the Pump Test operations the temporary steel casing was removed from the borehole BH 09 and a 50mm diameter standpipe was installed to allow for the monitoring of groundwater levels over a prolonged period of time.

Reference should be made to the engineering logs for a detailed description of the ground conditions encountered.

The borehole locations were set out on site using a GPS Surveying Unit and the co-ordinates are included on the logs presented in the appendices.

The fieldwork was carried out in accordance with BS5930 (1999), Code of Practice for Site Investigations.

Ronan Killeen
Chartered Engineers
Irish Drilling Limited
January 7th 2013.

APPENDIX 1

BOREHOLE RECORDS (ROTARY CORE)

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 1

Job No	Date	Ground Level (m)	Co-Ordinates ()
	30-11-12 30-11-12	77.22	E 127,497.8 N 134,642.5

Engineer: Tobin

Sheet 1 of 1

Rev.

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities / Detail	DESCRIPTION: Main	Geology	Instrument/ Backfill
							Open hole drilling - no recovery.		
					(6.00)				
			71.22		6.00		BH terminated at 6.00m bgl on RE's instruction.		

Drilling Progress and Water Observations							
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From (m)	To (m)	Type	Return (%)

GENERAL REMARKS

50mm standpipe installed to 6m depth.
Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit Geobore DesignS	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 2

Job No	Date	Ground Level (m)	Co-Ordinates ()
	30-11-12 30-11-12	76.90	E 127,508.3 N 134,584.5

Engineer: Tobin

Sheet 1 of 1

Rev.

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities / Detail	DESCRIPTION: Main	Geology	Instrument/ Backfill
							Open hole drilling - no recovery.		
					(6.00)				
			70.90		6.00		BH terminated at 6.00m bgl on RE's instruction.		

Drilling Progress and Water Observations							
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From (m)	To (m)	Type	Return (%)

GENERAL REMARKS

50mm standpipe installed to 6m depth.
Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit Geobore DesignS	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 3

Job No	Date	Ground Level (m)	Co-Ordinates ()
	29-11-12 29-11-12	75.50	E 127,515.7 N 134,542.5

Engineer	Sheet	Rev.
Tobin	1 of 1	

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities / Detail	DESCRIPTION: Main	Geology	Instrument/ Backfill
							Open hole drilling - no recovery.		
					(6.00)				
			69.50		6.00		BH terminated at 6.00m bgl on RE's instruction.		

Drilling Progress and Water Observations							
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From (m)	To (m)	Type	Return (%)

GENERAL REMARKS

50mm standpipe installed to 6m depth.
Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit Geobore DesignS	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 9

Job No	Date	Ground Level (m)	Co-Ordinates ()
	04-12-12 04-12-12	67.97	E 127,350.5 N 134,567.6

Engineer	Sheet	Rev.
Tobin	1 of 4	

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities / Detail	DESCRIPTION: Main	Geology	Instrument/ Backfill
0.00						0.00 m to 13.90m: overburden.	Open hole drilling - no recovery.		
	0 (-) -	NA			(13.00)				

Drilling Progress and Water Observations							
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From (m)	To (m)	Type	Return (%)
0	30.00	water	100%

GENERAL REMARKS

50mm standpipe installed to 30m depth.
Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit Geobore DesignS	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 9

Job No	Date	Ground Level (m)	Co-Ordinates ()
	04-12-12 04-12-12	67.97	E 127,350.5 N 134,567.6

Engineer	Sheet	Rev.
Tobin	2 of 4	

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities / Detail	DESCRIPTION: Main	Geology	Instrument/ Backfill
13.00		NA	54.97		13.00		Open hole drilling - no recovery. *(continued)*		
	40 (22) 0	NA	54.07		(0.90) 13.90		No recovery. Probable weathered rock.		
14.50		NI				13.90 m to 14.50m: Non-intact as weathered rock.	Weathered LIMESTONE rock. Recovered as angular medium to coarse gravel and cobble sized clasts with some orange and orange brown clay and orange iron stain and smear. 14.50m to 17.50m: core loss due to tube failing to lock.		
17.50	67 (44) 21	NR/NI	50.27		(3.80) 17.70	14.50 m to 17.50m: Non-intact as weathered rock. No recovery as tube failed to lock during drilling.			
19.00	100 (93) 43	NI 1 15				17.70 m to 30.00m: Medium spaced, dipping 36 to 38°, undulating, locally irregular, locally interlocking, smooth, with a little grey clay and orange iron stain and smear. 17.90 m to 18.05m: Joint: subvertical dip, undulating, smooth, with orange iron stain, open. 18.35 m to 18.85m: Joint: subvertical dip, undulating, smooth, with orange and orange brown iron stain, open.	Extremely strong apparently massive grey 'marbled' light grey and white fine and medium grained sparry LIMESTONE. Weathered with a colour change to light grey along discontinuities penetrating 1mm to 2mm.		
	100 (98) 92	1							

Drilling Progress and Water Observations							
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From (m)	To (m)	Type	Return (%)

GENERAL REMARKS

50mm standpipe installed to 30m depth.
Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit Geobore DesignS	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 9

Job No	Date	Ground Level (m)	Co-Ordinates ()
	04-12-12 04-12-12	67.97	E 127,350.5 N 134,567.6

Engineer	Sheet	Rev.
Tobin	3 of 4	

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities / Detail	DESCRIPTION: Main	Geology	Instrument/ Backfill
20.50							Extremely strong apparently massive grey 'marbled' light grey and white fine and medium grained sparry LIMESTONE. Weathered with a colour change to light grey along discontinuities penetrating 1mm to 2mm. *(continued)*		
	100 (95) 77	2				20.80 m to 20.95m: Joint: subvertical dip, undulating, rough, with a little orange brown iron stain, open.			
22.00		4				21.10 m to 21.20m: Joint: dipping 60°, undulating, interlocking, smooth, with orange and orange brown iron stain, open.			
	100 (94) 61	2							
23.50		7				22.75 m to 22.90m: Joint: subvertical dip, undulating, smooth, with minor orange brown iron stain, open. 23.10 m to 23.50m: Joint: subvertical dip, undulating, rough, with orange and orange brown iron stain, open.			
	100 (93) 63				(12.30)	23.70 m to 24.05m: Joint: subvertical dip, undulating, rough, with orange and orange brown iron stain, open.			
25.00		3							
	100 (91) 62	3				25.75 m to 26.05m: Joint: subvertical dip, undulating, smooth, with minor dark orange brown iron stain, open. 26.10 m to 27.90m: Joint: subvertical dip, undulating, locally planar, rough, with a little orange brown clay and some orange and orange brown iron stain and smear, open.			
26.50		11							
	100 (96) 8								
28.00		7							
	100 (82) 59	3							
29.50		4							
30.00	100 (98) 92		37.97		30.00				

Drilling Progress and Water Observations							
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From (m)	To (m)	Type	Return (%)

GENERAL REMARKS

50mm standpipe installed to 30m depth.
Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit Designs Geobore	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 10

Job No	Date	Ground Level (m)	Co-Ordinates ()
	03-12-12 04-12-12	75.10	E 127,421.9 N 134,630.3

Engineer	Sheet	Rev.
Tobin	1 of 3	

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities / Detail	DESCRIPTION: Main	Geology	Instrument / Backfill
0.00						0.00 m to 13.20m: overburden.	Open hole drilling - no recovery.		
	0 (-)	NA			(13.20)				

Drilling Progress and Water Observations							
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From (m)	To (m)	Type	Return (%)
0	20.00	water	100%

GENERAL REMARKS

50mm standpipe installed to 20m depth.
Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit Design PQ	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 10

Job No	Date	Ground Level (m)	Co-Ordinates ()
	03-12-12 04-12-12	75.10	E 127,421.9 N 134,630.3

Engineer	Sheet	Rev.
Tobin	2 of 3	

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities / Detail	DESCRIPTION: Main	Geology	Instrument/ Backfill
13.20			61.90		13.20		Open hole drilling - no recovery. *(continued)*		
14.50	92 (88) 66	2				13.20 m to 20.00m: Medium spaced, dipping 18 to 20°, irregular, locally interlocking, rough, with some orange brown clay and much orange brown and orange iron stain and smear.	Extremely strong apparently massive light grey 'marbled' brownish white fine and medium grained sparry LIMESTONE. Weathered with a colour change to light grey along discontinuities penetrating 1mm to 2mm.		
16.00	100 (96) 70	2 5				15.70 m to 16.00m: Joint: subvertical dip, undulating, locally irregular, rough, with a little orange brown clay and minor orange iron stain, open.			
17.50	100 (95) 56	5 5			(6.80)	16.15 m to 16.80m: Joint: subvertical dip, undulating, locally irregular, rough, with a little orange brown clay and minor orange iron stain, open.			
19.00	67 (32) 14	5				17.30 m to 17.80m: Joint: subvertical dip, undulating, locally irregular, rough, with a little orange brown clay and much orange and orange brown iron stain smear and powder, open.	17.80 to 20.00m: becoming brownish grey vuggy weakly dolomitised.		
20.00	90 (0) 0	NR/NI	55.10		20.00	18.50 m to 20.00m: Non-intact as weathered rock. No recovery as possible washout of fines during drilling.	18.50m: non-intact as angular fine to coarse gravel and cobble sized clasts with much orange brown clay and much orange brown iron stain and smear.		

Drilling Progress and Water Observations								Rotary Flush				GENERAL REMARKS
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing	From (m)	To (m)	Type	Return (%)	50mm standpipe installed to 20m depth. Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit Design PQ	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

IDL

DRILLHOLE LOG

Project	Location	DRILLHOLE No
Newcastle West Landfill Restoration	Newcastle West , Co Limerick	BH 10

Job No	Date	Ground Level (m)	Co-Ordinates ()
	03-12-12 04-12-12	75.10	E 127,421.9 N 134,630.3

Engineer	Sheet	Rev.
Tobin	3 of 3	

RUN DETAILS					STRATA				
Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thick-ness)	DESCRIPTION: Discontinuities	Detail	Main	Geology	Instrument/ Backfill
								BH terminated at 20.00m bgl on RE's instruction.		

Drilling Progress and Water Observations							
Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush			
From (m)	To (m)	Type	Return (%)

GENERAL REMARKS

50mm standpipe installed to 20m depth.
Gas monitoring tap fitted.

All dimensions in metres Scale 1:62.5	Client Limerick County Council	Method/ Plant Used Hydreq	Bit PQ Design	Driller NV	Logged By EAT

IDL AGS3 UK DH NEWCASTLE WEST LANDFILL BHS 9 AND 10 DEC 21 2012.GPJ IDL TP TEMPLATE.GDT 7/1/13

APPENDIX 2

PUMP TEST RECORDS

HYDRO ENVIRONMENTAL SERVICES

22 Lower Main St
Dungarvan
Co.Waterford
Ireland

tel: +353 (0)58 44122
fax: +353 (0)58 44244
email: info@hydroenvironmental.ie
web: www.hydroenvironmental.ie

PUMPING TEST FACTUAL REPORT
NEWCASTLEWEST, CO. LIMERICK

DRAFT REPORT

Prepared for:

IRISH DRILLING LTD

Prepared by:

HYDRO-ENVIRONMENTAL SERVICES

REPORT NO.: P1211
REPORT DATE: 4th January 2013

DOCUMENT INFORMATION

DOCUMENT TITLE:	**PUMPING TEST FACTUAL REPORT – NEWCASTLEWEST, CO. LIMERICK**
ISSUE DATE:	**04TH JANUARY 2013**
PROJECT NUMBER:	**P1211**
PROJECT REPORTING HISTORY:	**NONE**
CURRNET REVISION NO:	**P1211**
AUTHOR(S):	**MICHAEL GILL** **DAVID BRODERICK**
SIGNED:	Michael Gill **Michael Gill B.A., B.A.I., M.Sc., MIEI** **Managing Director – Hydro-Environmental Services**

Disclaimer:
This report has been prepared by HES with all reasonable skill, care and diligence within the terms of the contract with the client incorporating our terms and conditions and taking account of the resources devoted to it by agreement with the client. We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above. This report is confidential to the client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies upon the report at their own risk.

TABLE OF CONTENTS

FIGURES

TABLES IN TEXT

APPENDICES

1.0 PUMPING TEST RESULTS

1.1 INTRODUCTION

Hydro-Environmental Services (HES) were commissioned to complete a 72 hour pumping test at an old restored landfill site near Newcastlewest, Co. Limerick.

Along with the pumping well (PW1) a total of 5 no. observation wells were monitored during the pumping test. These were MW03, MW06, MW07, MW08, MW10. The layout of the pumping well and the monitoring wells are shown on Figure 1.

This report provides recorded water level data from the pumping test and subsequent recovery period. Field chemistry data and flow data, which were recorded regularly throughout the test, are also presented.

1.2 PW1 - PUMPING TEST METHODOLOGY

A 4" electrical submersible pump was installed in the pumping well PW1 on 10th December 2012. A 2" discharge line (40m of 2" layflat discharge hose) was laid out and directed away from the pumping well with the final outfall to a County Council owned stormwater culvert located on the public road to the south of the site. A 2" mag meter (electrical water meter) was connected along the discharge line and a gate valve was also included (in-line) to allow regulation/variation of the discharge rate (flow), if required. The pump was connected to a 6 KV diesel generator. A photograph of the flowmeter and discharge line is shown below.

Plate 1. Photograph of pumping test setup at PW1.

"Diver"[1] water level dataloggers were installed in the pumping well (PW1) and the five observation wells (MW3, MW6, MW7, MW8 and MW10) to allow continuous monitoring of water levels during the pumping test and subsequent recovery test. Groundwater levels were recorded in the pumping well at 1 minute intervals and in the observation wells at 5 or 15 minute intervals for the duration of the test.

[1] Water level pressure transducers with inbuilt datalogger. (http://www.slb.com/content/services/additional/water/monitoring/dataloggers/index.asp).

The pumping test was completed in accordance with BS5930: 1999 – Code of practice for site investigations, and with BS6316: 1992 Code of practice for test pumping of water wells. Additional guidance on pumping test methodology was taken from Wright, 1985.

Manual groundwater level monitoring in the pumping well was completed when possible at the intervals shown in Table A. Discharge (flow) from the pumping well was also recorded regularly throughout the test. Manual water level monitoring was also completed regularly in the observation wells during the test.

Table A. Groundwater level monitoring frequencies.

Time Interval	Monitoring Frequency
0-2 mins	Every 30 seconds
2-5 mins	Every 1 minute
5-20 mins	Every 2 minutes 30 seconds
20-40 mins	Every 5 minutes
40-60 mins	Every 10 minutes
60-75 mins	Every 15 minutes
75-100 mins	Every 25 minutes
100-120 mins	Every 20 minutes
2-8 hours	Every 30 minutes

1.3 PW1 – PRE-PUMPING TEST

A standard step test was initially attempted on the pumping well on 10th December 2012, however due to the relatively low discharge rate (due to the low yield of the pumping well) of the well this was abandoned. Instead a short pre-pumping test lasting approximately 45 minutes was undertaken. Initially PW1 was pumped at a discharge rate of 0.5L/s (43.2m³/day); however by the end of the pre-pumping test the discharge rate was regulated down to 0.3L/s (25.9m³/day) which is the estimated long-term sustainable yield of the well.

1.4 PW1 - PUMPING TEST RESULTS

The 72 hour pumping test in well PW1 was initiated at 09:00 on 11th December 2012. Starting water levels recorded in the pumping well and observation wells prior to the initiation of the pumping test are summarised in Table B below. The water levels for the observation wells and PW1 shown in Table B are not static water levels as the production well was developed for a period of 1 to 2 hours on 10th December 2012. In addition the 45 minute pre-pumping test was also completed on this date. The well development and pre-pumping test appear to have lowered the water levels in the observation wells prior to the initiation of the 72 hour pumping test on 11th December 2012. This was indicated by the excess recovery noted in a number of the monitoring wells.

Table B. Starting Water levels recorded prior to initiation of pumping test.

Well ID	Water Level (mAOD)*	Water Level (mbdl)
PW1	To be updated	4.0
MW03	To be updated	6.97
MW06	To be updated	5.52
MW07	To be updated	5.09
MW08	To be updated	7.58
MW10	To be updated	8.80

mAOD - meters above Ordnance Datum Malin Head
mbdl – meters below datum level

The pumping rate remained relatively constant throughout the 72 hour test, but did show some decline falling from an initial rate of 0.3L/s (25.92m³/day) to a rate of 0.26L/s (22.44m³/day) towards the end of the test. Discharge measurement recordings are shown in Appendix I.

The water level recovery in the pumping well was only monitored for a period of 2 hours after the pumping test due to a requirement that the submersible pump had to be removed on completion of the pumping test. The water level recovery in the observation wells (*i.e.* by means of data loggers only) was monitored for a period of 72 hours after the pumping test.

A drawdown and recovery plot for PW1 is shown as Figure 2 and a combined plot of drawdown and recovery for observations wells MW03, MW06, MW07, MW08 and MW10 is shown as Figure 3. Water level data recorded during the pumping test are presented in Appendix II. The corrected data have been compared and adjusted to manual dip data to ensure that the data provided in the appendices are correct and internally and externally consistent. Maximum drawdown data recorded during the pumping test are summarised in Table C.

The recovery plots show that some of the observation wells (*i.e.* MW03 and MW07) recovered to a higher level than the starting water level shown in Table B. This is likely due to the effect of the production well development lowering the water table prior to the initiation of the pumping test. Also, rainfall recharge prior to and during the pumping test may also be a factor. The recovery plots also indicate that there might be an external influence, such as a pumping well, in the vicinity of the site that is affecting the water levels in the observation wells.

Table C: Maximum drawdown recorded during pumping test.

Well ID	Drawdown (m)	Water Level (mbdl)	Distance from pumping well (m)
PW1	13.699	17.699	To be updated
MW03	0.614	7.584	To be updated
MW06	0.173	5.693	To be updated
MW07	0.319	5.409	To be updated
MW08	0.653	8.233	To be updated
MW10	0.287	9.087	To be updated

1.5 HYDROCHEMISTRY

Field hydrochemistry (*i.e.* Temperature, Electrical Conductivity and pH) of the discharge water were recorded at the well head using a calibrated YSI 556 multi-meter probe and flow through cell. These data are shown in Table D below.

Table D: Field Hydrochemistry Data.

Date	Time	Electrical Conductivity (µS/cm)	Temperature (° C)	pH [H^+ ion]	Visual
11/12/2012	09:45	970	11.4	8.5	Cloudy/silty
11/12/2012	15:20	980	11.3	7.6	Cloudy/silty
11/12/2012	16:45	977	10.9	7.3	Cloudy/silty
12/12/2012	08:15	984	11.3	7.5	Cloudy/silty
12/12/2012	16:34	991	11.9	7.6	Cloudy/silty
13/12/2012	08:15	988	11.7	7.7	Cloudy/silty
13/12/2012	18:40	992	11.8	7.7	Cloudy/silty
14/12/2012	09:02	994	12.0	7.7	Clearing

2.0 REFERENCES

British Standards Institution	1992	BS6316 - Code of Practice for Test Pumping of Water Wells.
British Standards Institution	1999	BS5930 - Code of Practice for Site Investigations.
British Standards Institution	2003	BS ISO14686:2003 - Hydrometric determinations — Pumping tests for water wells — Considerations and guidelines for design, performance and use.
Wright, G.R. - Geological Survey of Ireland Information Circular 85/2,	1985	Pumping Tests: A guide to the testing of water wells for public, industrial, and farm supplies.

Tree And Hedge Line

MW1 MW3 MW7 MW9 MW6 MW8

BH1 BH2 BH3 BH9 BH10

GW1 GW2 GW3

LW01 LW02 LW03

BM 68.74

69.7

74.7

74.5

EXISTING BUNGALOW

EXISTING TWO STOREY HOUSES

EXISTING BUNGALOW

EXISTING TWO-STOREY HOUSES

EXISTING BUNGALOW

EXISTING TWO-STOREY HOUSES

EXISTING PUBLIC HOUSE

Shed

ROAD

General Notes

IRISH DRILLING LIMITED

Legend

- Existing BH
- IDL BH 2012
- Proposed Gas Monitoring BH

No.	Revision/Issue	Date

Firm Name and Address

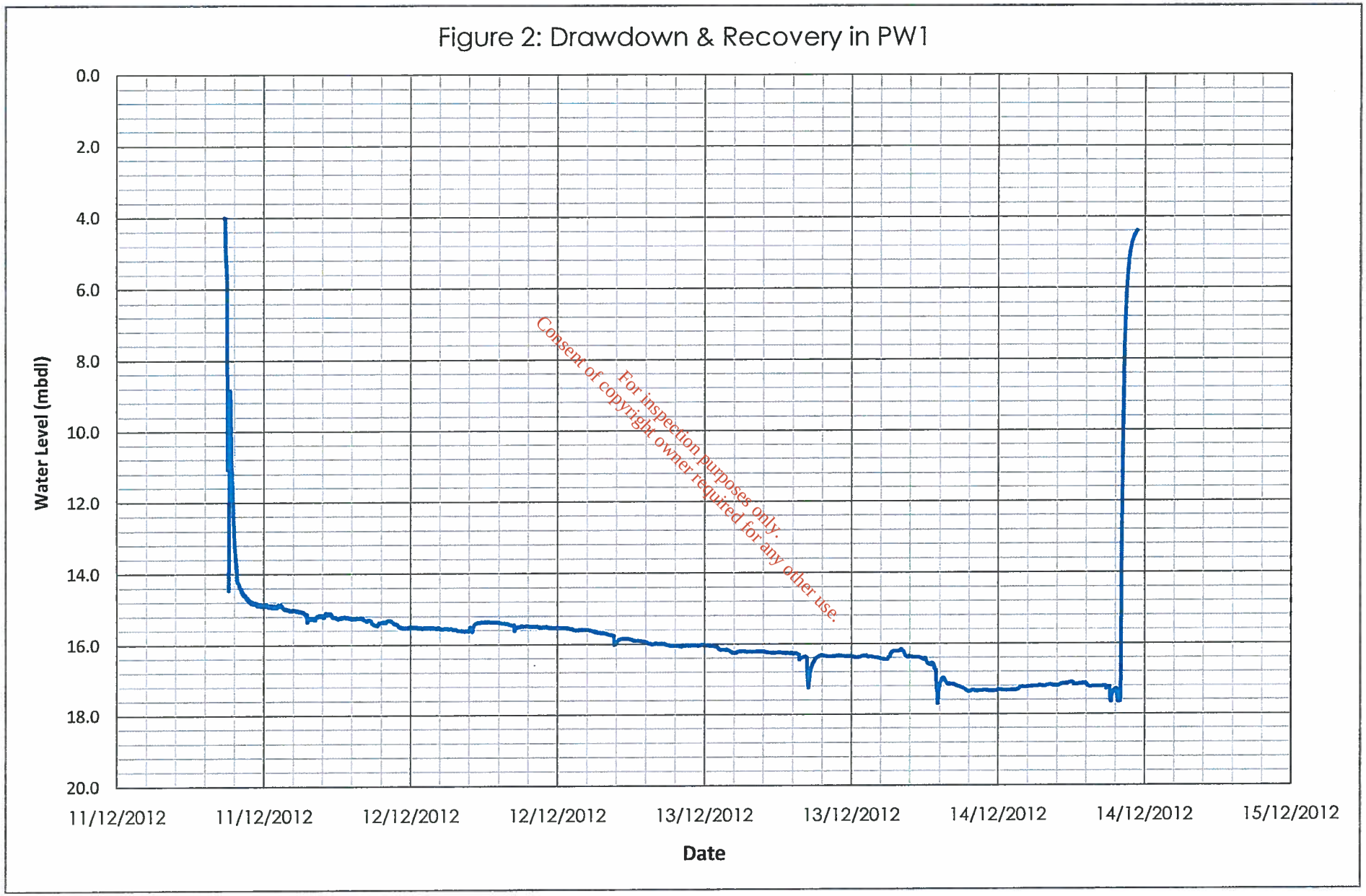
LIMERICK COUNTY COUNCIL
Comhairle Chontae Luimnigh

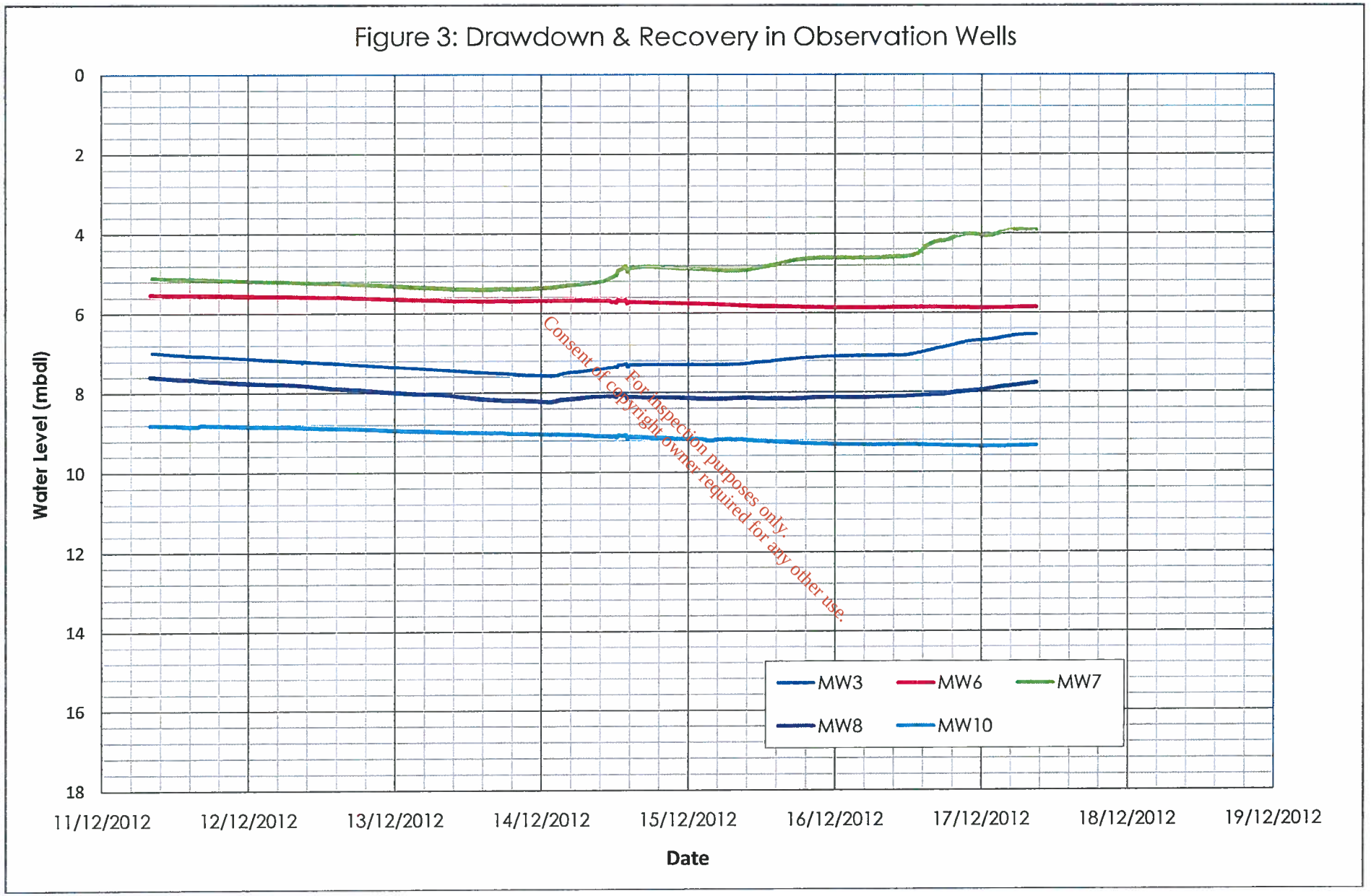
Project Name and Address

Limerick County Council
Churchtown Landfill Site
Tier 2 Main Investigation
IDL (AS BUILT) BOREHOLE LOCATIONS

Project	Sheet
Churchtown	01-01
Date: 25/10/12	
Scale: As Noted	

FIGURES





APPENDIX I
PW1 DISCHARGE DATA

Date / Time	m3/day
11/12/2012 09:10	25.920
11/12/2012 09:12	25.920
11/12/2012 09:15	21.600
11/12/2012 09:20	22.464
11/12/2012 09:21	23.328
11/12/2012 09:22	24.192
11/12/2012 09:50	24.192
11/12/2012 10:19	23.328
11/12/2012 10:30	23.328
11/12/2012 10:40	23.328
11/12/2012 10:50	24.192
11/12/2012 11:00	24.192
11/12/2012 11:10	23.328
11/12/2012 11:20	23.328
11/12/2012 11:30	24.192
11/12/2012 11:40	24.192
11/12/2012 11:50	24.192
11/12/2012 12:00	24.192
11/12/2012 12:10	24.192
11/12/2012 12:20	24.192
11/12/2012 12:32	24.192
11/12/2012 12:40	24.192
11/12/2012 12:50	24.192
11/12/2012 13:00	24.192
11/12/2012 13:10	24.192
11/12/2012 13:20	24.192
11/12/2012 13:30	23.328
11/12/2012 14:10	23.328
11/12/2012 15:20	23.328
11/12/2012 16:40	24.192
11/12/2012 20:30	23.328
12/12/2012 08:15	24.192
12/12/2012 16:29	23.328
13/12/2012 07:36	24.192
13/12/2012 18:37	23.328
14/12/2012 08:56	23.328
14/12/2012 09:55	22.464

APPENDIX II
ALL PUMPING TEST WATER LEVEL DATA

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
11/12/2012 08:45	4.000	11/12/2012 13:25	14.868	11/12/2012 18:00	15.243
11/12/2012 08:50	3.994	11/12/2012 13:30	14.920	11/12/2012 18:05	15.271
11/12/2012 08:55	5.089	11/12/2012 13:35	14.941	11/12/2012 18:10	15.253
11/12/2012 09:00	5.565	11/12/2012 13:40	14.978	11/12/2012 18:15	15.227
11/12/2012 09:10	13.430	11/12/2012 13:45	15.001	11/12/2012 18:20	15.219
11/12/2012 09:15	9.807	11/12/2012 13:50	14.971	11/12/2012 18:25	15.228
11/12/2012 09:20	10.296	11/12/2012 13:55	14.980	11/12/2012 18:30	15.235
11/12/2012 09:25	11.464	11/12/2012 14:00	15.013	11/12/2012 18:35	15.216
11/12/2012 09:30	12.070	11/12/2012 14:05	15.004	11/12/2012 18:40	15.223
11/12/2012 09:35	12.798	11/12/2012 14:10	15.039	11/12/2012 18:45	15.215
11/12/2012 09:40	13.347	11/12/2012 14:15	15.021	11/12/2012 18:50	15.235
11/12/2012 09:45	13.686	11/12/2012 14:20	15.030	11/12/2012 18:55	15.215
11/12/2012 09:50	14.175	11/12/2012 14:25	15.021	11/12/2012 19:00	15.232
11/12/2012 09:55	14.223	11/12/2012 14:30	15.010	11/12/2012 19:05	15.250
11/12/2012 10:00	14.291	11/12/2012 14:35	15.017	11/12/2012 19:10	15.260
11/12/2012 10:05	14.399	11/12/2012 14:40	15.036	11/12/2012 19:15	15.262
11/12/2012 10:10	14.425	11/12/2012 14:45	15.055	11/12/2012 19:20	15.271
11/12/2012 10:15	14.480	11/12/2012 14:50	15.041	11/12/2012 19:25	15.239
11/12/2012 10:20	14.576	11/12/2012 14:55	15.050	11/12/2012 19:30	15.251
11/12/2012 10:25	14.587	11/12/2012 15:00	15.067	11/12/2012 19:35	15.261
11/12/2012 10:30	14.618	11/12/2012 15:05	15.074	11/12/2012 19:40	15.257
11/12/2012 10:35	14.662	11/12/2012 15:10	15.087	11/12/2012 19:45	15.248
11/12/2012 10:40	14.651	11/12/2012 15:15	15.075	11/12/2012 19:50	15.244
11/12/2012 10:45	14.723	11/12/2012 15:20	15.117	11/12/2012 19:55	15.236
11/12/2012 10:50	14.752	11/12/2012 15:25	15.127	11/12/2012 20:00	15.244
11/12/2012 10:55	14.743	11/12/2012 15:30	15.140	11/12/2012 20:05	15.267
11/12/2012 11:00	14.820	11/12/2012 15:35	15.349	11/12/2012 20:10	15.278
11/12/2012 11:05	14.815	11/12/2012 15:40	15.263	11/12/2012 20:15	15.285
11/12/2012 11:10	14.808	11/12/2012 15:45	15.241	11/12/2012 20:20	15.303
11/12/2012 11:15	14.797	11/12/2012 15:50	15.266	11/12/2012 20:25	15.330
11/12/2012 11:20	14.827	11/12/2012 15:55	15.250	11/12/2012 20:30	15.323
11/12/2012 11:25	14.813	11/12/2012 16:00	15.244	11/12/2012 20:35	15.284
11/12/2012 11:30	14.821	11/12/2012 16:05	15.250	11/12/2012 20:40	15.291
11/12/2012 11:35	14.846	11/12/2012 16:10	15.271	11/12/2012 20:45	15.308
11/12/2012 11:40	14.898	11/12/2012 16:15	15.285	11/12/2012 20:50	15.372
11/12/2012 11:45	14.893	11/12/2012 16:20	15.219	11/12/2012 20:55	15.389
11/12/2012 11:50	14.885	11/12/2012 16:25	15.192	11/12/2012 21:00	15.425
11/12/2012 11:55	14.907	11/12/2012 16:30	15.199	11/12/2012 21:05	15.425
11/12/2012 12:00	14.857	11/12/2012 16:35	15.167	11/12/2012 21:10	15.452
11/12/2012 12:05	14.899	11/12/2012 16:40	15.177	11/12/2012 21:15	15.446
11/12/2012 12:10	14.898	11/12/2012 16:45	15.163	11/12/2012 21:20	15.441
11/12/2012 12:15	14.880	11/12/2012 16:50	15.180	11/12/2012 21:25	15.407
11/12/2012 12:20	14.900	11/12/2012 16:55	15.211	11/12/2012 21:30	15.388
11/12/2012 12:25	14.927	11/12/2012 17:00	15.151	11/12/2012 21:35	15.388
11/12/2012 12:30	14.943	11/12/2012 17:05	15.097	11/12/2012 21:40	15.368
11/12/2012 12:35	14.903	11/12/2012 17:10	15.131	11/12/2012 21:45	15.361
11/12/2012 12:40	14.893	11/12/2012 17:15	15.125	11/12/2012 21:50	15.349
11/12/2012 12:45	14.927	11/12/2012 17:20	15.115	11/12/2012 21:55	15.367
11/12/2012 12:50	14.933	11/12/2012 17:25	15.139	11/12/2012 22:00	15.369
11/12/2012 12:55	14.948	11/12/2012 17:30	15.134	11/12/2012 22:05	15.337
11/12/2012 13:00	14.896	11/12/2012 17:35	15.159	11/12/2012 22:10	15.307
11/12/2012 13:05	14.952	11/12/2012 17:40	15.191	11/12/2012 22:15	15.306
11/12/2012 13:10	14.917	11/12/2012 17:45	15.224	11/12/2012 22:20	15.301
11/12/2012 13:15	14.913	11/12/2012 17:50	15.229	11/12/2012 22:25	15.311
11/12/2012 13:20	14.902	11/12/2012 17:55	15.221	11/12/2012 22:30	15.351

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
11/12/2012 22:35	15.381	12/12/2012 03:10	15.566	12/12/2012 07:45	15.415
11/12/2012 22:40	15.406	12/12/2012 03:15	15.556	12/12/2012 07:50	15.415
11/12/2012 22:45	15.415	12/12/2012 03:20	15.547	12/12/2012 07:55	15.415
11/12/2012 22:50	15.408	12/12/2012 03:25	15.564	12/12/2012 08:00	15.420
11/12/2012 22:55	15.438	12/12/2012 03:30	15.579	12/12/2012 08:05	15.448
11/12/2012 23:00	15.456	12/12/2012 03:35	15.581	12/12/2012 08:10	15.440
11/12/2012 23:05	15.476	12/12/2012 03:40	15.574	12/12/2012 08:15	15.452
11/12/2012 23:10	15.496	12/12/2012 03:45	15.570	12/12/2012 08:20	15.452
11/12/2012 23:15	15.497	12/12/2012 03:50	15.605	12/12/2012 08:25	15.451
11/12/2012 23:20	15.514	12/12/2012 03:55	15.610	12/12/2012 08:30	15.619
11/12/2012 23:25	15.527	12/12/2012 04:00	15.609	12/12/2012 08:35	15.553
11/12/2012 23:30	15.532	12/12/2012 04:05	15.616	12/12/2012 08:40	15.527
11/12/2012 23:35	15.532	12/12/2012 04:10	15.618	12/12/2012 08:45	15.525
11/12/2012 23:40	15.526	12/12/2012 04:15	15.606	12/12/2012 08:50	15.512
11/12/2012 23:45	15.514	12/12/2012 04:20	15.617	12/12/2012 08:55	15.505
11/12/2012 23:50	15.510	12/12/2012 04:25	15.632	12/12/2012 09:00	15.502
11/12/2012 23:55	15.517	12/12/2012 04:30	15.627	12/12/2012 09:05	15.480
12/12/2012 00:00	15.505	12/12/2012 04:35	15.608	12/12/2012 09:10	15.494
12/12/2012 00:05	15.505	12/12/2012 04:40	15.610	12/12/2012 09:15	15.491
12/12/2012 00:10	15.503	12/12/2012 04:45	15.612	12/12/2012 09:20	15.491
12/12/2012 00:15	15.498	12/12/2012 04:50	15.542	12/12/2012 09:25	15.494
12/12/2012 00:20	15.507	12/12/2012 04:55	15.511	12/12/2012 09:30	15.493
12/12/2012 00:25	15.515	12/12/2012 05:00	15.547	12/12/2012 09:35	15.497
12/12/2012 00:30	15.514	12/12/2012 05:05	15.619	12/12/2012 09:40	15.499
12/12/2012 00:35	15.520	12/12/2012 05:10	15.488	12/12/2012 09:45	15.494
12/12/2012 00:40	15.523	12/12/2012 05:15	15.440	12/12/2012 09:50	15.502
12/12/2012 00:45	15.525	12/12/2012 05:20	15.414	12/12/2012 09:55	15.496
12/12/2012 00:50	15.526	12/12/2012 05:25	15.392	12/12/2012 10:00	15.501
12/12/2012 00:55	15.523	12/12/2012 05:30	15.371	12/12/2012 10:05	15.490
12/12/2012 01:00	15.535	12/12/2012 05:35	15.379	12/12/2012 10:10	15.505
12/12/2012 01:05	15.534	12/12/2012 05:40	15.378	12/12/2012 10:15	15.495
12/12/2012 01:10	15.530	12/12/2012 05:45	15.367	12/12/2012 10:20	15.495
12/12/2012 01:15	15.513	12/12/2012 05:50	15.354	12/12/2012 10:25	15.515
12/12/2012 01:20	15.525	12/12/2012 05:55	15.374	12/12/2012 10:30	15.518
12/12/2012 01:25	15.516	12/12/2012 06:00	15.365	12/12/2012 10:35	15.513
12/12/2012 01:30	15.526	12/12/2012 06:05	15.353	12/12/2012 10:40	15.523
12/12/2012 01:35	15.522	12/12/2012 06:10	15.384	12/12/2012 10:45	15.516
12/12/2012 01:40	15.521	12/12/2012 06:15	15.365	12/12/2012 10:50	15.522
12/12/2012 01:45	15.521	12/12/2012 06:20	15.365	12/12/2012 10:55	15.523
12/12/2012 01:50	15.517	12/12/2012 06:25	15.355	12/12/2012 11:00	15.512
12/12/2012 01:55	15.539	12/12/2012 06:30	15.354	12/12/2012 11:05	15.500
12/12/2012 02:00	15.542	12/12/2012 06:35	15.377	12/12/2012 11:10	15.517
12/12/2012 02:05	15.531	12/12/2012 06:40	15.366	12/12/2012 11:15	15.519
12/12/2012 02:10	15.530	12/12/2012 06:45	15.371	12/12/2012 11:20	15.522
12/12/2012 02:15	15.533	12/12/2012 06:50	15.372	12/12/2012 11:25	15.527
12/12/2012 02:20	15.529	12/12/2012 06:55	15.372	12/12/2012 11:30	15.539
12/12/2012 02:25	15.548	12/12/2012 07:00	15.364	12/12/2012 11:35	15.541
12/12/2012 02:30	15.566	12/12/2012 07:05	15.365	12/12/2012 11:40	15.541
12/12/2012 02:35	15.558	12/12/2012 07:10	15.379	12/12/2012 11:45	15.539
12/12/2012 02:40	15.567	12/12/2012 07:15	15.386	12/12/2012 11:50	15.539
12/12/2012 02:45	15.550	12/12/2012 07:20	15.392	12/12/2012 11:55	15.529
12/12/2012 02:50	15.559	12/12/2012 07:25	15.396	12/12/2012 12:00	15.542
12/12/2012 02:55	15.541	12/12/2012 07:30	15.397	12/12/2012 12:05	15.544
12/12/2012 03:00	15.552	12/12/2012 07:35	15.401	12/12/2012 12:10	15.533
12/12/2012 03:05	15.549	12/12/2012 07:40	15.391	12/12/2012 12:15	15.551

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
12/12/2012 12:20	15.543	12/12/2012 16:55	15.916	12/12/2012 21:30	16.047
12/12/2012 12:25	15.540	12/12/2012 17:00	15.893	12/12/2012 21:35	16.052
12/12/2012 12:30	15.527	12/12/2012 17:05	15.870	12/12/2012 21:40	16.044
12/12/2012 12:35	15.533	12/12/2012 17:10	15.861	12/12/2012 21:45	16.049
12/12/2012 12:40	15.525	12/12/2012 17:15	15.851	12/12/2012 21:50	16.048
12/12/2012 12:45	15.534	12/12/2012 17:20	15.856	12/12/2012 21:55	16.051
12/12/2012 12:50	15.543	12/12/2012 17:25	15.845	12/12/2012 22:00	16.069
12/12/2012 12:55	15.555	12/12/2012 17:30	15.847	12/12/2012 22:05	16.073
12/12/2012 13:00	15.557	12/12/2012 17:35	15.847	12/12/2012 22:10	16.058
12/12/2012 13:05	15.554	12/12/2012 17:40	15.855	12/12/2012 22:15	16.061
12/12/2012 13:10	15.573	12/12/2012 17:45	15.842	12/12/2012 22:20	16.052
12/12/2012 13:15	15.567	12/12/2012 17:50	15.847	12/12/2012 22:25	16.042
12/12/2012 13:20	15.596	12/12/2012 17:55	15.854	12/12/2012 22:30	16.046
12/12/2012 13:25	15.596	12/12/2012 18:00	15.874	12/12/2012 22:35	16.044
12/12/2012 13:30	15.600	12/12/2012 18:05	15.880	12/12/2012 22:40	16.039
12/12/2012 13:35	15.605	12/12/2012 18:10	15.883	12/12/2012 22:45	16.046
12/12/2012 13:40	15.594	12/12/2012 18:15	15.893	12/12/2012 22:50	16.038
12/12/2012 13:45	15.597	12/12/2012 18:20	15.901	12/12/2012 22:55	16.033
12/12/2012 13:50	15.592	12/12/2012 18:25	15.910	12/12/2012 23:00	16.037
12/12/2012 13:55	15.582	12/12/2012 18:30	15.895	12/12/2012 23:05	16.032
12/12/2012 14:00	15.589	12/12/2012 18:35	15.894	12/12/2012 23:10	16.043
12/12/2012 14:05	15.585	12/12/2012 18:40	15.912	12/12/2012 23:15	16.034
12/12/2012 14:10	15.589	12/12/2012 18:45	15.910	12/12/2012 23:20	16.042
12/12/2012 14:15	15.593	12/12/2012 18:50	15.923	12/12/2012 23:25	16.043
12/12/2012 14:20	15.601	12/12/2012 18:55	15.929	12/12/2012 23:30	16.056
12/12/2012 14:25	15.593	12/12/2012 19:00	15.937	12/12/2012 23:35	16.035
12/12/2012 14:30	15.597	12/12/2012 19:05	15.933	12/12/2012 23:40	16.026
12/12/2012 14:35	15.591	12/12/2012 19:10	15.942	12/12/2012 23:45	16.039
12/12/2012 14:40	15.614	12/12/2012 19:15	15.944	12/12/2012 23:50	16.025
12/12/2012 14:45	15.617	12/12/2012 19:20	15.961	12/12/2012 23:55	16.031
12/12/2012 14:50	15.619	12/12/2012 19:25	15.967	13/12/2012 00:00	16.042
12/12/2012 14:55	15.633	12/12/2012 19:30	15.983	13/12/2012 00:05	16.044
12/12/2012 15:00	15.634	12/12/2012 19:35	15.995	13/12/2012 00:10	16.035
12/12/2012 15:05	15.641	12/12/2012 19:40	15.994	13/12/2012 00:15	16.039
12/12/2012 15:10	15.676	12/12/2012 19:45	16.007	13/12/2012 00:20	16.047
12/12/2012 15:15	15.672	12/12/2012 19:50	16.001	13/12/2012 00:25	16.043
12/12/2012 15:20	15.684	12/12/2012 19:55	15.994	13/12/2012 00:30	16.052
12/12/2012 15:25	15.680	12/12/2012 20:00	15.993	13/12/2012 00:35	16.056
12/12/2012 15:30	15.672	12/12/2012 20:05	15.982	13/12/2012 00:40	16.049
12/12/2012 15:35	15.689	12/12/2012 20:10	15.990	13/12/2012 00:45	16.060
12/12/2012 15:40	15.692	12/12/2012 20:15	15.999	13/12/2012 00:50	16.064
12/12/2012 15:45	15.681	12/12/2012 20:20	15.990	13/12/2012 00:55	16.068
12/12/2012 15:50	15.686	12/12/2012 20:25	15.989	13/12/2012 01:00	16.083
12/12/2012 15:55	15.691	12/12/2012 20:30	15.986	13/12/2012 01:05	16.095
12/12/2012 16:00	15.711	12/12/2012 20:35	15.991	13/12/2012 01:10	16.130
12/12/2012 16:05	15.700	12/12/2012 20:40	15.991	13/12/2012 01:15	16.156
12/12/2012 16:10	15.722	12/12/2012 20:45	15.986	13/12/2012 01:20	16.177
12/12/2012 16:15	15.733	12/12/2012 20:50	16.008	13/12/2012 01:25	16.173
12/12/2012 16:20	15.746	12/12/2012 20:55	16.025	13/12/2012 01:30	16.166
12/12/2012 16:25	15.737	12/12/2012 21:00	16.024	13/12/2012 01:35	16.165
12/12/2012 16:30	15.748	12/12/2012 21:05	16.033	13/12/2012 01:40	16.161
12/12/2012 16:35	15.762	12/12/2012 21:10	16.041	13/12/2012 01:45	16.173
12/12/2012 16:40	15.992	12/12/2012 21:15	16.048	13/12/2012 01:50	16.160
12/12/2012 16:45	15.979	12/12/2012 21:20	16.047	13/12/2012 01:55	16.176
12/12/2012 16:50	15.935	12/12/2012 21:25	16.058	13/12/2012 02:00	16.186

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
13/12/2012 02:05	16.204	13/12/2012 06:40	16.263	13/12/2012 11:15	16.338
13/12/2012 02:10	16.219	13/12/2012 06:45	16.260	13/12/2012 11:20	16.356
13/12/2012 02:15	16.241	13/12/2012 06:50	16.259	13/12/2012 11:25	16.346
13/12/2012 02:20	16.257	13/12/2012 06:55	16.265	13/12/2012 11:30	16.357
13/12/2012 02:25	16.256	13/12/2012 07:00	16.274	13/12/2012 11:35	16.363
13/12/2012 02:30	16.241	13/12/2012 07:05	16.256	13/12/2012 11:40	16.351
13/12/2012 02:35	16.256	13/12/2012 07:10	16.258	13/12/2012 11:45	16.359
13/12/2012 02:40	16.243	13/12/2012 07:15	16.267	13/12/2012 11:50	16.361
13/12/2012 02:45	16.224	13/12/2012 07:20	16.269	13/12/2012 11:55	16.355
13/12/2012 02:50	16.216	13/12/2012 07:25	16.273	13/12/2012 12:00	16.360
13/12/2012 02:55	16.208	13/12/2012 07:30	16.270	13/12/2012 12:05	16.358
13/12/2012 03:00	16.218	13/12/2012 07:35	16.281	13/12/2012 12:10	16.359
13/12/2012 03:05	16.215	13/12/2012 07:40	16.294	13/12/2012 12:15	16.372
13/12/2012 03:10	16.198	13/12/2012 07:45	16.301	13/12/2012 12:20	16.378
13/12/2012 03:15	16.205	13/12/2012 07:50	16.431	13/12/2012 12:25	16.389
13/12/2012 03:20	16.206	13/12/2012 07:55	16.394	13/12/2012 12:30	16.390
13/12/2012 03:25	16.219	13/12/2012 08:00	16.393	13/12/2012 12:35	16.381
13/12/2012 03:30	16.230	13/12/2012 08:05	16.384	13/12/2012 12:40	16.380
13/12/2012 03:35	16.221	13/12/2012 08:10	16.371	13/12/2012 12:45	16.369
13/12/2012 03:40	16.221	13/12/2012 08:15	16.359	13/12/2012 12:50	16.349
13/12/2012 03:45	16.216	13/12/2012 08:20	16.389	13/12/2012 12:55	16.341
13/12/2012 03:50	16.222	13/12/2012 08:25	16.728	13/12/2012 13:00	16.345
13/12/2012 03:55	16.220	13/12/2012 08:30	17.187	13/12/2012 13:05	16.345
13/12/2012 04:00	16.218	13/12/2012 08:35	16.996	13/12/2012 13:10	16.337
13/12/2012 04:05	16.219	13/12/2012 08:40	16.786	13/12/2012 13:15	16.336
13/12/2012 04:10	16.216	13/12/2012 08:45	16.662	13/12/2012 13:20	16.356
13/12/2012 04:15	16.221	13/12/2012 08:50	16.579	13/12/2012 13:25	16.376
13/12/2012 04:20	16.217	13/12/2012 08:55	16.532	13/12/2012 13:30	16.365
13/12/2012 04:25	16.208	13/12/2012 09:00	16.478	13/12/2012 13:35	16.364
13/12/2012 04:30	16.210	13/12/2012 09:05	16.434	13/12/2012 13:40	16.370
13/12/2012 04:35	16.208	13/12/2012 09:10	16.402	13/12/2012 13:45	16.381
13/12/2012 04:40	16.214	13/12/2012 09:15	16.379	13/12/2012 13:50	16.383
13/12/2012 04:45	16.216	13/12/2012 09:20	16.363	13/12/2012 13:55	16.385
13/12/2012 04:50	16.221	13/12/2012 09:25	16.345	13/12/2012 14:00	16.392
13/12/2012 04:55	16.219	13/12/2012 09:30	16.336	13/12/2012 14:05	16.385
13/12/2012 05:00	16.228	13/12/2012 09:35	16.317	13/12/2012 14:10	16.403
13/12/2012 05:05	16.236	13/12/2012 09:40	16.335	13/12/2012 14:15	16.401
13/12/2012 05:10	16.234	13/12/2012 09:45	16.328	13/12/2012 14:20	16.413
13/12/2012 05:15	16.241	13/12/2012 09:50	16.339	13/12/2012 14:25	16.421
13/12/2012 05:20	16.244	13/12/2012 09:55	16.348	13/12/2012 14:30	16.432
13/12/2012 05:25	16.246	13/12/2012 10:00	16.352	13/12/2012 14:35	16.436
13/12/2012 05:30	16.252	13/12/2012 10:05	16.362	13/12/2012 14:40	16.450
13/12/2012 05:35	16.251	13/12/2012 10:10	16.366	13/12/2012 14:45	16.448
13/12/2012 05:40	16.253	13/12/2012 10:15	16.367	13/12/2012 14:50	16.448
13/12/2012 05:45	16.248	13/12/2012 10:20	16.367	13/12/2012 14:55	16.452
13/12/2012 05:50	16.246	13/12/2012 10:25	16.367	13/12/2012 15:00	16.404
13/12/2012 05:55	16.246	13/12/2012 10:30	16.353	13/12/2012 15:05	16.369
13/12/2012 06:00	16.249	13/12/2012 10:35	16.359	13/12/2012 15:10	16.335
13/12/2012 06:05	16.249	13/12/2012 10:40	16.345	13/12/2012 15:15	16.266
13/12/2012 06:10	16.234	13/12/2012 10:45	16.350	13/12/2012 15:20	16.227
13/12/2012 06:15	16.250	13/12/2012 10:50	16.343	13/12/2012 15:25	16.210
13/12/2012 06:20	16.252	13/12/2012 10:55	16.328	13/12/2012 15:30	16.199
13/12/2012 06:25	16.254	13/12/2012 11:00	16.328	13/12/2012 15:35	16.205
13/12/2012 06:30	16.261	13/12/2012 11:05	16.335	13/12/2012 15:40	16.212
13/12/2012 06:35	16.258	13/12/2012 11:10	16.333	13/12/2012 15:45	16.207

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
13/12/2012 15:50	16.210	13/12/2012 20:25	17.162	14/12/2012 01:00	17.328
13/12/2012 15:55	16.194	13/12/2012 20:30	17.176	14/12/2012 01:05	17.325
13/12/2012 16:00	16.183	13/12/2012 20:35	17.189	14/12/2012 01:10	17.320
13/12/2012 16:05	16.157	13/12/2012 20:40	17.206	14/12/2012 01:15	17.318
13/12/2012 16:10	16.187	13/12/2012 20:45	17.212	14/12/2012 01:20	17.317
13/12/2012 16:15	16.203	13/12/2012 20:50	17.219	14/12/2012 01:25	17.320
13/12/2012 16:20	16.268	13/12/2012 20:55	17.237	14/12/2012 01:30	17.314
13/12/2012 16:25	16.321	13/12/2012 21:00	17.250	14/12/2012 01:35	17.306
13/12/2012 16:30	16.356	13/12/2012 21:05	17.260	14/12/2012 01:40	17.289
13/12/2012 16:35	16.382	13/12/2012 21:10	17.271	14/12/2012 01:45	17.265
13/12/2012 16:40	16.382	13/12/2012 21:15	17.288	14/12/2012 01:50	17.241
13/12/2012 16:45	16.349	13/12/2012 21:20	17.305	14/12/2012 01:55	17.234
13/12/2012 16:50	16.356	13/12/2012 21:25	17.336	14/12/2012 02:00	17.230
13/12/2012 16:55	16.380	13/12/2012 21:30	17.349	14/12/2012 02:05	17.232
13/12/2012 17:00	16.376	13/12/2012 21:35	17.357	14/12/2012 02:10	17.239
13/12/2012 17:05	16.377	13/12/2012 21:40	17.367	14/12/2012 02:15	17.229
13/12/2012 17:10	16.382	13/12/2012 21:45	17.359	14/12/2012 02:20	17.237
13/12/2012 17:15	16.385	13/12/2012 21:50	17.336	14/12/2012 02:25	17.230
13/12/2012 17:20	16.381	13/12/2012 21:55	17.323	14/12/2012 02:30	17.217
13/12/2012 17:25	16.368	13/12/2012 22:00	17.325	14/12/2012 02:35	17.228
13/12/2012 17:30	16.384	13/12/2012 22:05	17.335	14/12/2012 02:40	17.220
13/12/2012 17:35	16.400	13/12/2012 22:10	17.347	14/12/2012 02:45	17.214
13/12/2012 17:40	16.403	13/12/2012 22:15	17.352	14/12/2012 02:50	17.213
13/12/2012 17:45	16.422	13/12/2012 22:20	17.356	14/12/2012 02:55	17.203
13/12/2012 17:50	16.431	13/12/2012 22:25	17.343	14/12/2012 03:00	17.211
13/12/2012 17:55	16.457	13/12/2012 22:30	17.337	14/12/2012 03:05	17.207
13/12/2012 18:00	16.406	13/12/2012 22:35	17.339	14/12/2012 03:10	17.213
13/12/2012 18:05	16.435	13/12/2012 22:40	17.339	14/12/2012 03:15	17.210
13/12/2012 18:10	16.522	13/12/2012 22:45	17.333	14/12/2012 03:20	17.203
13/12/2012 18:15	16.551	13/12/2012 22:50	17.324	14/12/2012 03:25	17.182
13/12/2012 18:20	16.574	13/12/2012 22:55	17.331	14/12/2012 03:30	17.189
13/12/2012 18:25	16.589	13/12/2012 23:00	17.326	14/12/2012 03:35	17.195
13/12/2012 18:30	16.572	13/12/2012 23:05	17.333	14/12/2012 03:40	17.198
13/12/2012 18:35	16.583	13/12/2012 23:10	17.330	14/12/2012 03:45	17.214
13/12/2012 18:40	16.566	13/12/2012 23:15	17.351	14/12/2012 03:50	17.206
13/12/2012 18:45	16.628	13/12/2012 23:20	17.345	14/12/2012 03:55	17.203
13/12/2012 18:50	16.724	13/12/2012 23:25	17.342	14/12/2012 04:00	17.188
13/12/2012 18:55	16.766	13/12/2012 23:30	17.345	14/12/2012 04:05	17.184
13/12/2012 19:00	17.265	13/12/2012 23:35	17.335	14/12/2012 04:10	17.176
13/12/2012 19:05	17.545	13/12/2012 23:40	17.342	14/12/2012 04:15	17.170
13/12/2012 19:10	17.242	13/12/2012 23:45	17.339	14/12/2012 04:20	17.165
13/12/2012 19:15	17.136	13/12/2012 23:50	17.337	14/12/2012 04:25	17.177
13/12/2012 19:20	17.064	13/12/2012 23:55	17.333	14/12/2012 04:30	17.181
13/12/2012 19:25	17.016	14/12/2012 00:00	17.318	14/12/2012 04:35	17.195
13/12/2012 19:30	16.973	14/12/2012 00:05	17.307	14/12/2012 04:40	17.198
13/12/2012 19:35	17.010	14/12/2012 00:10	17.311	14/12/2012 04:45	17.194
13/12/2012 19:40	17.049	14/12/2012 00:15	17.316	14/12/2012 04:50	17.199
13/12/2012 19:45	17.091	14/12/2012 00:20	17.322	14/12/2012 04:55	17.195
13/12/2012 19:50	17.121	14/12/2012 00:25	17.322	14/12/2012 05:00	17.185
13/12/2012 19:55	17.132	14/12/2012 00:30	17.325	14/12/2012 05:05	17.173
13/12/2012 20:00	17.157	14/12/2012 00:35	17.329	14/12/2012 05:10	17.148
13/12/2012 20:05	17.143	14/12/2012 00:40	17.334	14/12/2012 05:15	17.145
13/12/2012 20:10	17.142	14/12/2012 00:45	17.331	14/12/2012 05:20	17.142
13/12/2012 20:15	17.146	14/12/2012 00:50	17.331	14/12/2012 05:25	17.139
13/12/2012 20:20	17.147	14/12/2012 00:55	17.326	14/12/2012 05:30	17.131

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
14/12/2012 05:35	17.136	14/12/2012 10:10	11.602		
14/12/2012 05:40	17.131	14/12/2012 10:15	9.367		
14/12/2012 05:45	17.123	14/12/2012 10:20	7.885		
14/12/2012 05:50	17.115	14/12/2012 10:25	6.881		
14/12/2012 05:55	17.111	14/12/2012 10:30	6.181		
14/12/2012 06:00	17.104	14/12/2012 10:35	5.685		
14/12/2012 06:05	17.104	14/12/2012 10:40	5.335		
14/12/2012 06:10	17.121	14/12/2012 10:45	5.079		
14/12/2012 06:15	17.159	14/12/2012 10:50	4.900		
14/12/2012 06:20	17.158	14/12/2012 10:55	4.766		
14/12/2012 06:25	17.158	14/12/2012 11:00	4.660		
14/12/2012 06:30	17.156	14/12/2012 11:05	4.572		
14/12/2012 06:35	17.149	14/12/2012 11:10	4.510		
14/12/2012 06:40	17.143	14/12/2012 11:15	4.456		
14/12/2012 06:45	17.141	14/12/2012 11:20	4.407		
14/12/2012 06:50	17.132				
14/12/2012 06:55	17.131				
14/12/2012 07:00	17.137				
14/12/2012 07:05	17.126				
14/12/2012 07:10	17.133				
14/12/2012 07:15	17.145				
14/12/2012 07:20	17.187				
14/12/2012 07:25	17.206				
14/12/2012 07:30	17.228				
14/12/2012 07:35	17.233				
14/12/2012 07:40	17.228				
14/12/2012 07:45	17.222				
14/12/2012 07:50	17.220				
14/12/2012 07:55	17.218				
14/12/2012 08:00	17.226				
14/12/2012 08:05	17.223				
14/12/2012 08:10	17.217				
14/12/2012 08:15	17.220				
14/12/2012 08:20	17.217				
14/12/2012 08:25	17.221				
14/12/2012 08:30	17.216				
14/12/2012 08:35	17.210				
14/12/2012 08:40	17.210				
14/12/2012 08:45	17.209				
14/12/2012 08:50	17.205				
14/12/2012 08:55	17.253				
14/12/2012 09:00	17.235				
14/12/2012 09:05	17.231				
14/12/2012 09:10	17.384				
14/12/2012 09:15	17.641				
14/12/2012 09:20	17.462				
14/12/2012 09:25	17.380				
14/12/2012 09:30	17.328				
14/12/2012 09:35	17.311				
14/12/2012 09:40	17.284				
14/12/2012 09:45	17.492				
14/12/2012 09:50	17.642				
14/12/2012 09:55	17.547				
14/12/2012 10:00	17.637				
14/12/2012 10:05	14.954				

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
11/12/2012 08:20	6.975	11/12/2012 22:05	7.11	12/12/2012 11:50	7.236
11/12/2012 08:35	6.978	11/12/2012 22:20	7.115	12/12/2012 12:05	7.239
11/12/2012 08:50	6.979	11/12/2012 22:35	7.119	12/12/2012 12:20	7.24
11/12/2012 09:05	6.985	11/12/2012 22:50	7.122	12/12/2012 12:35	7.243
11/12/2012 09:20	6.989	11/12/2012 23:05	7.121	12/12/2012 12:50	7.241
11/12/2012 09:35	6.988	11/12/2012 23:20	7.126	12/12/2012 13:05	7.245
11/12/2012 09:50	6.993	11/12/2012 23:35	7.127	12/12/2012 13:20	7.246
11/12/2012 10:05	6.996	11/12/2012 23:50	7.131	12/12/2012 13:35	7.248
11/12/2012 10:20	6.999	12/12/2012 00:05	7.128	12/12/2012 13:50	7.249
11/12/2012 10:35	7.003	12/12/2012 00:20	7.133	12/12/2012 14:05	7.252
11/12/2012 10:50	7.008	12/12/2012 00:35	7.135	12/12/2012 14:20	7.26
11/12/2012 11:05	7.007	12/12/2012 00:50	7.136	12/12/2012 14:35	7.254
11/12/2012 11:20	7.014	12/12/2012 01:05	7.144	12/12/2012 14:50	7.26
11/12/2012 11:35	7.015	12/12/2012 01:20	7.145	12/12/2012 15:05	7.26
11/12/2012 11:50	7.022	12/12/2012 01:35	7.141	12/12/2012 15:20	7.265
11/12/2012 12:05	7.021	12/12/2012 01:50	7.144	12/12/2012 15:35	7.264
11/12/2012 12:20	7.03	12/12/2012 02:05	7.147	12/12/2012 15:50	7.266
11/12/2012 12:35	7.028	12/12/2012 02:20	7.152	12/12/2012 16:05	7.274
11/12/2012 12:50	7.032	12/12/2012 02:35	7.159	12/12/2012 16:20	7.272
11/12/2012 13:05	7.036	12/12/2012 02:50	7.155	12/12/2012 16:35	7.276
11/12/2012 13:20	7.04	12/12/2012 03:05	7.155	12/12/2012 16:50	7.276
11/12/2012 13:35	7.041	12/12/2012 03:20	7.159	12/12/2012 17:05	7.278
11/12/2012 13:50	7.042	12/12/2012 03:35	7.159	12/12/2012 17:20	7.28
11/12/2012 14:05	7.053	12/12/2012 03:50	7.164	12/12/2012 17:35	7.283
11/12/2012 14:20	7.047	12/12/2012 04:05	7.168	12/12/2012 17:50	7.284
11/12/2012 14:35	7.054	12/12/2012 04:20	7.166	12/12/2012 18:05	7.286
11/12/2012 14:50	7.053	12/12/2012 04:35	7.169	12/12/2012 18:20	7.289
11/12/2012 15:05	7.053	12/12/2012 04:50	7.174	12/12/2012 18:35	7.297
11/12/2012 15:20	7.056	12/12/2012 05:05	7.177	12/12/2012 18:50	7.298
11/12/2012 15:35	7.063	12/12/2012 05:20	7.179	12/12/2012 19:05	7.302
11/12/2012 15:50	7.057	12/12/2012 05:35	7.177	12/12/2012 19:20	7.3
11/12/2012 16:05	7.064	12/12/2012 05:50	7.183	12/12/2012 19:35	7.304
11/12/2012 16:20	7.055	12/12/2012 06:05	7.182	12/12/2012 19:50	7.306
11/12/2012 16:35	7.06	12/12/2012 06:20	7.187	12/12/2012 20:05	7.314
11/12/2012 16:50	7.066	12/12/2012 06:35	7.189	12/12/2012 20:20	7.312
11/12/2012 17:05	7.064	12/12/2012 06:50	7.189	12/12/2012 20:35	7.315
11/12/2012 17:20	7.068	12/12/2012 07:05	7.188	12/12/2012 20:50	7.316
11/12/2012 17:35	7.069	12/12/2012 07:20	7.194	12/12/2012 21:05	7.318
11/12/2012 17:50	7.075	12/12/2012 07:35	7.195	12/12/2012 21:20	7.324
11/12/2012 18:05	7.072	12/12/2012 07:50	7.2	12/12/2012 21:35	7.322
11/12/2012 18:20	7.077	12/12/2012 08:05	7.205	12/12/2012 21:50	7.329
11/12/2012 18:35	7.08	12/12/2012 08:20	7.201	12/12/2012 22:05	7.33
11/12/2012 18:50	7.077	12/12/2012 08:35	7.208	12/12/2012 22:20	7.336
11/12/2012 19:05	7.086	12/12/2012 08:50	7.241	12/12/2012 22:35	7.335
11/12/2012 19:20	7.085	12/12/2012 09:05	7.211	12/12/2012 22:50	7.34
11/12/2012 19:35	7.089	12/12/2012 09:20	7.202	12/12/2012 23:05	7.342
11/12/2012 19:50	7.09	12/12/2012 09:35	7.212	12/12/2012 23:20	7.343
11/12/2012 20:05	7.095	12/12/2012 09:50	7.21	12/12/2012 23:35	7.348
11/12/2012 20:20	7.093	12/12/2012 10:05	7.214	12/12/2012 23:50	7.354
11/12/2012 20:35	7.097	12/12/2012 10:20	7.221	13/12/2012 00:05	7.353
11/12/2012 20:50	7.101	12/12/2012 10:35	7.219	13/12/2012 00:20	7.352
11/12/2012 21:05	7.101	12/12/2012 10:50	7.226	13/12/2012 00:35	7.354
11/12/2012 21:20	7.103	12/12/2012 11:05	7.226	13/12/2012 00:50	7.362
11/12/2012 21:35	7.109	12/12/2012 11:20	7.228	13/12/2012 01:05	7.362
11/12/2012 21:50	7.108	12/12/2012 11:35	7.23	13/12/2012 01:20	7.365

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
13/12/2012 01:35	7.363	13/12/2012 15:20	7.504	14/12/2012 05:05	7.492
13/12/2012 01:50	7.368	13/12/2012 15:35	7.508	14/12/2012 05:20	7.488
13/12/2012 02:05	7.372	13/12/2012 15:50	7.512	14/12/2012 05:35	7.488
13/12/2012 02:20	7.376	13/12/2012 16:05	7.506	14/12/2012 05:50	7.485
13/12/2012 02:35	7.376	13/12/2012 16:20	7.507	14/12/2012 06:05	7.481
13/12/2012 02:50	7.378	13/12/2012 16:35	7.513	14/12/2012 06:20	7.477
13/12/2012 03:05	7.382	13/12/2012 16:50	7.517	14/12/2012 06:35	7.475
13/12/2012 03:20	7.38	13/12/2012 17:05	7.517	14/12/2012 06:50	7.471
13/12/2012 03:35	7.383	13/12/2012 17:20	7.516	14/12/2012 07:05	7.464
13/12/2012 03:50	7.388	13/12/2012 17:35	7.521	14/12/2012 07:20	7.459
13/12/2012 04:05	7.39	13/12/2012 17:50	7.515	14/12/2012 07:35	7.448
13/12/2012 04:20	7.397	13/12/2012 18:05	7.522	14/12/2012 07:50	7.446
13/12/2012 04:35	7.391	13/12/2012 18:20	7.526	14/12/2012 08:05	7.438
13/12/2012 04:50	7.4	13/12/2012 18:35	7.529	14/12/2012 08:20	7.438
13/12/2012 05:05	7.4	13/12/2012 18:50	7.532	14/12/2012 08:35	7.426
13/12/2012 05:20	7.406	13/12/2012 19:05	7.533	14/12/2012 08:50	7.424
13/12/2012 05:35	7.406	13/12/2012 19:20	7.536	14/12/2012 09:05	7.421
13/12/2012 05:50	7.408	13/12/2012 19:35	7.541	14/12/2012 09:20	7.416
13/12/2012 06:05	7.414	13/12/2012 19:50	7.538	14/12/2012 09:35	7.412
13/12/2012 06:20	7.413	13/12/2012 20:05	7.546	14/12/2012 09:50	7.406
13/12/2012 06:35	7.414	13/12/2012 20:20	7.549	14/12/2012 10:05	7.404
13/12/2012 06:50	7.418	13/12/2012 20:35	7.548	14/12/2012 10:20	7.397
13/12/2012 07:05	7.424	13/12/2012 20:50	7.546	14/12/2012 10:35	7.39
13/12/2012 07:20	7.426	13/12/2012 21:05	7.55	14/12/2012 10:50	7.382
13/12/2012 07:35	7.427	13/12/2012 21:20	7.552	14/12/2012 11:05	7.378
13/12/2012 07:50	7.43	13/12/2012 21:35	7.558	14/12/2012 11:20	7.372
13/12/2012 08:05	7.434	13/12/2012 21:50	7.564	14/12/2012 11:35	7.37
13/12/2012 08:20	7.438	13/12/2012 22:05	7.558	14/12/2012 11:50	7.362
13/12/2012 08:35	7.44	13/12/2012 22:20	7.558	14/12/2012 12:05	7.349
13/12/2012 08:50	7.44	13/12/2012 22:35	7.562	14/12/2012 12:20	7.369
13/12/2012 09:05	7.44	13/12/2012 22:50	7.559	14/12/2012 12:35	7.312
13/12/2012 09:20	7.445	13/12/2012 23:05	7.567	14/12/2012 12:50	7.306
13/12/2012 09:35	7.452	13/12/2012 23:20	7.566	14/12/2012 13:05	7.308
13/12/2012 09:50	7.446	13/12/2012 23:35	7.565	14/12/2012 13:20	7.298
13/12/2012 10:05	7.452	13/12/2012 23:50	7.567	14/12/2012 13:35	7.288
13/12/2012 10:20	7.456	14/12/2012 00:05	7.571	14/12/2012 13:50	7.272
13/12/2012 10:35	7.456	14/12/2012 00:20	7.572	14/12/2012 14:05	7.353
13/12/2012 10:50	7.46	14/12/2012 00:35	7.575	14/12/2012 14:20	7.326
13/12/2012 11:05	7.467	14/12/2012 00:50	7.575	14/12/2012 14:35	7.304
13/12/2012 11:20	7.466	14/12/2012 01:05	7.577	14/12/2012 14:50	7.304
13/12/2012 11:35	7.466	14/12/2012 01:20	7.578	14/12/2012 15:05	7.303
13/12/2012 11:50	7.474	14/12/2012 01:35	7.584	14/12/2012 15:20	7.299
13/12/2012 12:05	7.474	14/12/2012 01:50	7.577	14/12/2012 15:35	7.301
13/12/2012 12:20	7.476	14/12/2012 02:05	7.576	14/12/2012 15:50	7.299
13/12/2012 12:35	7.478	14/12/2012 02:20	7.572	14/12/2012 16:05	7.299
13/12/2012 12:50	7.479	14/12/2012 02:35	7.564	14/12/2012 16:20	7.297
13/12/2012 13:05	7.484	14/12/2012 02:50	7.551	14/12/2012 16:35	7.297
13/12/2012 13:20	7.484	14/12/2012 03:05	7.544	14/12/2012 16:50	7.297
13/12/2012 13:35	7.49	14/12/2012 03:20	7.535	14/12/2012 17:05	7.294
13/12/2012 13:50	7.486	14/12/2012 03:35	7.525	14/12/2012 17:20	7.293
13/12/2012 14:05	7.494	14/12/2012 03:50	7.515	14/12/2012 17:35	7.291
13/12/2012 14:20	7.497	14/12/2012 04:05	7.51	14/12/2012 17:50	7.292
13/12/2012 14:35	7.496	14/12/2012 04:20	7.504	14/12/2012 18:05	7.297
13/12/2012 14:50	7.499	14/12/2012 04:35	7.496	14/12/2012 18:20	7.293
13/12/2012 15:05	7.504	14/12/2012 04:50	7.498	14/12/2012 18:35	7.296

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
14/12/2012 18:50	7.291	15/12/2012 08:35	7.285	15/12/2012 22:20	7.101
14/12/2012 19:05	7.295	15/12/2012 08:50	7.281	15/12/2012 22:35	7.093
14/12/2012 19:20	7.294	15/12/2012 09:05	7.281	15/12/2012 22:50	7.095
14/12/2012 19:35	7.295	15/12/2012 09:20	7.275	15/12/2012 23:05	7.093
14/12/2012 19:50	7.294	15/12/2012 09:35	7.275	15/12/2012 23:20	7.097
14/12/2012 20:05	7.289	15/12/2012 09:50	7.271	15/12/2012 23:35	7.093
14/12/2012 20:20	7.291	15/12/2012 10:05	7.269	15/12/2012 23:50	7.094
14/12/2012 20:35	7.293	15/12/2012 10:20	7.259	16/12/2012 00:05	7.089
14/12/2012 20:50	7.291	15/12/2012 10:35	7.257	16/12/2012 00:20	7.089
14/12/2012 21:05	7.292	15/12/2012 10:50	7.253	16/12/2012 00:35	7.087
14/12/2012 21:20	7.29	15/12/2012 11:05	7.247	16/12/2012 00:50	7.084
14/12/2012 21:35	7.29	15/12/2012 11:20	7.248	16/12/2012 01:05	7.084
14/12/2012 21:50	7.293	15/12/2012 11:35	7.245	16/12/2012 01:20	7.086
14/12/2012 22:05	7.294	15/12/2012 11:50	7.24	16/12/2012 01:35	7.083
14/12/2012 22:20	7.294	15/12/2012 12:05	7.237	16/12/2012 01:50	7.081
14/12/2012 22:35	7.291	15/12/2012 12:20	7.237	16/12/2012 02:05	7.083
14/12/2012 22:50	7.291	15/12/2012 12:35	7.232	16/12/2012 02:20	7.079
14/12/2012 23:05	7.294	15/12/2012 12:50	7.232	16/12/2012 02:35	7.078
14/12/2012 23:20	7.296	15/12/2012 13:05	7.231	16/12/2012 02:50	7.08
14/12/2012 23:35	7.296	15/12/2012 13:20	7.222	16/12/2012 03:05	7.081
14/12/2012 23:50	7.298	15/12/2012 13:35	7.22	16/12/2012 03:20	7.08
15/12/2012 00:05	7.294	15/12/2012 13:50	7.209	16/12/2012 03:35	7.075
15/12/2012 00:20	7.293	15/12/2012 14:05	7.207	16/12/2012 03:50	7.081
15/12/2012 00:35	7.292	15/12/2012 14:20	7.201	16/12/2012 04:05	7.073
15/12/2012 00:50	7.291	15/12/2012 14:35	7.199	16/12/2012 04:20	7.079
15/12/2012 01:05	7.296	15/12/2012 14:50	7.193	16/12/2012 04:35	7.077
15/12/2012 01:20	7.294	15/12/2012 15:05	7.187	16/12/2012 04:50	7.073
15/12/2012 01:35	7.296	15/12/2012 15:20	7.181	16/12/2012 05:05	7.073
15/12/2012 01:50	7.294	15/12/2012 15:35	7.177	16/12/2012 05:20	7.075
15/12/2012 02:05	7.298	15/12/2012 15:50	7.17	16/12/2012 05:35	7.081
15/12/2012 02:20	7.293	15/12/2012 16:05	7.165	16/12/2012 05:50	7.077
15/12/2012 02:35	7.298	15/12/2012 16:20	7.159	16/12/2012 06:05	7.081
15/12/2012 02:50	7.297	15/12/2012 16:35	7.156	16/12/2012 06:20	7.079
15/12/2012 03:05	7.302	15/12/2012 16:50	7.157	16/12/2012 06:35	7.079
15/12/2012 03:20	7.296	15/12/2012 17:05	7.151	16/12/2012 06:50	7.075
15/12/2012 03:35	7.3	15/12/2012 17:20	7.147	16/12/2012 07:05	7.077
15/12/2012 03:50	7.296	15/12/2012 17:35	7.149	16/12/2012 07:20	7.071
15/12/2012 04:05	7.299	15/12/2012 17:50	7.145	16/12/2012 07:35	7.077
15/12/2012 04:20	7.301	15/12/2012 18:05	7.139	16/12/2012 07:50	7.075
15/12/2012 04:35	7.301	15/12/2012 18:20	7.135	16/12/2012 08:05	7.075
15/12/2012 04:50	7.301	15/12/2012 18:35	7.136	16/12/2012 08:20	7.075
15/12/2012 05:05	7.301	15/12/2012 18:50	7.135	16/12/2012 08:35	7.07
15/12/2012 05:20	7.3	15/12/2012 19:05	7.131	16/12/2012 08:50	7.071
15/12/2012 05:35	7.303	15/12/2012 19:20	7.125	16/12/2012 09:05	7.064
15/12/2012 05:50	7.3	15/12/2012 19:35	7.121	16/12/2012 09:20	7.068
15/12/2012 06:05	7.303	15/12/2012 19:50	7.121	16/12/2012 09:35	7.067
15/12/2012 06:20	7.294	15/12/2012 20:05	7.115	16/12/2012 09:50	7.073
15/12/2012 06:35	7.297	15/12/2012 20:20	7.121	16/12/2012 10:05	7.07
15/12/2012 06:50	7.29	15/12/2012 20:35	7.115	16/12/2012 10:20	7.07
15/12/2012 07:05	7.292	15/12/2012 20:50	7.116	16/12/2012 10:35	7.07
15/12/2012 07:20	7.296	15/12/2012 21:05	7.113	16/12/2012 10:50	7.074
15/12/2012 07:35	7.291	15/12/2012 21:20	7.109	16/12/2012 11:05	7.074
15/12/2012 07:50	7.289	15/12/2012 21:35	7.105	16/12/2012 11:20	7.07
15/12/2012 08:05	7.285	15/12/2012 21:50	7.105	16/12/2012 11:35	7.066
15/12/2012 08:20	7.29	15/12/2012 22:05	7.101	16/12/2012 11:50	7.063

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
16/12/2012 12:05	7.058				
16/12/2012 12:20	7.048				
16/12/2012 12:35	7.046				
16/12/2012 12:50	7.034				
16/12/2012 13:05	7.026				
16/12/2012 13:20	7.018				
16/12/2012 13:35	7.008				
16/12/2012 13:50	7.004				
16/12/2012 14:05	6.995				
16/12/2012 14:20	6.987				
16/12/2012 14:35	6.98				
16/12/2012 14:50	6.969				
16/12/2012 15:05	6.961				
16/12/2012 15:20	6.951				
16/12/2012 15:35	6.941				
16/12/2012 15:50	6.926				
16/12/2012 16:05	6.923				
16/12/2012 16:20	6.911				
16/12/2012 16:35	6.904				
16/12/2012 16:50	6.89				
16/12/2012 17:05	6.884				
16/12/2012 17:20	6.876				
16/12/2012 17:35	6.868				
16/12/2012 17:50	6.86				
16/12/2012 18:05	6.855				
16/12/2012 18:20	6.848				
16/12/2012 18:35	6.84				
16/12/2012 18:50	6.832				
16/12/2012 19:05	6.824				
16/12/2012 19:20	6.81				
16/12/2012 19:35	6.802				
16/12/2012 19:50	6.792				
16/12/2012 20:05	6.781				
16/12/2012 20:20	6.775				
16/12/2012 20:35	6.759				
16/12/2012 20:50	6.753				
16/12/2012 21:05	6.743				
16/12/2012 21:20	6.731				
16/12/2012 21:35	6.725				
16/12/2012 21:50	6.719				
16/12/2012 22:05	6.713				
16/12/2012 22:20	6.713				
16/12/2012 22:35	6.707				
16/12/2012 22:50	6.699				
16/12/2012 23:05	6.697				
16/12/2012 23:20	6.693				
16/12/2012 23:35	6.689				
16/12/2012 23:50	6.695				
17/12/2012 00:05	6.693				

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
11/12/2012 08:00	5.520	11/12/2012 21:45	5.551	12/12/2012 11:30	5.590
11/12/2012 08:15	5.521	11/12/2012 22:00	5.553	12/12/2012 11:45	5.592
11/12/2012 08:30	5.522	11/12/2012 22:15	5.552	12/12/2012 12:00	5.590
11/12/2012 08:45	5.524	11/12/2012 22:30	5.553	12/12/2012 12:15	5.590
11/12/2012 09:00	5.525	11/12/2012 22:45	5.554	12/12/2012 12:30	5.593
11/12/2012 09:15	5.526	11/12/2012 23:00	5.555	12/12/2012 12:45	5.592
11/12/2012 09:30	5.527	11/12/2012 23:15	5.555	12/12/2012 13:00	5.592
11/12/2012 09:45	5.527	11/12/2012 23:30	5.555	12/12/2012 13:15	5.592
11/12/2012 10:00	5.528	11/12/2012 23:45	5.557	12/12/2012 13:30	5.592
11/12/2012 10:15	5.530	12/12/2012 00:00	5.559	12/12/2012 13:45	5.592
11/12/2012 10:30	5.530	12/12/2012 00:15	5.560	12/12/2012 14:00	5.594
11/12/2012 10:45	5.532	12/12/2012 00:30	5.560	12/12/2012 14:15	5.593
11/12/2012 11:00	5.532	12/12/2012 00:45	5.561	12/12/2012 14:30	5.593
11/12/2012 11:15	5.533	12/12/2012 01:00	5.561	12/12/2012 14:45	5.594
11/12/2012 11:30	5.532	12/12/2012 01:15	5.562	12/12/2012 15:00	5.595
11/12/2012 11:45	5.534	12/12/2012 01:30	5.562	12/12/2012 15:15	5.595
11/12/2012 12:00	5.531	12/12/2012 01:45	5.563	12/12/2012 15:30	5.598
11/12/2012 12:15	5.531	12/12/2012 02:00	5.563	12/12/2012 15:45	5.600
11/12/2012 12:30	5.531	12/12/2012 02:15	5.563	12/12/2012 16:00	5.600
11/12/2012 12:45	5.530	12/12/2012 02:30	5.565	12/12/2012 16:15	5.602
11/12/2012 13:00	5.530	12/12/2012 02:45	5.564	12/12/2012 16:30	5.604
11/12/2012 13:15	5.530	12/12/2012 03:00	5.566	12/12/2012 16:45	5.606
11/12/2012 13:30	5.531	12/12/2012 03:15	5.566	12/12/2012 17:00	5.606
11/12/2012 13:45	5.529	12/12/2012 03:30	5.567	12/12/2012 17:15	5.609
11/12/2012 14:00	5.530	12/12/2012 03:45	5.567	12/12/2012 17:30	5.608
11/12/2012 14:15	5.529	12/12/2012 04:00	5.566	12/12/2012 17:45	5.610
11/12/2012 14:30	5.529	12/12/2012 04:15	5.566	12/12/2012 18:00	5.610
11/12/2012 14:45	5.528	12/12/2012 04:30	5.568	12/12/2012 18:15	5.612
11/12/2012 15:00	5.531	12/12/2012 04:45	5.567	12/12/2012 18:30	5.614
11/12/2012 15:15	5.531	12/12/2012 05:00	5.567	12/12/2012 18:45	5.613
11/12/2012 15:30	5.532	12/12/2012 05:15	5.568	12/12/2012 19:00	5.615
11/12/2012 15:45	5.533	12/12/2012 05:30	5.569	12/12/2012 19:15	5.618
11/12/2012 16:00	5.533	12/12/2012 05:45	5.569	12/12/2012 19:30	5.619
11/12/2012 16:15	5.536	12/12/2012 06:00	5.569	12/12/2012 19:45	5.620
11/12/2012 16:30	5.535	12/12/2012 06:15	5.571	12/12/2012 20:00	5.621
11/12/2012 16:45	5.535	12/12/2012 06:30	5.572	12/12/2012 20:15	5.623
11/12/2012 17:00	5.537	12/12/2012 06:45	5.572	12/12/2012 20:30	5.624
11/12/2012 17:15	5.538	12/12/2012 07:00	5.573	12/12/2012 20:45	5.625
11/12/2012 17:30	5.538	12/12/2012 07:15	5.574	12/12/2012 21:00	5.626
11/12/2012 17:45	5.538	12/12/2012 07:30	5.575	12/12/2012 21:15	5.627
11/12/2012 18:00	5.540	12/12/2012 07:45	5.577	12/12/2012 21:30	5.628
11/12/2012 18:15	5.541	12/12/2012 08:00	5.578	12/12/2012 21:45	5.630
11/12/2012 18:30	5.541	12/12/2012 08:15	5.578	12/12/2012 22:00	5.632
11/12/2012 18:45	5.542	12/12/2012 08:30	5.580	12/12/2012 22:15	5.633
11/12/2012 19:00	5.543	12/12/2012 08:45	5.581	12/12/2012 22:30	5.634
11/12/2012 19:15	5.543	12/12/2012 09:00	5.581	12/12/2012 22:45	5.637
11/12/2012 19:30	5.544	12/12/2012 09:15	5.582	12/12/2012 23:00	5.637
11/12/2012 19:45	5.546	12/12/2012 09:30	5.583	12/12/2012 23:15	5.639
11/12/2012 20:00	5.545	12/12/2012 09:45	5.584	12/12/2012 23:30	5.640
11/12/2012 20:15	5.546	12/12/2012 10:00	5.584	12/12/2012 23:45	5.642
11/12/2012 20:30	5.545	12/12/2012 10:15	5.587	13/12/2012 00:00	5.645
11/12/2012 20:45	5.547	12/12/2012 10:30	5.588	13/12/2012 00:15	5.645
11/12/2012 21:00	5.548	12/12/2012 10:45	5.588	13/12/2012 00:30	5.645
11/12/2012 21:15	5.549	12/12/2012 11:00	5.589	13/12/2012 00:45	5.648
11/12/2012 21:30	5.550	12/12/2012 11:15	5.590	13/12/2012 01:00	5.649

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
13/12/2012 01:15	5.650	13/12/2012 15:00	5.692	14/12/2012 04:45	5.680
13/12/2012 01:30	5.651	13/12/2012 15:15	5.692	14/12/2012 05:00	5.679
13/12/2012 01:45	5.652	13/12/2012 15:30	5.691	14/12/2012 05:15	5.680
13/12/2012 02:00	5.654	13/12/2012 15:45	5.693	14/12/2012 05:30	5.678
13/12/2012 02:15	5.654	13/12/2012 16:00	5.692	14/12/2012 05:45	5.677
13/12/2012 02:30	5.656	13/12/2012 16:15	5.691	14/12/2012 06:00	5.677
13/12/2012 02:45	5.657	13/12/2012 16:30	5.689	14/12/2012 06:15	5.676
13/12/2012 03:00	5.659	13/12/2012 16:45	5.689	14/12/2012 06:30	5.676
13/12/2012 03:15	5.659	13/12/2012 17:00	5.688	14/12/2012 06:45	5.675
13/12/2012 03:30	5.661	13/12/2012 17:15	5.685	14/12/2012 07:00	5.675
13/12/2012 03:45	5.659	13/12/2012 17:30	5.684	14/12/2012 07:15	5.676
13/12/2012 04:00	5.660	13/12/2012 17:45	5.684	14/12/2012 07:30	5.675
13/12/2012 04:15	5.662	13/12/2012 18:00	5.687	14/12/2012 07:45	5.676
13/12/2012 04:30	5.662	13/12/2012 18:15	5.688	14/12/2012 08:00	5.677
13/12/2012 04:45	5.662	13/12/2012 18:30	5.689	14/12/2012 08:15	5.679
13/12/2012 05:00	5.664	13/12/2012 18:45	5.691	14/12/2012 08:30	5.679
13/12/2012 05:15	5.664	13/12/2012 19:00	5.691	14/12/2012 08:45	5.681
13/12/2012 05:30	5.665	13/12/2012 19:15	5.691	14/12/2012 09:00	5.682
13/12/2012 05:45	5.663	13/12/2012 19:30	5.691	14/12/2012 09:15	5.683
13/12/2012 06:00	5.667	13/12/2012 19:45	5.692	14/12/2012 09:30	5.683
13/12/2012 06:15	5.669	13/12/2012 20:00	5.692	14/12/2012 09:45	5.685
13/12/2012 06:30	5.669	13/12/2012 20:15	5.691	14/12/2012 10:00	5.686
13/12/2012 06:45	5.670	13/12/2012 20:30	5.692	14/12/2012 10:15	5.686
13/12/2012 07:00	5.671	13/12/2012 20:45	5.692	14/12/2012 10:30	5.686
13/12/2012 07:15	5.673	13/12/2012 21:00	5.689	14/12/2012 10:45	5.684
13/12/2012 07:30	5.673	13/12/2012 21:15	5.689	14/12/2012 11:00	5.684
13/12/2012 07:45	5.674	13/12/2012 21:30	5.687	14/12/2012 11:15	5.686
13/12/2012 08:00	5.674	13/12/2012 21:45	5.688	14/12/2012 11:30	5.721
13/12/2012 08:15	5.676	13/12/2012 22:00	5.688	14/12/2012 11:45	5.713
13/12/2012 08:30	5.677	13/12/2012 22:15	5.688	14/12/2012 12:00	5.718
13/12/2012 08:45	5.678	13/12/2012 22:30	5.687	14/12/2012 12:15	5.736
13/12/2012 09:00	5.681	13/12/2012 22:45	5.686	14/12/2012 12:30	5.669
13/12/2012 09:15	5.682	13/12/2012 23:00	5.684	14/12/2012 12:45	5.681
13/12/2012 09:30	5.684	13/12/2012 23:15	5.686	14/12/2012 13:00	5.682
13/12/2012 09:45	5.685	13/12/2012 23:30	5.684	14/12/2012 13:15	5.688
13/12/2012 10:00	5.685	13/12/2012 23:45	5.684	14/12/2012 13:30	5.687
13/12/2012 10:15	5.686	14/12/2012 00:00	5.684	14/12/2012 13:45	5.670
13/12/2012 10:30	5.686	14/12/2012 00:15	5.686	14/12/2012 14:00	5.753
13/12/2012 10:45	5.686	14/12/2012 00:30	5.684	14/12/2012 14:15	5.716
13/12/2012 11:00	5.686	14/12/2012 00:45	5.685	14/12/2012 14:30	5.724
13/12/2012 11:15	5.685	14/12/2012 01:00	5.684	14/12/2012 14:45	5.722
13/12/2012 11:30	5.685	14/12/2012 01:15	5.683	14/12/2012 15:00	5.723
13/12/2012 11:45	5.684	14/12/2012 01:30	5.686	14/12/2012 15:15	5.723
13/12/2012 12:00	5.685	14/12/2012 01:45	5.685	14/12/2012 15:30	5.725
13/12/2012 12:15	5.685	14/12/2012 02:00	5.681	14/12/2012 15:45	5.725
13/12/2012 12:30	5.685	14/12/2012 02:15	5.681	14/12/2012 16:00	5.727
13/12/2012 12:45	5.686	14/12/2012 02:30	5.681	14/12/2012 16:15	5.728
13/12/2012 13:00	5.688	14/12/2012 02:45	5.679	14/12/2012 16:30	5.728
13/12/2012 13:15	5.689	14/12/2012 03:00	5.683	14/12/2012 16:45	5.728
13/12/2012 13:30	5.690	14/12/2012 03:15	5.680	14/12/2012 17:00	5.731
13/12/2012 13:45	5.691	14/12/2012 03:30	5.680	14/12/2012 17:15	5.732
13/12/2012 14:00	5.692	14/12/2012 03:45	5.680	14/12/2012 17:30	5.733
13/12/2012 14:15	5.691	14/12/2012 04:00	5.681	14/12/2012 17:45	5.735
13/12/2012 14:30	5.692	14/12/2012 04:15	5.681	14/12/2012 18:00	5.735
13/12/2012 14:45	5.690	14/12/2012 04:30	5.680	14/12/2012 18:15	5.736

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
14/12/2012 18:30	5.737	15/12/2012 08:15	5.806	15/12/2012 22:00	5.863
14/12/2012 18:45	5.738	15/12/2012 08:30	5.809	15/12/2012 22:15	5.863
14/12/2012 19:00	5.740	15/12/2012 08:45	5.809	15/12/2012 22:30	5.864
14/12/2012 19:15	5.741	15/12/2012 09:00	5.811	15/12/2012 22:45	5.865
14/12/2012 19:30	5.741	15/12/2012 09:15	5.813	15/12/2012 23:00	5.866
14/12/2012 19:45	5.743	15/12/2012 09:30	5.815	15/12/2012 23:15	5.866
14/12/2012 20:00	5.744	15/12/2012 09:45	5.817	15/12/2012 23:30	5.868
14/12/2012 20:15	5.746	15/12/2012 10:00	5.818	15/12/2012 23:45	5.868
14/12/2012 20:30	5.747	15/12/2012 10:15	5.819	16/12/2012 00:00	5.869
14/12/2012 20:45	5.746	15/12/2012 10:30	5.821	16/12/2012 00:15	5.871
14/12/2012 21:00	5.748	15/12/2012 10:45	5.824	16/12/2012 00:30	5.870
14/12/2012 21:15	5.750	15/12/2012 11:00	5.826	16/12/2012 00:45	5.870
14/12/2012 21:30	5.750	15/12/2012 11:15	5.826	16/12/2012 01:00	5.871
14/12/2012 21:45	5.751	15/12/2012 11:30	5.830	16/12/2012 01:15	5.871
14/12/2012 22:00	5.753	15/12/2012 11:45	5.830	16/12/2012 01:30	5.871
14/12/2012 22:15	5.754	15/12/2012 12:00	5.830	16/12/2012 01:45	5.872
14/12/2012 22:30	5.756	15/12/2012 12:15	5.831	16/12/2012 02:00	5.873
14/12/2012 22:45	5.757	15/12/2012 12:30	5.833	16/12/2012 02:15	5.873
14/12/2012 23:00	5.758	15/12/2012 12:45	5.833	16/12/2012 02:30	5.872
14/12/2012 23:15	5.758	15/12/2012 13:00	5.833	16/12/2012 02:45	5.873
14/12/2012 23:30	5.759	15/12/2012 13:15	5.833	16/12/2012 03:00	5.873
14/12/2012 23:45	5.761	15/12/2012 13:30	5.834	16/12/2012 03:15	5.873
15/12/2012 00:00	5.762	15/12/2012 13:45	5.835	16/12/2012 03:30	5.872
15/12/2012 00:15	5.762	15/12/2012 14:00	5.835	16/12/2012 03:45	5.872
15/12/2012 00:30	5.763	15/12/2012 14:15	5.835	16/12/2012 04:00	5.872
15/12/2012 00:45	5.764	15/12/2012 14:30	5.835	16/12/2012 04:15	5.871
15/12/2012 01:00	5.763	15/12/2012 14:45	5.837	16/12/2012 04:30	5.870
15/12/2012 01:15	5.765	15/12/2012 15:00	5.838	16/12/2012 04:45	5.870
15/12/2012 01:30	5.765	15/12/2012 15:15	5.839	16/12/2012 05:00	5.869
15/12/2012 01:45	5.767	15/12/2012 15:30	5.839	16/12/2012 05:15	5.870
15/12/2012 02:00	5.767	15/12/2012 15:45	5.840	16/12/2012 05:30	5.873
15/12/2012 02:15	5.769	15/12/2012 16:00	5.842	16/12/2012 05:45	5.871
15/12/2012 02:30	5.769	15/12/2012 16:15	5.841	16/12/2012 06:00	5.869
15/12/2012 02:45	5.770	15/12/2012 16:30	5.843	16/12/2012 06:15	5.870
15/12/2012 03:00	5.771	15/12/2012 16:45	5.844	16/12/2012 06:30	5.870
15/12/2012 03:15	5.772	15/12/2012 17:00	5.845	16/12/2012 06:45	5.869
15/12/2012 03:30	5.774	15/12/2012 17:15	5.847	16/12/2012 07:00	5.869
15/12/2012 03:45	5.775	15/12/2012 17:30	5.848	16/12/2012 07:15	5.869
15/12/2012 04:00	5.777	15/12/2012 17:45	5.848	16/12/2012 07:30	5.870
15/12/2012 04:15	5.779	15/12/2012 18:00	5.849	16/12/2012 07:45	5.869
15/12/2012 04:30	5.780	15/12/2012 18:15	5.851	16/12/2012 08:00	5.868
15/12/2012 04:45	5.782	15/12/2012 18:30	5.851	16/12/2012 08:15	5.868
15/12/2012 05:00	5.784	15/12/2012 18:45	5.853	16/12/2012 08:30	5.867
15/12/2012 05:15	5.786	15/12/2012 19:00	5.853	16/12/2012 08:45	5.866
15/12/2012 05:30	5.786	15/12/2012 19:15	5.854	16/12/2012 09:00	5.865
15/12/2012 05:45	5.788	15/12/2012 19:30	5.856	16/12/2012 09:15	5.864
15/12/2012 06:00	5.789	15/12/2012 19:45	5.856	16/12/2012 09:30	5.863
15/12/2012 06:15	5.791	15/12/2012 20:00	5.857	16/12/2012 09:45	5.863
15/12/2012 06:30	5.794	15/12/2012 20:15	5.858	16/12/2012 10:00	5.863
15/12/2012 06:45	5.795	15/12/2012 20:30	5.859	16/12/2012 10:15	5.862
15/12/2012 07:00	5.796	15/12/2012 20:45	5.860	16/12/2012 10:30	5.862
15/12/2012 07:15	5.798	15/12/2012 21:00	5.860	16/12/2012 10:45	5.862
15/12/2012 07:30	5.801	15/12/2012 21:15	5.861	16/12/2012 11:00	5.862
15/12/2012 07:45	5.800	15/12/2012 21:30	5.862	16/12/2012 11:15	5.862
15/12/2012 08:00	5.803	15/12/2012 21:45	5.861	16/12/2012 11:30	5.863

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
16/12/2012 11:45	5.860				
16/12/2012 12:00	5.860				
16/12/2012 12:15	5.859				
16/12/2012 12:30	5.860				
16/12/2012 12:45	5.859				
16/12/2012 13:00	5.857				
16/12/2012 13:15	5.858				
16/12/2012 13:30	5.858				
16/12/2012 13:45	5.858				
16/12/2012 14:00	5.858				
16/12/2012 14:15	5.857				
16/12/2012 14:30	5.859				
16/12/2012 14:45	5.858				
16/12/2012 15:00	5.858				
16/12/2012 15:15	5.859				
16/12/2012 15:30	5.860				
16/12/2012 15:45	5.859				
16/12/2012 16:00	5.861				
16/12/2012 16:15	5.860				
16/12/2012 16:30	5.861				
16/12/2012 16:45	5.861				
16/12/2012 17:00	5.862				
16/12/2012 17:15	5.863				
16/12/2012 17:30	5.865				
16/12/2012 17:45	5.866				
16/12/2012 18:00	5.868				
16/12/2012 18:15	5.866				
16/12/2012 18:30	5.868				
16/12/2012 18:45	5.867				
16/12/2012 19:00	5.868				
16/12/2012 19:15	5.869				
16/12/2012 19:30	5.869				
16/12/2012 19:45	5.870				
16/12/2012 20:00	5.871				
16/12/2012 20:15	5.871				
16/12/2012 20:30	5.872				
16/12/2012 20:45	5.873				
16/12/2012 21:00	5.872				
16/12/2012 21:15	5.874				
16/12/2012 21:30	5.874				
16/12/2012 21:45	5.874				
16/12/2012 22:00	5.874				
16/12/2012 22:15	5.875				
16/12/2012 22:30	5.876				
16/12/2012 22:45	5.877				
16/12/2012 23:00	5.878				
16/12/2012 23:15	5.878				
16/12/2012 23:30	5.879				
16/12/2012 23:45	5.879				
17/12/2012 00:00	5.880				

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
11/12/2012 08:20	5.090	11/12/2012 22:05	5.169	12/12/2012 11:50	5.242
11/12/2012 08:35	5.089	11/12/2012 22:20	5.178	12/12/2012 12:05	5.241
11/12/2012 08:50	5.088	11/12/2012 22:35	5.177	12/12/2012 12:20	5.242
11/12/2012 09:05	5.094	11/12/2012 22:50	5.179	12/12/2012 12:35	5.246
11/12/2012 09:20	5.097	11/12/2012 23:05	5.179	12/12/2012 12:50	5.239
11/12/2012 09:35	5.098	11/12/2012 23:20	5.181	12/12/2012 13:05	5.243
11/12/2012 09:50	5.103	11/12/2012 23:35	5.184	12/12/2012 13:20	5.242
11/12/2012 10:05	5.106	11/12/2012 23:50	5.187	12/12/2012 13:35	5.245
11/12/2012 10:20	5.109	12/12/2012 00:05	5.186	12/12/2012 13:50	5.247
11/12/2012 10:35	5.113	12/12/2012 00:20	5.188	12/12/2012 14:05	5.246
11/12/2012 10:50	5.116	12/12/2012 00:35	5.189	12/12/2012 14:20	5.246
11/12/2012 11:05	5.116	12/12/2012 00:50	5.191	12/12/2012 14:35	5.245
11/12/2012 11:20	5.119	12/12/2012 01:05	5.193	12/12/2012 14:50	5.247
11/12/2012 11:35	5.121	12/12/2012 01:20	5.194	12/12/2012 15:05	5.248
11/12/2012 11:50	5.123	12/12/2012 01:35	5.194	12/12/2012 15:20	5.253
11/12/2012 12:05	5.120	12/12/2012 01:50	5.195	12/12/2012 15:35	5.251
11/12/2012 12:20	5.124	12/12/2012 02:05	5.199	12/12/2012 15:50	5.257
11/12/2012 12:35	5.120	12/12/2012 02:20	5.196	12/12/2012 16:05	5.260
11/12/2012 12:50	5.121	12/12/2012 02:35	5.201	12/12/2012 16:20	5.259
11/12/2012 13:05	5.123	12/12/2012 02:50	5.199	12/12/2012 16:35	5.264
11/12/2012 13:20	5.126	12/12/2012 03:05	5.199	12/12/2012 16:50	5.264
11/12/2012 13:35	5.128	12/12/2012 03:20	5.201	12/12/2012 17:05	5.265
11/12/2012 13:50	5.124	12/12/2012 03:35	5.202	12/12/2012 17:20	5.264
11/12/2012 14:05	5.126	12/12/2012 03:50	5.204	12/12/2012 17:35	5.268
11/12/2012 14:20	5.123	12/12/2012 04:05	5.201	12/12/2012 17:50	5.270
11/12/2012 14:35	5.128	12/12/2012 04:20	5.199	12/12/2012 18:05	5.271
11/12/2012 14:50	5.127	12/12/2012 04:35	5.201	12/12/2012 18:20	5.272
11/12/2012 15:05	5.130	12/12/2012 04:50	5.203	12/12/2012 18:35	5.272
11/12/2012 15:20	5.131	12/12/2012 05:05	5.205	12/12/2012 18:50	5.273
11/12/2012 15:35	5.133	12/12/2012 05:20	5.204	12/12/2012 19:05	5.276
11/12/2012 15:50	5.132	12/12/2012 05:35	5.204	12/12/2012 19:20	5.276
11/12/2012 16:05	5.141	12/12/2012 05:50	5.205	12/12/2012 19:35	5.276
11/12/2012 16:20	5.138	12/12/2012 06:05	5.207	12/12/2012 19:50	5.281
11/12/2012 16:35	5.137	12/12/2012 06:20	5.210	12/12/2012 20:05	5.284
11/12/2012 16:50	5.134	12/12/2012 06:35	5.211	12/12/2012 20:20	5.284
11/12/2012 17:05	5.140	12/12/2012 06:50	5.213	12/12/2012 20:35	5.288
11/12/2012 17:20	5.143	12/12/2012 07:05	5.213	12/12/2012 20:50	5.289
11/12/2012 17:35	5.143	12/12/2012 07:20	5.218	12/12/2012 21:05	5.289
11/12/2012 17:50	5.144	12/12/2012 07:35	5.219	12/12/2012 21:20	5.295
11/12/2012 18:05	5.147	12/12/2012 07:50	5.218	12/12/2012 21:35	5.297
11/12/2012 18:20	5.148	12/12/2012 08:05	5.218	12/12/2012 21:50	5.298
11/12/2012 18:35	5.148	12/12/2012 08:20	5.217	12/12/2012 22:05	5.303
11/12/2012 18:50	5.149	12/12/2012 08:35	5.223	12/12/2012 22:20	5.304
11/12/2012 19:05	5.156	12/12/2012 08:50	5.227	12/12/2012 22:35	5.305
11/12/2012 19:20	5.155	12/12/2012 09:05	5.231	12/12/2012 22:50	5.312
11/12/2012 19:35	5.155	12/12/2012 09:20	5.226	12/12/2012 23:05	5.312
11/12/2012 19:50	5.155	12/12/2012 09:35	5.228	12/12/2012 23:20	5.310
11/12/2012 20:05	5.158	12/12/2012 09:50	5.230	12/12/2012 23:35	5.315
11/12/2012 20:20	5.158	12/12/2012 10:05	5.233	12/12/2012 23:50	5.320
11/12/2012 20:35	5.161	12/12/2012 10:20	5.235	13/12/2012 00:05	5.323
11/12/2012 20:50	5.165	12/12/2012 10:35	5.237	13/12/2012 00:20	5.321
11/12/2012 21:05	5.165	12/12/2012 10:50	5.238	13/12/2012 00:35	5.322
11/12/2012 21:20	5.165	12/12/2012 11:05	5.240	13/12/2012 00:50	5.327
11/12/2012 21:35	5.172	12/12/2012 11:20	5.239	13/12/2012 01:05	5.324
11/12/2012 21:50	5.171	12/12/2012 11:35	5.240	13/12/2012 01:20	5.327

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
13/12/2012 01:35	5.330	13/12/2012 15:20	5.400	14/12/2012 05:05	5.295
13/12/2012 01:50	5.334	13/12/2012 15:35	5.404	14/12/2012 05:20	5.291
13/12/2012 02:05	5.336	13/12/2012 15:50	5.407	14/12/2012 05:35	5.289
13/12/2012 02:20	5.340	13/12/2012 16:05	5.401	14/12/2012 05:50	5.284
13/12/2012 02:35	5.344	13/12/2012 16:20	5.391	14/12/2012 06:05	5.280
13/12/2012 02:50	5.346	13/12/2012 16:35	5.394	14/12/2012 06:20	5.278
13/12/2012 03:05	5.345	13/12/2012 16:50	5.396	14/12/2012 06:35	5.273
13/12/2012 03:20	5.346	13/12/2012 17:05	5.390	14/12/2012 06:50	5.267
13/12/2012 03:35	5.345	13/12/2012 17:20	5.385	14/12/2012 07:05	5.264
13/12/2012 03:50	5.346	13/12/2012 17:35	5.384	14/12/2012 07:20	5.259
13/12/2012 04:05	5.351	13/12/2012 17:50	5.385	14/12/2012 07:35	5.253
13/12/2012 04:20	5.351	13/12/2012 18:05	5.390	14/12/2012 07:50	5.246
13/12/2012 04:35	5.348	13/12/2012 18:20	5.395	14/12/2012 08:05	5.246
13/12/2012 04:50	5.354	13/12/2012 18:35	5.393	14/12/2012 08:20	5.243
13/12/2012 05:05	5.355	13/12/2012 18:50	5.397	14/12/2012 08:35	5.234
13/12/2012 05:20	5.356	13/12/2012 19:05	5.398	14/12/2012 08:50	5.234
13/12/2012 05:35	5.360	13/12/2012 19:20	5.393	14/12/2012 09:05	5.224
13/12/2012 05:50	5.359	13/12/2012 19:35	5.398	14/12/2012 09:20	5.218
13/12/2012 06:05	5.363	13/12/2012 19:50	5.394	14/12/2012 09:35	5.214
13/12/2012 06:20	5.361	13/12/2012 20:05	5.393	14/12/2012 09:50	5.208
13/12/2012 06:35	5.363	13/12/2012 20:20	5.394	14/12/2012 10:05	5.197
13/12/2012 06:50	5.365	13/12/2012 20:35	5.393	14/12/2012 10:20	5.181
13/12/2012 07:05	5.369	13/12/2012 20:50	5.390	14/12/2012 10:35	5.166
13/12/2012 07:20	5.371	13/12/2012 21:05	5.388	14/12/2012 10:50	5.148
13/12/2012 07:35	5.371	13/12/2012 21:20	5.384	14/12/2012 11:05	5.134
13/12/2012 07:50	5.374	13/12/2012 21:35	5.384	14/12/2012 11:20	5.118
13/12/2012 08:05	5.377	13/12/2012 21:50	5.382	14/12/2012 11:35	5.093
13/12/2012 08:20	5.379	13/12/2012 22:05	5.386	14/12/2012 11:50	5.064
13/12/2012 08:35	5.382	13/12/2012 22:20	5.382	14/12/2012 12:05	5.035
13/12/2012 08:50	5.384	13/12/2012 22:35	5.381	14/12/2012 12:20	5.021
13/12/2012 09:05	5.384	13/12/2012 22:50	5.375	14/12/2012 12:35	4.920
13/12/2012 09:20	5.387	13/12/2012 23:05	5.370	14/12/2012 12:50	4.895
13/12/2012 09:35	5.388	13/12/2012 23:20	5.371	14/12/2012 13:05	4.883
13/12/2012 09:50	5.387	13/12/2012 23:35	5.366	14/12/2012 13:20	4.862
13/12/2012 10:05	5.394	13/12/2012 23:50	5.372	14/12/2012 13:35	4.838
13/12/2012 10:20	5.395	14/12/2012 00:05	5.367	14/12/2012 13:50	4.812
13/12/2012 10:35	5.391	14/12/2012 00:20	5.370	14/12/2012 14:05	4.942
13/12/2012 10:50	5.392	14/12/2012 00:35	5.367	14/12/2012 14:20	4.879
13/12/2012 11:05	5.396	14/12/2012 00:50	5.363	14/12/2012 14:35	4.861
13/12/2012 11:20	5.394	14/12/2012 01:05	5.361	14/12/2012 14:50	4.854
13/12/2012 11:35	5.390	14/12/2012 01:20	5.359	14/12/2012 15:05	4.850
13/12/2012 11:50	5.394	14/12/2012 01:35	5.361	14/12/2012 15:20	4.844
13/12/2012 12:05	5.392	14/12/2012 01:50	5.354	14/12/2012 15:35	4.842
13/12/2012 12:20	5.395	14/12/2012 02:05	5.348	14/12/2012 15:50	4.838
13/12/2012 12:35	5.396	14/12/2012 02:20	5.350	14/12/2012 16:05	4.832
13/12/2012 12:50	5.401	14/12/2012 02:35	5.339	14/12/2012 16:20	4.828
13/12/2012 13:05	5.403	14/12/2012 02:50	5.336	14/12/2012 16:35	4.826
13/12/2012 13:20	5.403	14/12/2012 03:05	5.327	14/12/2012 16:50	4.823
13/12/2012 13:35	5.407	14/12/2012 03:20	5.328	14/12/2012 17:05	4.821
13/12/2012 13:50	5.406	14/12/2012 03:35	5.322	14/12/2012 17:20	4.822
13/12/2012 14:05	5.406	14/12/2012 03:50	5.316	14/12/2012 17:35	4.817
13/12/2012 14:20	5.404	14/12/2012 04:05	5.313	14/12/2012 17:50	4.823
13/12/2012 14:35	5.403	14/12/2012 04:20	5.306	14/12/2012 18:05	4.824
13/12/2012 14:50	5.404	14/12/2012 04:35	5.303	14/12/2012 18:20	4.827
13/12/2012 15:05	5.403	14/12/2012 04:50	5.301	14/12/2012 18:35	4.828

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
14/12/2012 18:50	4.830	15/12/2012 08:35	4.923	15/12/2012 22:20	4.609
14/12/2012 19:05	4.836	15/12/2012 08:50	4.917	15/12/2012 22:35	4.610
14/12/2012 19:20	4.839	15/12/2012 09:05	4.916	15/12/2012 22:50	4.608
14/12/2012 19:35	4.842	15/12/2012 09:20	4.912	15/12/2012 23:05	4.611
14/12/2012 19:50	4.845	15/12/2012 09:35	4.907	15/12/2012 23:20	4.608
14/12/2012 20:05	4.841	15/12/2012 09:50	4.905	15/12/2012 23:35	4.609
14/12/2012 20:20	4.844	15/12/2012 10:05	4.898	15/12/2012 23:50	4.609
14/12/2012 20:35	4.848	15/12/2012 10:20	4.885	16/12/2012 00:05	4.614
14/12/2012 20:50	4.845	15/12/2012 10:35	4.875	16/12/2012 00:20	4.612
14/12/2012 21:05	4.851	15/12/2012 10:50	4.874	16/12/2012 00:35	4.608
14/12/2012 21:20	4.850	15/12/2012 11:05	4.861	16/12/2012 00:50	4.607
14/12/2012 21:35	4.852	15/12/2012 11:20	4.861	16/12/2012 01:05	4.606
14/12/2012 21:50	4.855	15/12/2012 11:35	4.857	16/12/2012 01:20	4.611
14/12/2012 22:05	4.861	15/12/2012 11:50	4.846	16/12/2012 01:35	4.607
14/12/2012 22:20	4.860	15/12/2012 12:05	4.838	16/12/2012 01:50	4.605
14/12/2012 22:35	4.863	15/12/2012 12:20	4.830	16/12/2012 02:05	4.613
14/12/2012 22:50	4.862	15/12/2012 12:35	4.827	16/12/2012 02:20	4.612
14/12/2012 23:05	4.865	15/12/2012 12:50	4.819	16/12/2012 02:35	4.615
14/12/2012 23:20	4.867	15/12/2012 13:05	4.817	16/12/2012 02:50	4.621
14/12/2012 23:35	4.865	15/12/2012 13:20	4.805	16/12/2012 03:05	4.616
14/12/2012 23:50	4.868	15/12/2012 13:35	4.795	16/12/2012 03:20	4.618
15/12/2012 00:05	4.872	15/12/2012 13:50	4.793	16/12/2012 03:35	4.615
15/12/2012 00:20	4.872	15/12/2012 14:05	4.791	16/12/2012 03:50	4.617
15/12/2012 00:35	4.871	15/12/2012 14:20	4.780	16/12/2012 04:05	4.612
15/12/2012 00:50	4.874	15/12/2012 14:35	4.777	16/12/2012 04:20	4.613
15/12/2012 01:05	4.878	15/12/2012 14:50	4.767	16/12/2012 04:35	4.612
15/12/2012 01:20	4.876	15/12/2012 15:05	4.753	16/12/2012 04:50	4.611
15/12/2012 01:35	4.879	15/12/2012 15:20	4.742	16/12/2012 05:05	4.613
15/12/2012 01:50	4.879	15/12/2012 15:35	4.731	16/12/2012 05:20	4.615
15/12/2012 02:05	4.886	15/12/2012 15:50	4.721	16/12/2012 05:35	4.612
15/12/2012 02:20	4.885	15/12/2012 16:05	4.712	16/12/2012 05:50	4.607
15/12/2012 02:35	4.887	15/12/2012 16:20	4.705	16/12/2012 06:05	4.608
15/12/2012 02:50	4.891	15/12/2012 16:35	4.692	16/12/2012 06:20	4.613
15/12/2012 03:05	4.896	15/12/2012 16:50	4.685	16/12/2012 06:35	4.611
15/12/2012 03:20	4.896	15/12/2012 17:05	4.676	16/12/2012 06:50	4.607
15/12/2012 03:35	4.899	15/12/2012 17:20	4.670	16/12/2012 07:05	4.608
15/12/2012 03:50	4.899	15/12/2012 17:35	4.666	16/12/2012 07:20	4.606
15/12/2012 04:05	4.907	15/12/2012 17:50	4.660	16/12/2012 07:35	4.608
15/12/2012 04:20	4.909	15/12/2012 18:05	4.652	16/12/2012 07:50	4.600
15/12/2012 04:35	4.909	15/12/2012 18:20	4.652	16/12/2012 08:05	4.602
15/12/2012 04:50	4.910	15/12/2012 18:35	4.649	16/12/2012 08:20	4.597
15/12/2012 05:05	4.912	15/12/2012 18:50	4.647	16/12/2012 08:35	4.593
15/12/2012 05:20	4.914	15/12/2012 19:05	4.640	16/12/2012 08:50	4.591
15/12/2012 05:35	4.914	15/12/2012 19:20	4.637	16/12/2012 09:05	4.585
15/12/2012 05:50	4.922	15/12/2012 19:35	4.632	16/12/2012 09:20	4.587
15/12/2012 06:05	4.925	15/12/2012 19:50	4.630	16/12/2012 09:35	4.584
15/12/2012 06:20	4.922	15/12/2012 20:05	4.626	16/12/2012 09:50	4.584
15/12/2012 06:35	4.927	15/12/2012 20:20	4.628	16/12/2012 10:05	4.581
15/12/2012 06:50	4.925	15/12/2012 20:35	4.622	16/12/2012 10:20	4.584
15/12/2012 07:05	4.925	15/12/2012 20:50	4.624	16/12/2012 10:35	4.579
15/12/2012 07:20	4.927	15/12/2012 21:05	4.619	16/12/2012 10:50	4.581
15/12/2012 07:35	4.926	15/12/2012 21:20	4.614	16/12/2012 11:05	4.581
15/12/2012 07:50	4.926	15/12/2012 21:35	4.612	16/12/2012 11:20	4.579
15/12/2012 08:05	4.926	15/12/2012 21:50	4.610	16/12/2012 11:35	4.574
15/12/2012 08:20	4.927	15/12/2012 22:05	4.611	16/12/2012 11:50	4.568

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
16/12/2012 12:05	4.561				
16/12/2012 12:20	4.558				
16/12/2012 12:35	4.550				
16/12/2012 12:50	4.541				
16/12/2012 13:05	4.527				
16/12/2012 13:20	4.516				
16/12/2012 13:35	4.503				
16/12/2012 13:50	4.473				
16/12/2012 14:05	4.444				
16/12/2012 14:20	4.412				
16/12/2012 14:35	4.364				
16/12/2012 14:50	4.333				
16/12/2012 15:05	4.308				
16/12/2012 15:20	4.284				
16/12/2012 15:35	4.268				
16/12/2012 15:50	4.250				
16/12/2012 16:05	4.238				
16/12/2012 16:20	4.221				
16/12/2012 16:35	4.212				
16/12/2012 16:50	4.198				
16/12/2012 17:05	4.191				
16/12/2012 17:20	4.185				
16/12/2012 17:35	4.189				
16/12/2012 17:50	4.183				
16/12/2012 18:05	4.173				
16/12/2012 18:20	4.167				
16/12/2012 18:35	4.154				
16/12/2012 18:50	4.137				
16/12/2012 19:05	4.124				
16/12/2012 19:20	4.104				
16/12/2012 19:35	4.087				
16/12/2012 19:50	4.073				
16/12/2012 20:05	4.057				
16/12/2012 20:20	4.048				
16/12/2012 20:35	4.035				
16/12/2012 20:50	4.029				
16/12/2012 21:05	4.022				
16/12/2012 21:20	4.014				
16/12/2012 21:35	4.011				
16/12/2012 21:50	4.008				
16/12/2012 22:05	4.006				
16/12/2012 22:20	4.010				
16/12/2012 22:35	4.007				
16/12/2012 22:50	4.012				
16/12/2012 23:05	4.016				
16/12/2012 23:20	4.025				
16/12/2012 23:35	4.029				
16/12/2012 23:50	4.039				
17/12/2012 00:05	4.044				

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
11/12/2012 08:00	7.580	11/12/2012 21:45	7.735	12/12/2012 11:30	7.849
11/12/2012 08:15	7.585	11/12/2012 22:00	7.737	12/12/2012 11:45	7.853
11/12/2012 08:30	7.588	11/12/2012 22:15	7.739	12/12/2012 12:00	7.857
11/12/2012 08:45	7.591	11/12/2012 22:30	7.741	12/12/2012 12:15	7.862
11/12/2012 09:00	7.595	11/12/2012 22:45	7.742	12/12/2012 12:30	7.867
11/12/2012 09:15	7.599	11/12/2012 23:00	7.744	12/12/2012 12:45	7.872
11/12/2012 09:30	7.603	11/12/2012 23:15	7.745	12/12/2012 13:00	7.875
11/12/2012 09:45	7.608	11/12/2012 23:30	7.748	12/12/2012 13:15	7.878
11/12/2012 10:00	7.612	11/12/2012 23:45	7.751	12/12/2012 13:30	7.883
11/12/2012 10:15	7.617	12/12/2012 00:00	7.753	12/12/2012 13:45	7.887
11/12/2012 10:30	7.619	12/12/2012 00:15	7.753	12/12/2012 14:00	7.890
11/12/2012 10:45	7.623	12/12/2012 00:30	7.755	12/12/2012 14:15	7.892
11/12/2012 11:00	7.625	12/12/2012 00:45	7.758	12/12/2012 14:30	7.892
11/12/2012 11:15	7.629	12/12/2012 01:00	7.759	12/12/2012 14:45	7.894
11/12/2012 11:30	7.632	12/12/2012 01:15	7.762	12/12/2012 15:00	7.898
11/12/2012 11:45	7.637	12/12/2012 01:30	7.765	12/12/2012 15:15	7.901
11/12/2012 12:00	7.640	12/12/2012 01:45	7.768	12/12/2012 15:30	7.904
11/12/2012 12:15	7.644	12/12/2012 02:00	7.770	12/12/2012 15:45	7.906
11/12/2012 12:30	7.646	12/12/2012 02:15	7.771	12/12/2012 16:00	7.907
11/12/2012 12:45	7.648	12/12/2012 02:30	7.772	12/12/2012 16:15	7.910
11/12/2012 13:00	7.650	12/12/2012 02:45	7.773	12/12/2012 16:30	7.913
11/12/2012 13:15	7.651	12/12/2012 03:00	7.774	12/12/2012 16:45	7.918
11/12/2012 13:30	7.654	12/12/2012 03:15	7.776	12/12/2012 17:00	7.918
11/12/2012 13:45	7.655	12/12/2012 03:30	7.777	12/12/2012 17:15	7.921
11/12/2012 14:00	7.656	12/12/2012 03:45	7.778	12/12/2012 17:30	7.922
11/12/2012 14:15	7.657	12/12/2012 04:00	7.778	12/12/2012 17:45	7.921
11/12/2012 14:30	7.658	12/12/2012 04:15	7.778	12/12/2012 18:00	7.924
11/12/2012 14:45	7.658	12/12/2012 04:30	7.779	12/12/2012 18:15	7.925
11/12/2012 15:00	7.658	12/12/2012 04:45	7.779	12/12/2012 18:30	7.928
11/12/2012 15:15	7.661	12/12/2012 05:00	7.780	12/12/2012 18:45	7.931
11/12/2012 15:30	7.665	12/12/2012 05:15	7.781	12/12/2012 19:00	7.935
11/12/2012 15:45	7.669	12/12/2012 05:30	7.782	12/12/2012 19:15	7.939
11/12/2012 16:00	7.672	12/12/2012 05:45	7.783	12/12/2012 19:30	7.942
11/12/2012 16:15	7.676	12/12/2012 06:00	7.784	12/12/2012 19:45	7.944
11/12/2012 16:30	7.679	12/12/2012 06:15	7.787	12/12/2012 20:00	7.947
11/12/2012 16:45	7.684	12/12/2012 06:30	7.788	12/12/2012 20:15	7.950
11/12/2012 17:00	7.688	12/12/2012 06:45	7.789	12/12/2012 20:30	7.954
11/12/2012 17:15	7.692	12/12/2012 07:00	7.791	12/12/2012 20:45	7.954
11/12/2012 17:30	7.695	12/12/2012 07:15	7.793	12/12/2012 21:00	7.958
11/12/2012 17:45	7.697	12/12/2012 07:30	7.795	12/12/2012 21:15	7.961
11/12/2012 18:00	7.699	12/12/2012 07:45	7.797	12/12/2012 21:30	7.963
11/12/2012 18:15	7.701	12/12/2012 08:00	7.801	12/12/2012 21:45	7.967
11/12/2012 18:30	7.703	12/12/2012 08:15	7.802	12/12/2012 22:00	7.970
11/12/2012 18:45	7.704	12/12/2012 08:30	7.806	12/12/2012 22:15	7.972
11/12/2012 19:00	7.706	12/12/2012 08:45	7.809	12/12/2012 22:30	7.975
11/12/2012 19:15	7.706	12/12/2012 09:00	7.811	12/12/2012 22:45	7.976
11/12/2012 19:30	7.708	12/12/2012 09:15	7.812	12/12/2012 23:00	7.979
11/12/2012 19:45	7.711	12/12/2012 09:30	7.816	12/12/2012 23:15	7.983
11/12/2012 20:00	7.716	12/12/2012 09:45	7.819	12/12/2012 23:30	7.985
11/12/2012 20:15	7.718	12/12/2012 10:00	7.822	12/12/2012 23:45	7.989
11/12/2012 20:30	7.721	12/12/2012 10:15	7.827	13/12/2012 00:00	7.991
11/12/2012 20:45	7.727	12/12/2012 10:30	7.832	13/12/2012 00:15	7.995
11/12/2012 21:00	7.728	12/12/2012 10:45	7.838	13/12/2012 00:30	7.997
11/12/2012 21:15	7.731	12/12/2012 11:00	7.841	13/12/2012 00:45	7.999
11/12/2012 21:30	7.732	12/12/2012 11:15	7.845	13/12/2012 01:00	8.002

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
13/12/2012 01:15	8.004	13/12/2012 15:00	8.168	14/12/2012 04:45	8.166
13/12/2012 01:30	8.007	13/12/2012 15:15	8.171	14/12/2012 05:00	8.163
13/12/2012 01:45	8.010	13/12/2012 15:30	8.173	14/12/2012 05:15	8.159
13/12/2012 02:00	8.012	13/12/2012 15:45	8.176	14/12/2012 05:30	8.156
13/12/2012 02:15	8.015	13/12/2012 16:00	8.179	14/12/2012 05:45	8.152
13/12/2012 02:30	8.016	13/12/2012 16:15	8.181	14/12/2012 06:00	8.148
13/12/2012 02:45	8.018	13/12/2012 16:30	8.183	14/12/2012 06:15	8.144
13/12/2012 03:00	8.021	13/12/2012 16:45	8.186	14/12/2012 06:30	8.138
13/12/2012 03:15	8.023	13/12/2012 17:00	8.187	14/12/2012 06:45	8.131
13/12/2012 03:30	8.024	13/12/2012 17:15	8.190	14/12/2012 07:00	8.125
13/12/2012 03:45	8.026	13/12/2012 17:30	8.191	14/12/2012 07:15	8.121
13/12/2012 04:00	8.028	13/12/2012 17:45	8.192	14/12/2012 07:30	8.118
13/12/2012 04:15	8.028	13/12/2012 18:00	8.194	14/12/2012 07:45	8.114
13/12/2012 04:30	8.030	13/12/2012 18:15	8.195	14/12/2012 08:00	8.111
13/12/2012 04:45	8.032	13/12/2012 18:30	8.194	14/12/2012 08:15	8.108
13/12/2012 05:00	8.032	13/12/2012 18:45	8.194	14/12/2012 08:30	8.106
13/12/2012 05:15	8.034	13/12/2012 19:00	8.193	14/12/2012 08:45	8.104
13/12/2012 05:30	8.035	13/12/2012 19:15	8.193	14/12/2012 09:00	8.103
13/12/2012 05:45	8.037	13/12/2012 19:30	8.195	14/12/2012 09:15	8.100
13/12/2012 06:00	8.039	13/12/2012 19:45	8.195	14/12/2012 09:30	8.099
13/12/2012 06:15	8.040	13/12/2012 20:00	8.196	14/12/2012 09:45	8.098
13/12/2012 06:30	8.041	13/12/2012 20:15	8.197	14/12/2012 10:00	8.097
13/12/2012 06:45	8.044	13/12/2012 20:30	8.198	14/12/2012 10:15	8.095
13/12/2012 07:00	8.046	13/12/2012 20:45	8.200	14/12/2012 10:30	8.094
13/12/2012 07:15	8.047	13/12/2012 21:00	8.200	14/12/2012 10:45	8.090
13/12/2012 07:30	8.049	13/12/2012 21:15	8.202	14/12/2012 11:00	8.094
13/12/2012 07:45	8.051	13/12/2012 21:30	8.203	14/12/2012 11:15	8.093
13/12/2012 08:00	8.054	13/12/2012 21:45	8.206	14/12/2012 11:30	8.095
13/12/2012 08:15	8.053	13/12/2012 22:00	8.208	14/12/2012 11:45	8.089
13/12/2012 08:30	8.056	13/12/2012 22:15	8.209	14/12/2012 12:00	8.092
13/12/2012 08:45	8.060	13/12/2012 22:30	8.211	14/12/2012 12:15	8.112
13/12/2012 09:00	8.063	13/12/2012 22:45	8.213	14/12/2012 12:30	8.044
13/12/2012 09:15	8.065	13/12/2012 23:00	8.214	14/12/2012 12:45	8.057
13/12/2012 09:30	8.070	13/12/2012 23:15	8.217	14/12/2012 13:00	8.059
13/12/2012 09:45	8.077	13/12/2012 23:30	8.219	14/12/2012 13:15	8.068
13/12/2012 10:00	8.083	13/12/2012 23:45	8.221	14/12/2012 13:30	8.070
13/12/2012 10:15	8.090	14/12/2012 00:00	8.224	14/12/2012 13:45	8.054
13/12/2012 10:30	8.095	14/12/2012 00:15	8.228	14/12/2012 14:00	8.138
13/12/2012 10:45	8.099	14/12/2012 00:30	8.229	14/12/2012 14:15	8.103
13/12/2012 11:00	8.104	14/12/2012 00:45	8.231	14/12/2012 14:30	8.111
13/12/2012 11:15	8.108	14/12/2012 01:00	8.233	14/12/2012 14:45	8.111
13/12/2012 11:30	8.111	14/12/2012 01:15	8.233	14/12/2012 15:00	8.111
13/12/2012 11:45	8.116	14/12/2012 01:30	8.233	14/12/2012 15:15	8.112
13/12/2012 12:00	8.120	14/12/2012 01:45	8.230	14/12/2012 15:30	8.112
13/12/2012 12:15	8.124	14/12/2012 02:00	8.225	14/12/2012 15:45	8.113
13/12/2012 12:30	8.129	14/12/2012 02:15	8.219	14/12/2012 16:00	8.115
13/12/2012 12:45	8.133	14/12/2012 02:30	8.210	14/12/2012 16:15	8.116
13/12/2012 13:00	8.138	14/12/2012 02:45	8.199	14/12/2012 16:30	8.118
13/12/2012 13:15	8.142	14/12/2012 03:00	8.191	14/12/2012 16:45	8.120
13/12/2012 13:30	8.145	14/12/2012 03:15	8.186	14/12/2012 17:00	8.123
13/12/2012 13:45	8.150	14/12/2012 03:30	8.182	14/12/2012 17:15	8.126
13/12/2012 14:00	8.153	14/12/2012 03:45	8.179	14/12/2012 17:30	8.126
13/12/2012 14:15	8.156	14/12/2012 04:00	8.177	14/12/2012 17:45	8.125
13/12/2012 14:30	8.159	14/12/2012 04:15	8.173	14/12/2012 18:00	8.123
13/12/2012 14:45	8.165	14/12/2012 04:30	8.169	14/12/2012 18:15	8.124

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
14/12/2012 18:30	8.124	15/12/2012 08:15	8.147	15/12/2012 22:00	8.132
14/12/2012 18:45	8.123	15/12/2012 08:30	8.146	15/12/2012 22:15	8.131
14/12/2012 19:00	8.123	15/12/2012 08:45	8.143	15/12/2012 22:30	8.129
14/12/2012 19:15	8.123	15/12/2012 09:00	8.142	15/12/2012 22:45	8.130
14/12/2012 19:30	8.123	15/12/2012 09:15	8.142	15/12/2012 23:00	8.129
14/12/2012 19:45	8.124	15/12/2012 09:30	8.141	15/12/2012 23:15	8.128
14/12/2012 20:00	8.125	15/12/2012 09:45	8.139	15/12/2012 23:30	8.127
14/12/2012 20:15	8.125	15/12/2012 10:00	8.139	15/12/2012 23:45	8.129
14/12/2012 20:30	8.127	15/12/2012 10:15	8.140	16/12/2012 00:00	8.129
14/12/2012 20:45	8.128	15/12/2012 10:30	8.142	16/12/2012 00:15	8.130
14/12/2012 21:00	8.130	15/12/2012 10:45	8.145	16/12/2012 00:30	8.130
14/12/2012 21:15	8.131	15/12/2012 11:00	8.148	16/12/2012 00:45	8.130
14/12/2012 21:30	8.132	15/12/2012 11:15	8.151	16/12/2012 01:00	8.130
14/12/2012 21:45	8.132	15/12/2012 11:30	8.154	16/12/2012 01:15	8.131
14/12/2012 22:00	8.133	15/12/2012 11:45	8.153	16/12/2012 01:30	8.131
14/12/2012 22:15	8.134	15/12/2012 12:00	8.155	16/12/2012 01:45	8.132
14/12/2012 22:30	8.135	15/12/2012 12:15	8.156	16/12/2012 02:00	8.132
14/12/2012 22:45	8.135	15/12/2012 12:30	8.159	16/12/2012 02:15	8.133
14/12/2012 23:00	8.137	15/12/2012 12:45	8.161	16/12/2012 02:30	8.134
14/12/2012 23:15	8.139	15/12/2012 13:00	8.163	16/12/2012 02:45	8.133
14/12/2012 23:30	8.140	15/12/2012 13:15	8.164	16/12/2012 03:00	8.133
14/12/2012 23:45	8.142	15/12/2012 13:30	8.164	16/12/2012 03:15	8.133
15/12/2012 00:00	8.143	15/12/2012 13:45	8.162	16/12/2012 03:30	8.133
15/12/2012 00:15	8.146	15/12/2012 14:00	8.160	16/12/2012 03:45	8.133
15/12/2012 00:30	8.147	15/12/2012 14:15	8.160	16/12/2012 04:00	8.134
15/12/2012 00:45	8.149	15/12/2012 14:30	8.161	16/12/2012 04:15	8.133
15/12/2012 01:00	8.151	15/12/2012 14:45	8.160	16/12/2012 04:30	8.133
15/12/2012 01:15	8.153	15/12/2012 15:00	8.162	16/12/2012 04:45	8.133
15/12/2012 01:30	8.158	15/12/2012 15:15	8.163	16/12/2012 05:00	8.134
15/12/2012 01:45	8.161	15/12/2012 15:30	8.164	16/12/2012 05:15	8.133
15/12/2012 02:00	8.162	15/12/2012 15:45	8.165	16/12/2012 05:30	8.133
15/12/2012 02:15	8.162	15/12/2012 16:00	8.165	16/12/2012 05:45	8.131
15/12/2012 02:30	8.164	15/12/2012 16:15	8.166	16/12/2012 06:00	8.128
15/12/2012 02:45	8.164	15/12/2012 16:30	8.166	16/12/2012 06:15	8.128
15/12/2012 03:00	8.165	15/12/2012 16:45	8.165	16/12/2012 06:30	8.126
15/12/2012 03:15	8.167	15/12/2012 17:00	8.165	16/12/2012 06:45	8.125
15/12/2012 03:30	8.168	15/12/2012 17:15	8.165	16/12/2012 07:00	8.125
15/12/2012 03:45	8.169	15/12/2012 17:30	8.164	16/12/2012 07:15	8.124
15/12/2012 04:00	8.169	15/12/2012 17:45	8.162	16/12/2012 07:30	8.123
15/12/2012 04:15	8.168	15/12/2012 18:00	8.160	16/12/2012 07:45	8.121
15/12/2012 04:30	8.168	15/12/2012 18:15	8.156	16/12/2012 08:00	8.118
15/12/2012 04:45	8.169	15/12/2012 18:30	8.155	16/12/2012 08:15	8.117
15/12/2012 05:00	8.168	15/12/2012 18:45	8.154	16/12/2012 08:30	8.116
15/12/2012 05:15	8.169	15/12/2012 19:00	8.152	16/12/2012 08:45	8.114
15/12/2012 05:30	8.167	15/12/2012 19:15	8.150	16/12/2012 09:00	8.112
15/12/2012 05:45	8.167	15/12/2012 19:30	8.147	16/12/2012 09:15	8.111
15/12/2012 06:00	8.164	15/12/2012 19:45	8.142	16/12/2012 09:30	8.111
15/12/2012 06:15	8.160	15/12/2012 20:00	8.140	16/12/2012 09:45	8.113
15/12/2012 06:30	8.158	15/12/2012 20:15	8.138	16/12/2012 10:00	8.112
15/12/2012 06:45	8.156	15/12/2012 20:30	8.136	16/12/2012 10:15	8.112
15/12/2012 07:00	8.155	15/12/2012 20:45	8.135	16/12/2012 10:30	8.111
15/12/2012 07:15	8.153	15/12/2012 21:00	8.135	16/12/2012 10:45	8.110
15/12/2012 07:30	8.152	15/12/2012 21:15	8.134	16/12/2012 11:00	8.111
15/12/2012 07:45	8.150	15/12/2012 21:30	8.134	16/12/2012 11:15	8.110
15/12/2012 08:00	8.150	15/12/2012 21:45	8.132	16/12/2012 11:30	8.106

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
16/12/2012 11:45	8.101				
16/12/2012 12:00	8.097				
16/12/2012 12:15	8.097				
16/12/2012 12:30	8.097				
16/12/2012 12:45	8.093				
16/12/2012 13:00	8.089				
16/12/2012 13:15	8.086				
16/12/2012 13:30	8.085				
16/12/2012 13:45	8.083				
16/12/2012 14:00	8.081				
16/12/2012 14:15	8.078				
16/12/2012 14:30	8.076				
16/12/2012 14:45	8.075				
16/12/2012 15:00	8.073				
16/12/2012 15:15	8.069				
16/12/2012 15:30	8.068				
16/12/2012 15:45	8.064				
16/12/2012 16:00	8.063				
16/12/2012 16:15	8.062				
16/12/2012 16:30	8.061				
16/12/2012 16:45	8.061				
16/12/2012 17:00	8.059				
16/12/2012 17:15	8.058				
16/12/2012 17:30	8.058				
16/12/2012 17:45	8.057				
16/12/2012 18:00	8.050				
16/12/2012 18:15	8.040				
16/12/2012 18:30	8.031				
16/12/2012 18:45	8.027				
16/12/2012 19:00	8.021				
16/12/2012 19:15	8.016				
16/12/2012 19:30	8.010				
16/12/2012 19:45	8.006				
16/12/2012 20:00	8.002				
16/12/2012 20:15	7.997				
16/12/2012 20:30	7.993				
16/12/2012 20:45	7.992				
16/12/2012 21:00	7.987				
16/12/2012 21:15	7.983				
16/12/2012 21:30	7.978				
16/12/2012 21:45	7.975				
16/12/2012 22:00	7.970				
16/12/2012 22:15	7.968				
16/12/2012 22:30	7.964				
16/12/2012 22:45	7.962				
16/12/2012 23:00	7.958				
16/12/2012 23:15	7.956				
16/12/2012 23:30	7.953				
16/12/2012 23:45	7.951				
17/12/2012 00:00	7.949				

Date / time	WL (mbdl)	Date / time	WL (mbdl)	Date / time	WL (mbdl)
13/12/2012 01:15	8.946	13/12/2012 15:00	9.001	14/12/2012 04:45	9.051
13/12/2012 01:30	8.946	13/12/2012 15:15	9.001	14/12/2012 05:00	9.056
13/12/2012 01:45	8.951	13/12/2012 15:30	9.006	14/12/2012 05:15	9.055
13/12/2012 02:00	8.949	13/12/2012 15:45	9.009	14/12/2012 05:30	9.057
13/12/2012 02:15	8.950	13/12/2012 16:00	9.010	14/12/2012 05:45	9.058
13/12/2012 02:30	8.950	13/12/2012 16:15	9.007	14/12/2012 06:00	9.055
13/12/2012 02:45	8.955	13/12/2012 16:30	9.007	14/12/2012 06:15	9.061
13/12/2012 03:00	8.957	13/12/2012 16:45	9.006	14/12/2012 06:30	9.058
13/12/2012 03:15	8.955	13/12/2012 17:00	9.007	14/12/2012 06:45	9.062
13/12/2012 03:30	8.958	13/12/2012 17:15	9.006	14/12/2012 07:00	9.063
13/12/2012 03:45	8.958	13/12/2012 17:30	9.007	14/12/2012 07:15	9.066
13/12/2012 04:00	8.956	13/12/2012 17:45	9.004	14/12/2012 07:30	9.067
13/12/2012 04:15	8.961	13/12/2012 18:00	9.010	14/12/2012 07:45	9.067
13/12/2012 04:30	8.956	13/12/2012 18:15	9.017	14/12/2012 08:00	9.072
13/12/2012 04:45	8.960	13/12/2012 18:30	9.019	14/12/2012 08:15	9.076
13/12/2012 05:00	8.960	13/12/2012 18:45	9.022	14/12/2012 08:30	9.079
13/12/2012 05:15	8.959	13/12/2012 19:00	9.025	14/12/2012 08:45	9.081
13/12/2012 05:30	8.963	13/12/2012 19:15	9.024	14/12/2012 09:00	9.083
13/12/2012 05:45	8.968	13/12/2012 19:30	9.030	14/12/2012 09:15	9.087
13/12/2012 06:00	8.969	13/12/2012 19:45	9.031	14/12/2012 09:30	9.086
13/12/2012 06:15	8.969	13/12/2012 20:00	9.030	14/12/2012 09:45	9.092
13/12/2012 06:30	8.969	13/12/2012 20:15	9.033	14/12/2012 10:00	9.094
13/12/2012 06:45	8.972	13/12/2012 20:30	9.034	14/12/2012 10:15	9.094
13/12/2012 07:00	8.977	13/12/2012 20:45	9.030	14/12/2012 10:30	9.094
13/12/2012 07:15	8.979	13/12/2012 21:00	9.029	14/12/2012 10:45	9.093
13/12/2012 07:30	8.977	13/12/2012 21:15	9.029	14/12/2012 11:00	9.093
13/12/2012 07:45	8.980	13/12/2012 21:30	9.029	14/12/2012 11:15	9.099
13/12/2012 08:00	8.978	13/12/2012 21:45	9.035	14/12/2012 11:30	9.099
13/12/2012 08:15	8.980	13/12/2012 22:00	9.036	14/12/2012 11:45	9.101
13/12/2012 08:30	8.983	13/12/2012 22:15	9.037	14/12/2012 12:00	9.091
13/12/2012 08:45	8.987	13/12/2012 22:30	9.036	14/12/2012 12:15	9.097
13/12/2012 09:00	8.988	13/12/2012 22:45	9.035	14/12/2012 12:30	9.090
13/12/2012 09:15	8.990	13/12/2012 23:00	9.038	14/12/2012 12:45	9.075
13/12/2012 09:30	8.994	13/12/2012 23:15	9.038	14/12/2012 13:00	9.075
13/12/2012 09:45	8.993	13/12/2012 23:30	9.039	14/12/2012 13:15	9.073
13/12/2012 10:00	8.992	13/12/2012 23:45	9.042	14/12/2012 13:30	9.076
13/12/2012 10:15	8.995	14/12/2012 00:00	9.041	14/12/2012 13:45	9.070
13/12/2012 10:30	8.997	14/12/2012 00:15	9.044	14/12/2012 14:00	9.127
13/12/2012 10:45	8.998	14/12/2012 00:30	9.044	14/12/2012 14:15	9.150
13/12/2012 11:00	8.999	14/12/2012 00:45	9.046	14/12/2012 14:30	9.113
13/12/2012 11:15	9.005	14/12/2012 01:00	9.046	14/12/2012 14:45	9.112
13/12/2012 11:30	9.000	14/12/2012 01:15	9.044	14/12/2012 15:00	9.118
13/12/2012 11:45	9.002	14/12/2012 01:30	9.048	14/12/2012 15:15	9.109
13/12/2012 12:00	9.007	14/12/2012 01:45	9.044	14/12/2012 15:30	9.115
13/12/2012 12:15	8.994	14/12/2012 02:00	9.044	14/12/2012 15:45	9.119
13/12/2012 12:30	8.994	14/12/2012 02:15	9.043	14/12/2012 16:00	9.116
13/12/2012 12:45	8.999	14/12/2012 02:30	9.046	14/12/2012 16:15	9.118
13/12/2012 13:00	8.997	14/12/2012 02:45	9.047	14/12/2012 16:30	9.120
13/12/2012 13:15	8.999	14/12/2012 03:00	9.046	14/12/2012 16:45	9.122
13/12/2012 13:30	9.000	14/12/2012 03:15	9.050	14/12/2012 17:00	9.122
13/12/2012 13:45	9.004	14/12/2012 03:30	9.051	14/12/2012 17:15	9.128
13/12/2012 14:00	9.003	14/12/2012 03:45	9.052	14/12/2012 17:30	9.131
13/12/2012 14:15	9.003	14/12/2012 04:00	9.053	14/12/2012 17:45	9.134
13/12/2012 14:30	9.002	14/12/2012 04:15	9.055	14/12/2012 18:00	9.135
13/12/2012 14:45	9.004	14/12/2012 04:30	9.050	14/12/2012 18:15	9.135

Gas monitoring results			
Contract:	Landfill Restoration	*Test carried out by:*	Irish Drilling Ltd.
Location:	Newcastle West	*Operators:*	DF
Client:	Limerick Co. Council	*Date installed:*	
Engineer:	Tobin	*Date:*	07/01/2013

Well/borehole	BH 1	BH 2	BH 3	BH 9	BH 10	BH 10
Date:	03/12/2012	03/12/2012	03/12/2012		04/12/2012	06/12/2012
Methane (CH4), %	58.8	40.6	38.5			
Carbon dioxide (C02), %	33.10	24.00	12.70			
Oxygen (O2), %	0.0	0.3	1.7			
Atmospheric pressure, mb	1000	1000	1001			
Hex, %	0.66	0.54	0.52			
HydrogenSulphide(H2S),ppm	-10.00	0.00	-10.00			
CarbonMonoxide(CO),ppm	0.00	-1.00	11.00			
Water Level (m)					7.60	7.80

Well/borehole	BH 1	BH 2	BH 3	BH 9	BH 10
Date:	04/12/2012	04/12/2012	04/12/2012		
Methane (CH4), %	59.7	56.6	40.7		
Carbon dioxide (C02), %	33.50	28.20	12.60		
Oxygen (O2), %	0.0	0.5	1.0		
Atmospheric pressure, mb	999	999	998		
Hex, %	0.66	0.65	0.53		
HydrogenSulphide(H2S),ppm	-10.00	-10.00	-10.00		
CarbonMonoxide(CO),ppm	1.00	-1.00	8.00		
Water Level (m)					

Well/borehole	BH 1	BH 2	BH 3*	BH 9	BH 10
Date:	05/12/2012	05/12/2012	05/12/2012		
Methane (CH4), %	58.7	62.9	N/A		
Carbon dioxide (C02), %	34.70	29.60	N/A		
Oxygen (O2), %	-0.7	-0.6	N/A		
Atmospheric pressure, mb	1011	1010	N/A		
Hex, %	0.65	0.67	N/A		
HydrogenSulphide(H2S),ppm	-10.00	-10.00	N/A		
CarbonMonoxide(CO),ppm	0.00	0.00	N/A		
Water Level (m)					

* Remarks: Gas tap open on inspection.

Well/borehole	BH 1	BH 2	BH 3	BH 9	BH 10
Date:	06/12/2012	06/12/2012	06/12/2012		
Methane (CH4), %	55.7	63.6	11.1		
Carbon dioxide (C02), %	34.10	29.50	11.40		
Oxygen (O2), %	0.0	0.0	7.8		
Atmospheric pressure, mb	999	998	998		
Hex, %	0.64	0.69	0.28		
HydrogenSulphide(H2S),ppm	0.00	0.00	0.00		
CarbonMonoxide(CO),ppm	-1.00	1.00	77.00		
Water Level (m)					

Well/borehole	BH 1	BH 2	BH 3	BH 9	BH 10
Date:	07/12/2012	07/12/2012	07/12/2012		
Methane (CH4), %	55.9	56.4	16.7		
Carbon dioxide (C02), %	31.80	26.20	12.40		
Oxygen (O2), %	0.0	1.3	5.3		
Atmospheric pressure, mb	1008	1008	1009		
Hex, %	0.64	0.64	0.34		
HydrogenSulphide(H2S),ppm	-10.00	-10.00	0.00		
CarbonMonoxide(CO),ppm	0.00	0.00	72.00		
Water Level (m)					

Well/borehole	BH 1	BH 2	BH 3	BH 9	BH 10
Date:	10/12/2012	10/12/2012	10/12/2012		
Methane (CH4), %	52.6	60.4	26.8		
Carbon dioxide (C02), %	30.60	31.20	12.30		
Oxygen (O2), %	0.0	0.2	1.7		
Atmospheric pressure, mb	1019	1019	1019		
Hex, %	0.53	0.67	0.43		
HydrogenSulphide(H2S),ppm	-10.00	-10.00	-10.00		
CarbonMonoxide(CO),ppm	0.00	-1.00	36.00		
Water Level (m)					

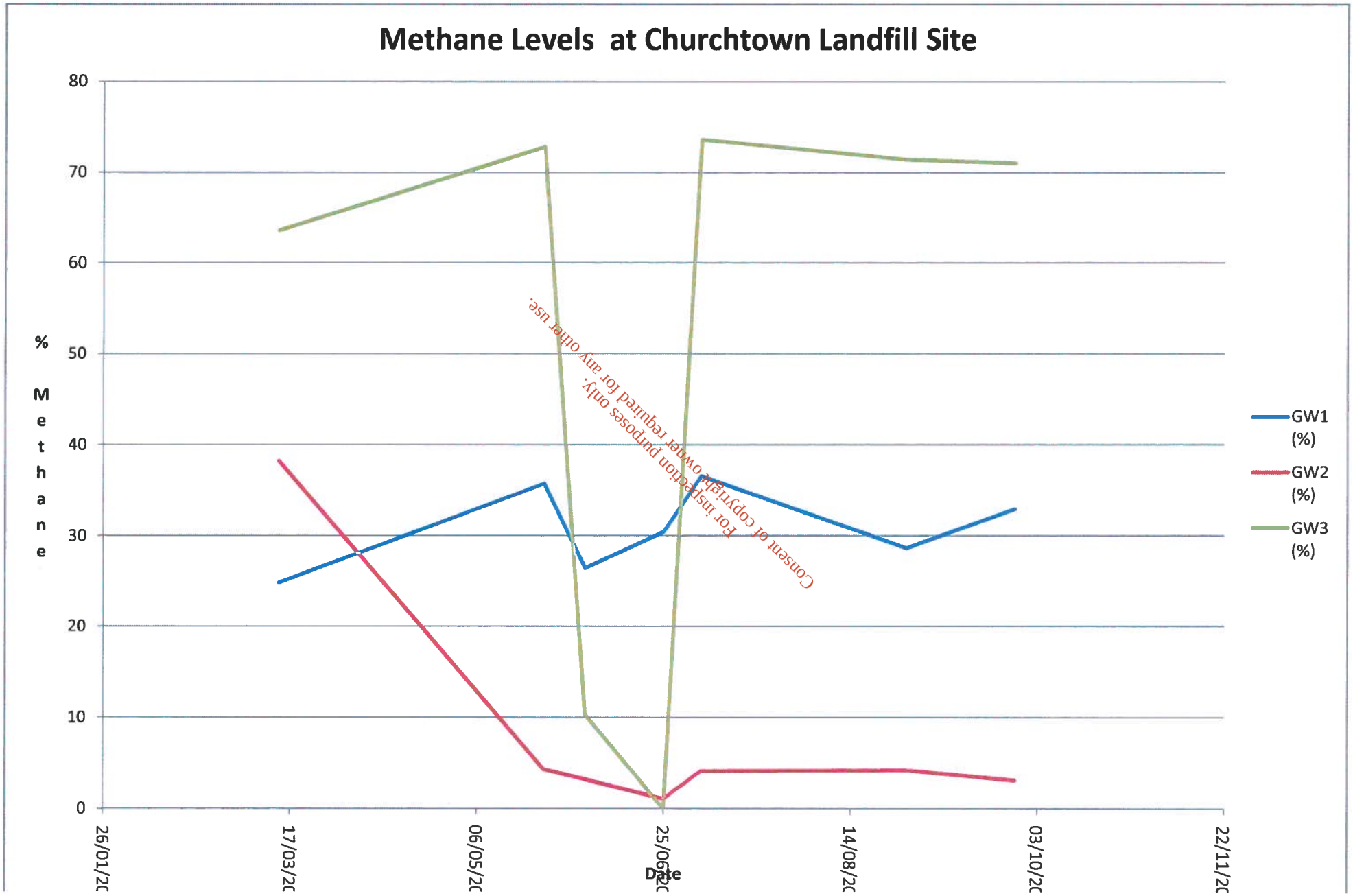
Well/borehole	BH 1	BH 2	BH 3	BH 9	BH 10
Date:	11/12/2012	11/12/2012	11/12/2012		
Methane (CH4), %	49.8	61.5	29.7		
Carbon dioxide (C02), %	32.80	30.70	12.70		
Oxygen (O2), %	0.0	0.0	0.7		
Atmospheric pressure, mb	1019	1019	1019		
Hex, %	0.60	0.67	0.45		
HydrogenSulphide(H2S),ppm	-10.00	-10.00	-10.00		
CarbonMonoxide(CO),ppm	0.00	-1.00	29.00		
Water Level (m)					

Well/borehole	BH 1*	BH 2	BH 3	BH 9	BH 10
Date:	17/12/2012	17/12/2012	17/12/2012	17/12/2012	
Methane (CH4), %	N/A	60.8	45.1	0.0	
Carbon dioxide (C02), %	N/A	27.90	11.80	2.00	
Oxygen (O2), %	N/A	0.0	0.0	14.8	
Atmospheric pressure, mb	N/A	990	990	990	
Hex, %	N/A	0.67	0.56	0.01	
HydrogenSulphide(H2S),ppm	N/A	-10.00	-10.00	-10.00	
CarbonMonoxide(CO),ppm	N/A	1.00	8.00	3.00	
Water Level (m)					

* Remarks: Gas tap open on inspection.

Notes: Gas levels are % gas and have not been converted to % L.E.L.
Tests carried out with G435 - Infra-red Gas Analyser
Water levels are recorded as depth to top of water from ground level.

Appendix 5
Gas Monitoring Boreholes



Historic Landfill Gas Monitoring Form

Facility Name: Churchtown **EPA REF: SS-02465**	**Facility Address:** Churchtown Newcastle West	
	Date of Sampling: 14/03/13	**Time of Sampling:** 12:45
Instrument Used: GFM Series	**Date next full calibaration: 28/03/14** **Last Field calibration: 19/04/13**	
Monitoring Personnel: **Barry Murphy** **Exec Engineer** **Limerick Co Council**	**Weather: Overcast and dry, easterly breeze**	**Barometric Pressure** 1011 steady **Mean Temperature** 9 deg

Results

Sample Station Number	CH_4	CO_2	O_2	Diff. P (mbar)	Flow l/hr	Comments
GW1	24.8	18.2	7.9	Nil	Nil	northern borehole
GW2	38.2	26.2	0.2	Nil	Nil	
GW3	63.6	17.0	0.6	Nil	Nil	southern borehole

General Comment: The differnetial pressure between atmospheric and borehole pressure was measured as nil at all three borehole locations.

Historic Landfill Gas Monitoring Form

Facility Name: Churchtown **EPA REF: SS-02465**	**Facility Address:** Churchtown Newcastle West	
	Date of Sampling: 24/05/13	**Time of Sampling:** 14:00
Instrument Used: GFM Series	**Date next full calibaration:28/03/14** **Last Field calibration:19/04/13**	
Monitoring Personnel: **Barry Murphy** **Exec Engineer** **Limerick Co Council**	**Weather: dry and sunny**	**Barometric Pressure** 1014 steady **Mean Temperature** 12 deg

Results

Sample Station Number	CH_4	CO_2	O_2	Diff. P (mbar)	Flow l/hr	Comments
GW1	35.7	23.0	1.3	Nil	Nil	northern borehole
GW2	4.3	4.2	15.9	Nil	Nil	
GW3	72.8	0.4	16.4	Nil	Nil	southern borehole

General Comment: The differnetial pressure between atmospheric and borehole pressure was measured as nil at all three borehole locations. The methane concentrations at GW3 are very high.

Historic Landfill Gas Monitoring Form

Facility Name: Churchtown **EPA REF: SS-02465**	**Facility Address:** Churchtown Newcastle West	
	Date of Sampling: 04/06/13	**Time of Sampling:** 14:30
Instrument Used: GFM Series	**Date next full calibaration:28/03/14** **Last Field calibration: 19/04/13**	
Monitoring Personnel: **Barry Murphy** **Exec Engineer** **Limerick Co Council**	**Weather:** Warm, dry and sunny	**Barometric Pressure** 1027 falling **Mean Temperature** 20 deg

Results

Sample Station Number	CH_4	CO_2	O_2	Diff. P	Flow	Comments
GW1	26.4	9.3	3.6	Nil	Nil	northern borehole
GW2	3.2	6.6	12.9	Nil	Nil	
GW3	10.3	3.6	16.6	Nil	Nil	southern borehole

General Comment: The differnetial pressure between atmospheric and borehole pressure was measured as nil at all three borehole locations. The methane concentrations at GW3 are very high.

Historic Landfill Gas Monitoring Form

Facility Name: Churchtown **EPA REF: SS-02465**	**Facility Address:** Churchtown Newcastle West	
	Date of Sampling: 25/06/13	**Time of Sampling:** 14:30
Instrument Used: GFM Series	**Date next full calibaration: 28/03/14** **Last Field calibration: 19/04/13**	
Monitoring Personnel: **Barry Murphy** **Exec Engineer** **Limerick Co Council**	**Weather:** Dry, SW wind	**Barometric Pressure** 1030 rising **Mean Temperature** 15 deg

Results

Sample Station Number	CH_4	CO_2	O_2	Diff. P	Flow	Comments
GW1	30.4	22.9	2.1	Nil	Nil	northern borehole
GW2	1.1	2.5	18.2	Nil	Nil	
GW3	0.0	19.6	1.6	Nil	Nil	southern borehole

General Comment: The differnetial pressure between atmospheric and borehole pressure was measured as nil at all three borehole locations.
The methane concentrations at GW3 are very high.
The methane concentrations at GW3 are very high at 73%, the previous reading taken on 25 June showed 0% methane.

Historic Landfill Gas Monitoring Form

Facility Name: Churchtown	**Facility Address:** Churchtown Newcastle West	
EPA REF: SS-02465	**Date of Sampling:** 05/07/13	**Time of Sampling:** 12:00
Instrument Used: GFM Series	**Date next full calibaration: 28/03/14**	
	Last Field calibration: 19/04/13	
Monitoring Personnel: **Barry Murphy** **Exec Engineer** **Limerick Co Council**	**Weather: Warm dry and overcast**	**Barometric Pressure** 1028 falling
		Mean Temperature 19 deg

Results

Sample Station Number	CH_4	CO_2	O_2	Diff. P	Flow	Comments
GW1	36.5	23.6	0.0	Nil	Nil	northern borehole
GW2	4.1	5.7	14.6	Nil	Nil	
GW3	73.6	16.9	0.6	Nil	Nil	southern borehole

General Comment: The differnetial pressure between atmospheric and borehole pressure was measured as nil at all three borehole locations.

Historic Landfill Gas Monitoring Form

Facility Name: Churchtown **EPA REF: SS-02465**	**Facility Address:** Churchtown Newcastle West	
	Date of Sampling: 29/08/13	**Time of Sampling:** 16:00
Instrument Used: GFM Series	**Date next full calibaration:** **Last Field calibration:**	
Monitoring Personnel: **Barry Murphy** **Exec Engineer** **Limerick Co Council**	**Weather: Warm dry and overcast**	**Barometric Pressure** 1013 falling **Mean Temperature** 17 deg

Results

Sample Station Number	CH_4	CO_2	O_2	Diff. P (Pa)	Flow (l/hr)	Comments
GW1	27.6	20.9	3.5	Nil	Nil	northern borehole
GW2	2.8	4.7	15.5	Nil	Nil	
GW3	71.4	23.3	0.0	10	2.8	southern borehole

General Comment: A very small gas flow was detected in GW3. This is the first time that a differential pressure and flow was recorded at any borehole since measurements began.

Historic Landfill Gas Monitoring Form

Facility Name: Churchtown **EPA REF: SS-02465**	**Facility Address:** Churchtown Newcastle West	
	Date of Sampling: 27/09/13	**Time of Sampling:** 14:15
Instrument Used: GFM Series	**Date next full calibaration:28/03/14** **Last Field calibration:19/04/13**	
Monitoring Personnel: **Barry Murphy** **Exec Engineer** **Limerick Co Council**	**Weather: Warm dry and sunny**	**Barometric Pressure** **1004** **Mean Temperature** 20 deg

Results

Sample Station Number	CH_4	CO_2	O_2	Diff. P (Pa)	Flow (l/hr)	Comments
GW1	32.9	23.0	2.0	0	0	northern borehole
GW2	3.1	5.2	15.0	0	0	
GW3	71.0	23.0	0.0	17	3.5	southern borehole

General Comment: A very small gas flow was detected in GW3. This flow was also detected during the previous survey carried out on 29 August 2013.

Historic Landfill Gas Monitoring Form

Facility Name: Churchtown	**Facility Address:** Churchtown Newcastle West	
EPA REF: SS-02465	**Date of Sampling:** 09/08/13	**Time of Sampling:** 15:00
Instrument Used: GFM Series	**Date next full calibaration: 28/03/14**	
	Last Field calibration: 19/04/13	
Monitoring Personnel: **Barry Murphy** **Exec Engineer** **Limerick Co Council**	**Weather: Warm dry and overcast**	**Barometric Pressure** 1015 steady
		Mean Temperature 18 deg

Results

Sample Station Number	CH_4	CO_2	O_2	Diff. P	Flow	Comments
GW1	28.6	21.2	3.3	Nil	Nil	northern borehole
GW2	4.2	5.7	14.8	Nil	Nil	
GW3	4.0	2.0	19.1	Nil	Nil	southern borehole

General Comment: The differnetial pressure between atmospheric and borehole pressure was measured as nil at all three borehole locations.

Appendix 6
VOC Surface Emissions and Flux Box Survey Boreholes

ODOUR & ENVIRONMENTAL CONSULTANTS

Unit 32 De Granville Court, Dublin Rd, Trim, Co. Meath

Tel: +353 46 9437922
Mobile: +353 86 8550401
E-mail: info@odourireland.com
www.odourireland.com

TOTAL VOLATILE ORGANIC COMPOUND SURFACE EMISSIONS AND FLUX BOX SURVEY FROM CHURCHTOWN LANDFILL SITE, NEWCASTLE WEST, CO. LIMERICK

PERFORMED BY ODOUR MONITORING IRELAND ON BEHALF OF TES

PREPARED BY:	Dr. John Casey & Dr. Brian Sheridan
ATTENTION:	Mr. John Dillon
DATE:	10/06/2013
REPORT NUMBER:	2013759
DOCUMENT VERSION:	Document Ver. 001
REVIEWERS:	

TABLE OF CONTENTS

DOCUMENT AMENDMENT RECORD

Client: *TES*

Title: Total volatile organic compound surface emissions and flux box survey from Churchtown Landfill Site, Newcastle West, Co. Limerick

Project Number: 2013759			**Document Reference:**		
2013759(1)	Document for review	JWC	BAS	JWC	10/06/2013
Revision	**Purpose/Description**	**Originated**	**Checked**	**Authorised**	**Date**

Executive Summary

Tobin Consulting engineers commissioned Odour Monitoring Ireland to perform a survey of landfill gas surface emissions and a flux box survey at Churchtown Landfill Site, Newcastle West, Co. Limerick.

During the surface emissions survey, the following tasks were performed on site:

- Identify geographically on a site map, the locations of landfill gas surface emissions,
- Perform a landfill gas flux box survey at the site.
- Provide a close out meeting with the management and to notify verbally of the main conclusions of the survey.

Four zones of surface emissions were identified within the landfill site that exceeded recommended levels. These zones are identified geographically on a site map contained in *Appendix I* of this report.

Flux chamber monitoring was carried out at eight distinct locations within the landfill footprint. The survey suggested that locations 1, 2 and 8 were in excess of the recommended guideline surface emission flux levels for such locations.

Gas flow measurements were attempted on GW1, GW2 and GW3. However no adequate measurement was recorded due to absence of sufficient differential pressure.

1. Introduction

1.1. Background to work

Odour Monitoring Ireland were commissioned by the Tobin Consulting Engineers to perform an Volatile organic compound (VOC) walkover surface emissions survey at Churchtown Landfill Site in order to ascertain location of significant VOC emission points located within the site. In addition a flux box survey was carried out at the site. This report presents a summary of the findings of the site visit to Churchtown Landfill Site, Newcastle West, Co. Limerick. The report is based on the scientific measurements and observations made during a site visit conducted on the 08th May 2013.

1.2. Tasks completed during inspection

The following tasks were completed during the inspection:

- Capping source monitoring using continuous kinematic VOC/GPS system to detect areas of potential landfill gas release/flux;
- Geo-referencing of detected landfill gas flux areas and plotting upon basemap for visual interpretation and remediation;
- Assessment of landfill gas flux utilising flux chamber method;
- Discussion meeting with management once survey was complete in order to communicate main surface emissions areas.

2. Techniques used

This section describes the techniques used throughout the study.

2.1. "Odour hog" monitoring within the landfill

The "Odour hog" VOC analyser is a portable, intrinsically safe, survey VOC dual monitor, which provides fast and accurate readings of organic and inorganic vapours. A Photo ionisation detector (PID) uses an Ultraviolet (UV) light source (*photo*) to ionise a gas sample and detect its concentration. Ionisation occurs when a molecule absorbs the high energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC molecules are ionised. A PID does not respond to methane. A FID is similar to a flame thermocouple detector, but measures the ions from the flame instead of the heat generated. The FID detects the methane fraction, which provides greater sensitivity in terms of methane leakage detection but not necessarily odour hence why the PID data is also interpreted. Both sensors were calibrated using NPL gravimetrically filled certified reference material isobutylene and methane.

Using the continuous kinematic "Odour hog" with integrated GPS, the capping of the landfill was surveyed for potential leakage areas. Those areas identified were geo-referenced and highlighted for remediation. This technique is useful for comparison in leakage area within the same landfill site on different surveys but is not for cross comparison of VOC leakage between different landfills due to a number of factors including, mass flow of VOC on the day of measurement, relative odourous nature of the detected compounds within individual facilities, etc.

In terms of surface emissions and based on best international guidance, efforts should be made to attain surface emissions <100 ppmv from open surfaces and <500 ppmv around features such as vertical wells, leachate collection sumps, leachate slope risers and other protrusions into the waste body (Casey et al., 2008).

2.2 Flux chamber survey and sample location selection

A dynamic surface emissions isolation flux chamber designed and operated in accordance with Environment Agency guidelines (LFTGN07) was utilised to perform flux emission measurements for volatile organic compounds at pre-selected locations within the landfill. A total of 8 locations were chosen. The flux chamber is used to isolate a known surface area for emissions measurement. The flux chamber was operated in accordance LFTGN 07 guidelines. The concentration of the exhaust gas was measured at the chamber outlet for VOCs with a FID.

The number of flux survey locations were chosen by the client Tobin Consulting Engineers. The locations of the flux measurements were chosen by Odour Monitoring Ireland.

2.3. Meteorological conditions

Table 2.1 illustrates the predominant meteorological conditions throughout the monitoring exercise. The meteorological conditions were characterised for the day of monitoring and were as follows:

Table 2.1. Meteorological conditions during surface emissions survey.

08/05/2013	
Average wind speed 4 m s^{-1}	Wind direction South Westerly
Dry weather	Start of survey - 1006 mbar Finish of survey – 1006 mbar
Temperature 12 ^{O}C	Capping moisture content high

During the surface emissions survey and gas field survey, wind direction deviated from the south. Capping moisture content was high, moisture has the effect of causing retention of landfill gas in the landfill cover material. Water has the effect of increasing the gas retention in the cell because cover material porosity is decreased and therefore the surface emissions of gas are restricted somewhat from the landfill cap.

3. Results

3.1. Volatile organic compound surface emissions locations identified within Churchtown landfill site

Figure 6.1 and Table 3.1 illustrates the results obtained for the capping surface emissions survey. A total of 5 individual surface emissions zones were identified. Each surface emissions zone is discussed separately.

Table 3.1. Capping VOC surface emissions locations results with source identities correlating with *Figure 6.1 (see Appendix I)*.

Location	Easting (m)	Northing (m)	Max VOC conc. (ppm)	Identification and Mitigation	Recommended limits
C1	127385	134567	62	Discrete Feature: Open area and Vertical Borehole	<500 ppmv (Not over trigger level)
C2	127496	134645	684	Discrete Feature: Vertical Borehole (GW1). Only at the top of the borehole.	<500 ppmv
C3	127535	134618	129	Discrete Location: Area in field beside Sheehan's	<100 ppmv
C4	127534	134583	634	Discrete Location: Area in McCoy's garden.	<100 ppmv
C5	127517	134540	4,406	Discrete Feature: Vertical Borehole (GW3). Only at the top of the borehole.	<500 ppmv

Five sources of landfill gas surface emissions were identified within the landfill (*see Figures 6.1 and Table 3.1*). The area surveyed is identified on *Figure 7.2*. Surface emissions locations C1 to C5 are landfill gas surface emissions from open areas within and in the vicinity of the landfill footprint.

3.2. Flux chamber survey results

The results of the flux chamber monitoring with FID carried out at 8 individual monitoring locations is presented in *Table 3.2*. The visual location of each monitoring location is presented in *Figure 7.1*.

Table 3.2. Flux chamber monitoring results for Churchtown landfill.

Location identity	Source specific surface emissions conc. max (ppmv)	X grid coordinate (m)	Y grid coordinate (m)	Area of flux (m^2)	Flux value ($mg/m^2/s$)	Guideline limit values for similar zones (LFTGN 07)	Compliance (Yes/No)
1	34	127534	134576	0.015	0.07	<0.0010	No
2	634	127533	134586	0.015	12.94	<0.0010	No
3	0.5	127486	134574	0.015	0.0006	<0.0010	Yes
4	0.5	127417	134573	0.015	0.0008	<0.0010	Yes
5	0.4	127416	134630	0.015	0.0008	<0.0010	Yes
6	0.44	127484	134645	0.015	0.0009	<0.0010	Yes
7	0.5	127498	134616	0.015	0.0008	<0.0010	Yes
8	120	127536	134618	0.015	0.13	<0.0010	No

As can be observed in *Table 3.2*, the flux of Total VOC's as methane was monitored at eight locations. The Total VOC's as methane flux from the permanently capped area at locations 3 to 7 were below the recommended flux limit of 0.0010 mg/m^2/s. Locations 1 ,2 and 8 (*See Figure 7.1 and Table 3.2*) were in excess of the recommended surface flux limit of 0.0010 mg/m^2/s.

Gas flow measurements were attempted on GW1, GW2 and GW3. However no adequate measurement was recorded due to absence of sufficient differential pressure.

3.3. Close out meeting

Following completion of the surface emissions and flux box survey, the surface emissions team and landfill management team discussed all aspects and general conclusions of the survey.

4. Conclusions

The surface emissions contour map generated from the kinematic Volatile organic compound (VOC) survey illustrated 5 separate surface areas of landfill gas surface emissions within the site. A number of key issues requiring immediate attention were also identified from the survey of the landfill gas management system.

The main conclusions of the survey included the following:

1. Five sources of landfill gas surface emissions were identified within the landfill (*see Figures 6.1 and Table 3.1*). Surface emissions at four of the locations were over the recommended trigger levels.

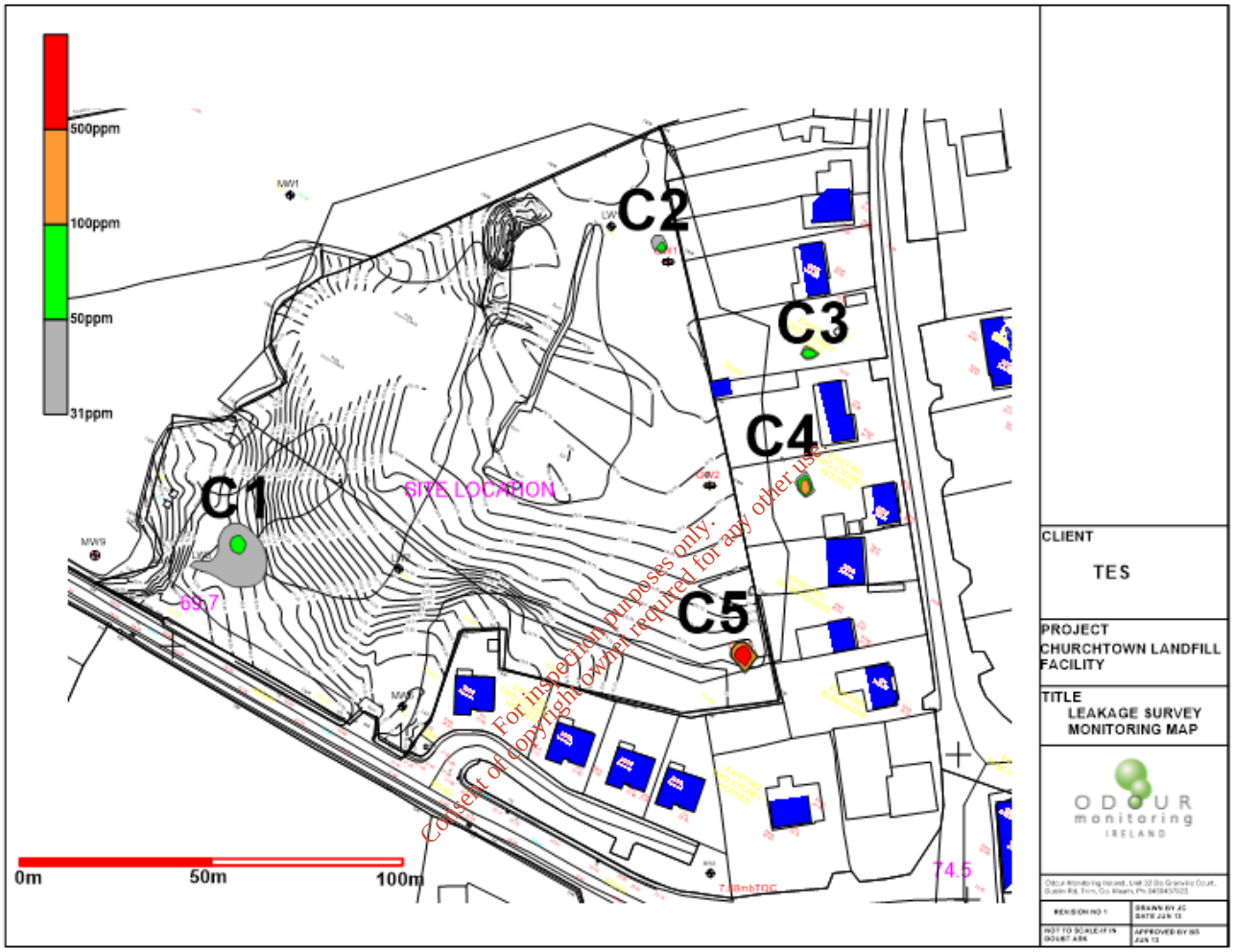
2. Flux chamber monitoring was carried out at 8 distinct locations within the landfill footprint. The survey suggested that locations 1, 2 and 8 were in excess of the recommended guideline surface emission flux levels for such locations.

5. References

1. Casey, J.W., Sheridan, B.A., Henry, M., Reynolds, K., (2008). Effective tools for managing odours from landfill facilities. International Conference on Environmental Odour Monitoring and Control**,** Rome, Italy**,** July 6-8, 2008**.**
2. LFTGN07. “Guidance on Monitoring landfill gas surface emissions" LFTGN 07, Environment Agency 2004.

6. *Appendix I* - Volatile organic compound surface emissions contour maps.

Figure 6.1. Landfill gas surface emissions monitoring within the landfill site (colour scale area indicating TVOC gas colour scale).



7. *Appendix II* – Flux chamber monitoring locations

Figure 7.1. Flux chamber monitoring locations in Churchtown landfill site.

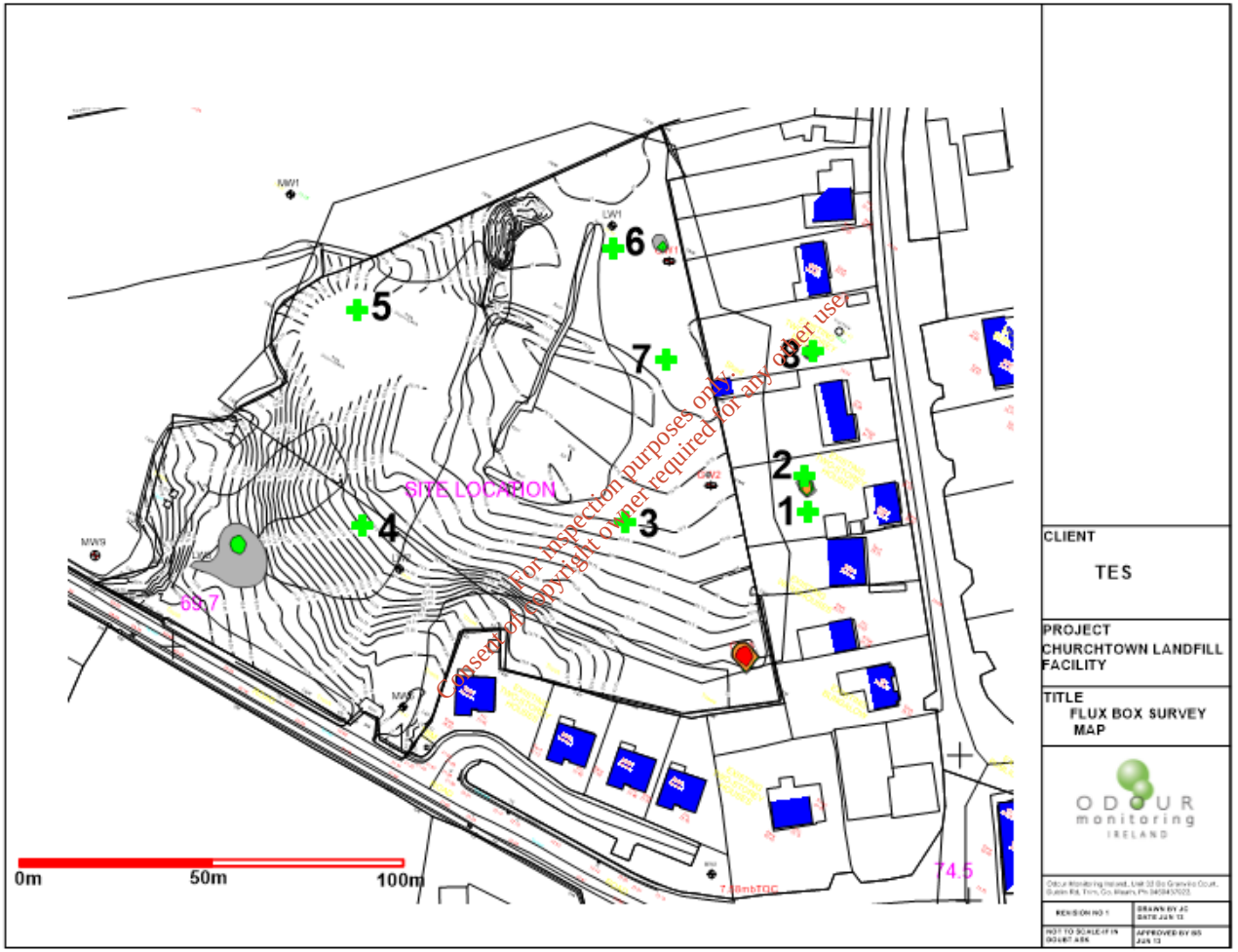
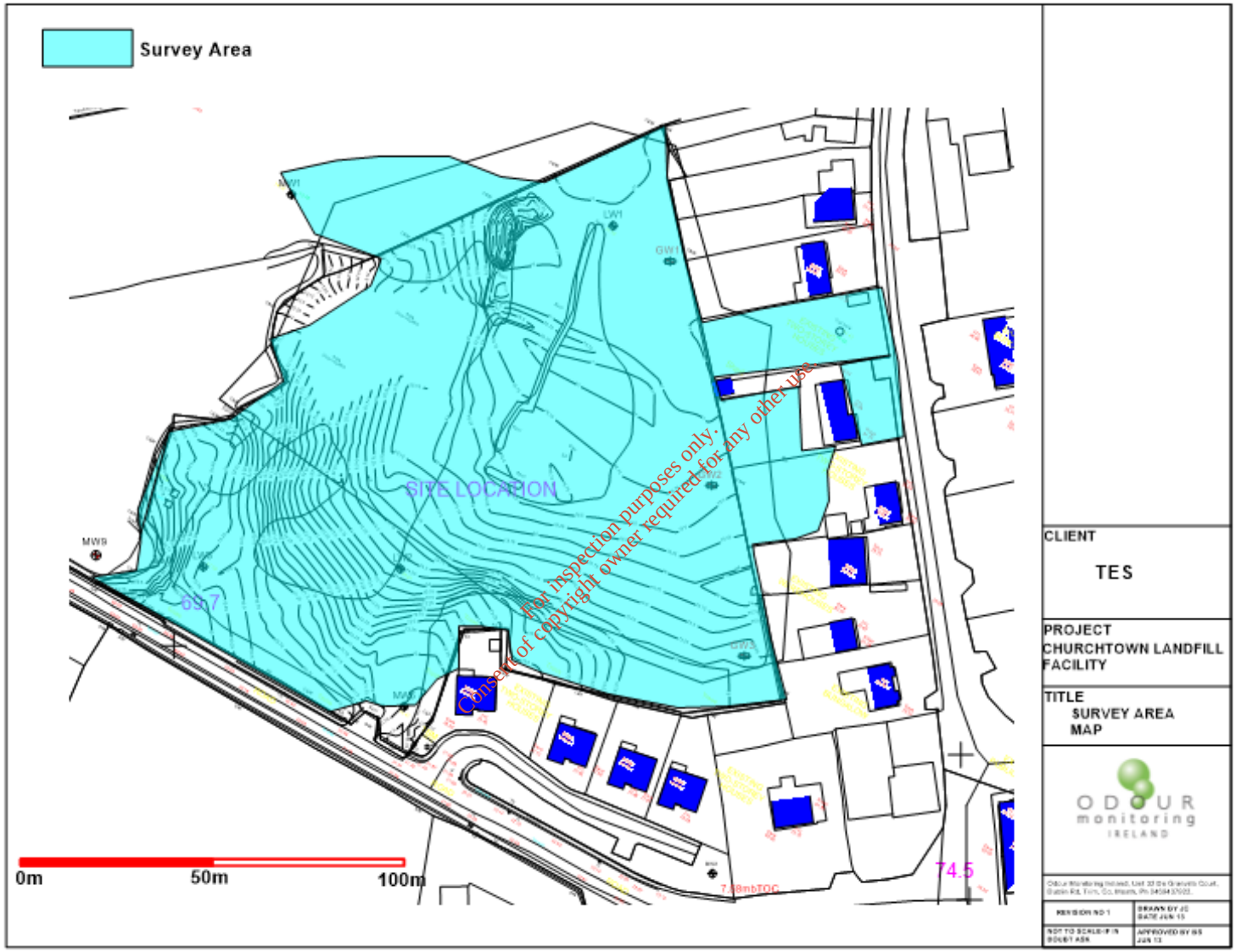


Figure 7.2. Area surveyed at the Churchtown landfill site.



Appendix 7

VOC Monitoring Adjacent to Old Landfill Site

The Tecpro Building,
Clonshaugh Business & Technology Park,
Dublin 17, Ireland.

T: + 353 1 847 4220
F: + 353 1 847 4257
E: info@awnconsulting.com
W: www.awnconsulting.com

VOC MONITORING ADJACENT TO AN OLD LANDFILL SITE IN NEWCASTLE WEST, CO. LIMERICK

Technical Report Prepared For

John Dillon,
Tobin Consulting Engineers,
Block 10-4,
Blanchardstown Corporate Park,
Dublin 15.

Technical Report Prepared By

Sean McMahon BSc. MSc.

Our Reference

SM/13/6663AR01

Date Of Issue

26 July 2013

Cork Office
Unit 5, ATS Building,
Carrigaline Industrial Estate,
Carrigaline, Co. Cork.
T: +353 21 438 7400
F: +353 21 483 4606

AWN Consulting Limited
Registered in Ireland No. 319812
Directors: F Callaghan, C Dilworth,
T Donnelly, E Porter
Associate Director: D Kelly

Document History

Document Reference		Original Issue Date	
13_6663AR01		26/07/13	
Revision Level	Revision Date	Description	Sections Affected

Record of Approval

Details	Written by	Approved by
Signature		
Name	Sean McMahon	Dr. Edward Porter
Title	Environmental Consultant	Director
Date	26/07/13	26/07/13

EXECUTIVE SUMMARY

AWN Consulting was commissioned by John Dillon of Tobin Consulting Engineers to carry out volatile organic compounds (VOCs) monitoring at five locations adjacent to an old landfill in Newcastle West, Co. Limerick. Active monitoring over a 2 hour period was carried out at each location and passive monitoring over a 30 day period was carried out at three of the five locations.

Council Directive 2008/50/EC has set a benzene ambient air quality standard of 5 μg/m^3 as an annual mean. Benzene concentrations over the 30 day sampling period were found to exceed this annual mean ambient air quality standard at Location 1 and Location 2. The concentration of benzene at Location 1 was 60 μg/m^3 which is 1200% of the ambient mean air quality standard. The concentration of benzene at Location 2 was 5.9 μg/m^3 which 118% of the ambient mean air quality standard. Extended monitoring over a longer period would be required in order to determine compliance with the annual mean air quality standard for benzene at both Location 1 and Location 2.

With regards to all other VOCs assessed and all other sampling locations, measured levels of VOCs were below the respective Environmental Assessment Levels over both the short-term and long-term sampling periods.

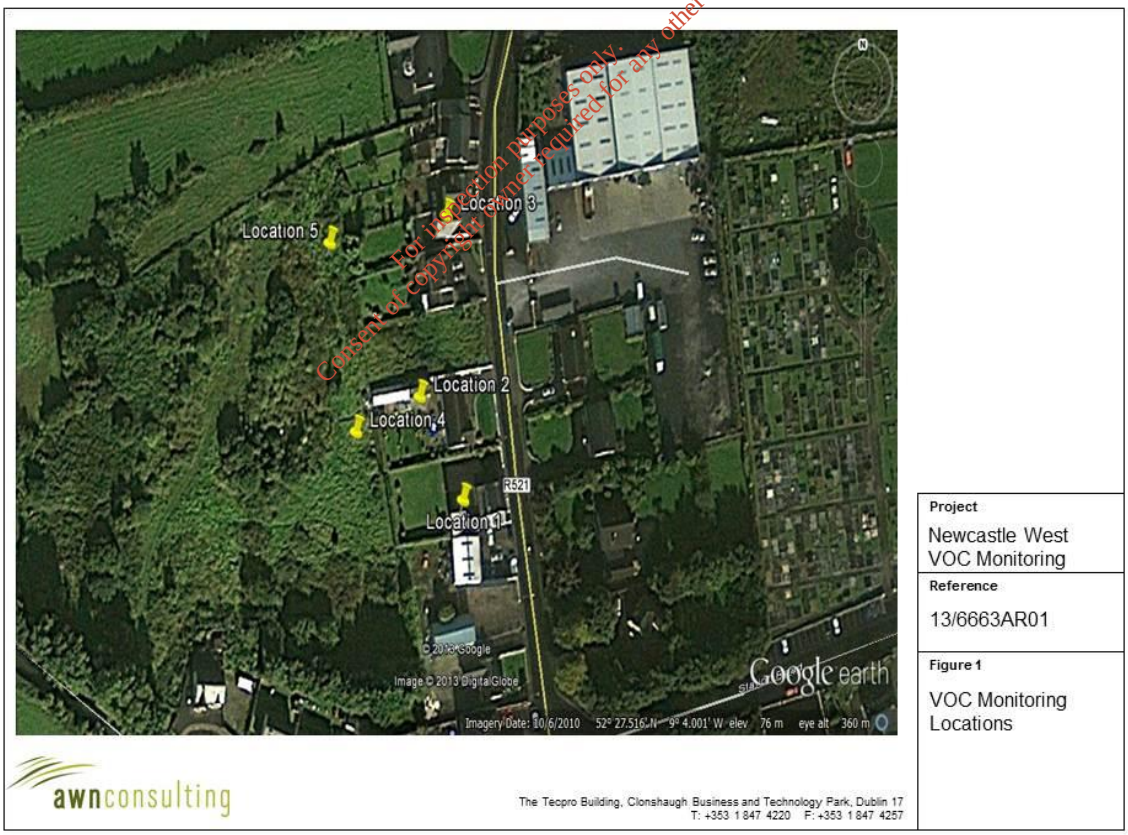
CONTENTS

1.0 INTRODUCTION

AWN Consulting were commissioned by John Dillon of Tobin Consulting Engineers to carry out VOC monitoring at five locations adjacent to an old landfill site in Newcastle West, Co. Limerick. Active monitoring over a 2 hour period was carried out at each location and passive monitoring over a 30 day period was carried out at three of the locations. Active monitoring was carried out on the 04/06/13 and passive monitoring was conducted between 04/06/13 – 04/07/13.

2.0 SAMPLING DETAILS

A survey for VOCs was carried out over a 30-day period at three locations adjacent to the old landfill site (locations 1-3), each of these locations were on residential property. Active monitoring was conducted over a two-hour period from approximately 1pm to 3pm at locations 1 -3. Passive monitoring was also undertaken at locations 1 – 3 and at two additional locations (locations 4 - 5) which were adjacent to two gas wells on the old landfill site. A map of the monitoring locations is shown in Figure 1. Details of the monitoring locations is outlined in Table 1.



Sampling Location	Details
Location 1	Garage on property of Paddy McCoy
Location 2	Garage on property of Gerry Sheehan
Location 3	Foinavon House
Location 4	Gas Well 1 (GW01)
Location 5	Gas Well 2 (GW02)

Table 1 Details of Monitoring Locations

3.0 MONITORING METHODOLOGY

3.1 VOCs

Monitoring for VOCs was carried out based on NIOSH Method 2549. Active sampling was carried out over a 2-hour period on 04/06/13 using SKC universal sampling pumps onto anasorb CSC coconut charcoal tubes at five static locations (locations 1 - 5). Sampling was undertaken at approximately 50 ml/min for 120 minutes giving a total volume sampled of 6 litrers which is the maximum volume outlined in NIOSH method 2549 in order to avoid overload of the adsorbent. These charcoal tubes were analysed at a UKAS accredited laboratory (ESG Laboratories, Staffordshire) using gas chromatography / mass spectrometry (GCMS). Passive Sampling was carried out over a 30-day period between 04/06/13 – 04/07/13 using ATD tubes at three static locations (locations 1-3).

Council Directive 2008/50/EC has set a benzene ambient air quality standard of 5 $\mu g/m^3$ as an annual mean to be complied with in the ambient environment.

However, no statutory air quality standards for the individual organic compounds exist in Irish legislation (except benzene). In the absence of statutory standards, it is common practice to reference other suitable authorities such as the World Health Organisation (WHO) or derive an ambient air quality guideline from occupational exposure limits (OEL).

Although the WHO has ambient air quality guidelines for a small range of volatile organic compounds, guidance has been issued by the UK Environment Agency entitled “IPPC Environmental Assessment and Appraisal of BAT” (Environment Agency, 2003) for an extensive range of organic compounds. The guidance outlines the approach for deriving both short-term and long-term environmental assessment levels (EAL). In relation to the long-term (annual) EAL, this can be derived by applying a factor of 100 to the 8-hour OEL. The factor of 100 allows for both the greater period of exposure and the greater sensitivity of the general population. For short-term (1-hour) exposure, the EAL is derived by applying a factor of 10 to the short term exposure limit (STEL). In this case, only the sensitivity of the general population needs be taken into account as there is no need for additional safety factors in terms of the period of exposure. Where STELs are not listed then a value of 3 times the 8-hour time weighted average occupational exposure limit may be used. No occupational exposure standards can be identified for certain compounds.

4.0 RESULTS

4.1 VOCs – Passive Monitoring.

Concentrations of a suite of VOCs measured over a 30-day sampling period at three locations between 04/06/13 – 04/07/13 are shown in Table 2 - 4.

The ESG analytical method used to determine ambient VOC levels in air considered a suite of 62 compounds comprising numerous VOCs, halogenated VOCs, alkanes and alkenes. Appendix 2 contains the ESG Laboratory report presenting the laboratory results for the full suite of VOCs considered during the analytical determination.

The long term environment assessment levels (EALs) for air (for the protection of human health) for each compound detected in the VOC suite, as set by the IPPC Horizontal Guidance Note for Environmental Assessment and Appraisal of BAT, are presented in Tables 2 - 4. The majority of the 62 compounds in the suite were not detected (see Appendix 2). A small number of the detected compounds do not have a corresponding long term EAL and thus have been excluded from the results.

21 of the 62 compounds in the VOC suite were detected at Location 1. 16 of the 21 detected VOCs are presented here as there are no established long term EALs for 5 of the VOCs detected at this location. Excluding benzene, the measured concentrations for these compounds were lower than their associated EALs (as shown in Table 2). Of those compounds detected, individual concentrations reached at most 37% of their limit values (for toulene). However, with regards to benzene, the measured concentration for this compound exceeded the ambient air quality standard for benzene, reaching 1200% of the annual limit value.

16 of the 62 compounds in the VOC suite were detected at Location 2. 13 of the 16 detected VOCs are presented here as there are no established long term EALs for 3 of the VOCs detected at this location. Excluding benzene, the measured concentrations for these compounds were lower than their associated EALs (as shown in Table 3). Of those compounds detected, individual concentrations reached at most 5% of their limit values (for toulene). However, with regards to benzene, the measured concentration for this compound exceeded the ambient air quality standard for benzene, reaching 118% of the annual limit value.

17 of the 62 compounds in the VOC suite were detected at Location 3. 13 of the 17 detected VOCs are presented here as there are no established long term EALs for 4 of the VOCs detected at this location. The measured concentrations for these compounds were lower than their associated EALs (as shown in Table 4). Of those compounds detected, individual concentrations reached at most 1% of their limit values (for toulene).

In summary, the results show that at two locations benzene was measured over a 30 day period at an ambient concentration in excess of the annual mean ambient air quality standard for benzene. This occurred at Location 1 and Location 2 where the levels of benzene reached 1200% and 118% respectively of the ambient air quality standard for benzene. Extended monitoring over a longer period would be required in order to determine compliance with the annual mean air quality standard for benzene at both Location 1 and Location 2.

Parameter	Concentration (µg/m^3)	Long Term EAL (µg/m^3)	Percentage of EAL (%)
Propan-2-ol	3.4	9,990	0.03%
n-Pentane	23.9	30,000	0.08%
n-Hexane	24.5	720	3.4%
n-Heptane	24.9	20,850	0.12%
n-Octane	11.2	14,500	0.08%
n-Nonane	38.5	10,500	0.37%
Dichloromethane	11.4	700	1.6%
Benzene	60.0	5	**1200%**
Toulene	703.6	1,910	36.8%
Ethylbenzene	82.4	4,410	1.9%
m and p-Xylene	406.4	4,410	9.2%
Styrene	4.5	800	0.57%
o-Xylene	150.5	4,410	3.4%
1,3,5-Trimethylbenzene	19.1	1,250	1.5%
1,2,4-Trimethylbenzene	65.2	1,250	5.2%
Naphthalene	4.4	530	0.84%

Table 2 Results of VOC Monitoring at Location 1 (Compounds above detection threshold only).

Parameter	Concentration (µg/m^3)	Long Term EAL (µg/m^3)	Percentage of EAL (%)
Propan-2-ol	2.4	9,990	0.02%
n-Hexane	7.1	720	0.99%
n-Heptane	3.8	20,850	0.02%
n-Octane	2.4	14,500	0.02%
n-Nonane	2.8	10,500	0.03%
Dichloromethane	7.5	700	1.07%
Benzene	5.9	5	**118%**
Toulene	86.9	1,910	4.6%
Ethylbenzene	5.2	4,410	0.12%
m and p-Xylene	27.1	4,410	0.61%
o-Xylene	9.0	4,410	0.2%
1,3,5-Trimethylbenzene	0.8	1,250	0.06%
1,2,4-Trimethylbenzene	2.2	1,250	0.18%

Table 3 Results of VOC Monitoring at Location 2 (Compounds above detection threshold only).

Parameter	Concentration (µg/m^3)	Long Term EAL (µg/m^3)	Percentage of EAL (%)
Propan-2-ol	1.9	9,990	0.02%
n-Hexane	4.3	720	0.6%
n-Heptane	1.0	20,850	0.005%
n-Nonane	2.8	10,500	0.03%
Dichloromethane	5.7	700	0.82%
Toulene	21.3	1,910	1.1%
Ethylbenzene	2.3	4,410	0.05%
m and p-Xylene	11.4	4,410	0.26%
Styrene	0.9	800	0.11%
o-Xylene	4.5	4,410	0.10%
1,3,5-Trimethylbenzene	0.8	1,250	0.06%
1,2,4-Trimethylbenzene	2.6	1,250	0.21%
Naphthalene	1.1	530	0.21%

Table 4 Results of VOC Monitoring at Location 3 (Compounds above detection threshold only).

4.2 VOCs – Active Monitoring

Concentrations of a suite of VOCs measured over a 2-hour sampling period at five locations on the 04/06/13 are shown in Table 5.

The ESG analytical method used to determine ambient VOC and hydrocarbon levels in air aimed to detect the top 20 most abundant analytes present on the tube. Appendix 3 contains the ESG Laboratory report presenting the laboratory results for detection of the top 20 most abundant VOCs present on the charcoal tubes.

The resulting concentrations from each of the sampled locations were all below the limit of detection.

Analytes	Location 1 Front (µg/m^3)	Location 1 Back-up (µg/m^3)
VOCs	<1225	<1225
	Location 2 Front (µg/m^3)	**Location 2 Back-up (µg/m^3)**
VOCs	<758	<758
	Location 3 Front (µg/m^3)	**Location 3 Back-up (µg/m^3)**
VOCs	<801	<801
	Location 4 Front (µg/m^3)	**Location 4 Back-up (µg/m^3)**
VOCs	<833	<833
	Location 5 Front (µg/m^3)	**Location 5 Back-up (µg/m^3)**
VOCs	<817	<817

Table 5 Results of Active VOC Monitoring at 5 locations

5.0 DISCUSSION

Council Directive 2008/50/EC has set a benzene ambient air quality standard of 5 μg/m^3 as an annual mean. Benzene concentrations over the 30 day sampling period were found to exceed this annual mean ambient air quality standard at Location 1 and Location 2. The concentration of benzene at Location 1 was 60 μg/m^3 which is 1200% of the ambient mean air quality standard. The concentration of benzene at Location 2 was 5.9 μg/m^3 which 118% of the ambient mean air quality standard. Extended monitoring over a longer period would be required in order to determine compliance with the annual mean air quality standard for benzene at both Location 1 and Location 2.

Environmental Assessment Levels (EALs) values have been set for a range of VOC compounds in order to provide a basis for ensuring the protection of human health in the ambient environment. With reference to Appendix D of the *IPPC Environmental Assessment and Appraisal of BAT*, the appropriate EAL, where available, has been applied for comparison with measured concentrations.

With regards to all other VOCs assessed and all other sampling locations, measured levels of VOCs were below the respective Environmental Assessment Levels over both the short-term and long-term sampling periods.

6.0 CONCLUSIONS

The concentration of benzene at Locations 1 and 2 was in excess of the annual mean ambient mean air quality standard for benzene. Extended monitoring over a longer period would be required in order to determine compliance with the annual mean air quality standard for benzene at both Location 1 and Location 2.

APPENDIX 1

SAMPLING AND ANALYSIS - METHODS AND DETAILS

A.1.1 Location of Sampling

R521 Churchtown Road,

Newcastle West,

Co. Limerick,

A.1.2 Date of Sampling

4th June 2013 – 4th July 2013

A.1.3 Personnel Present During Sampling

Sean McMahon, AWN Consulting

A.1.4 Personnel Involved in Analysis

Sean McMahon, AWN Consulting

Dr. Edward Porter, AWN Consulting

Environmental Scientifics Group Laboratories, Staffordshire

A.1.5 Instrumentation

SKC Universal Sampling Pumps

Multi-bed Sorbent Tubes

Anasorb CSC Coconut Charcoal Tubes

APPENDIX 2

LABORATORY RESULT SHEET (PASSIVE MONITORING)

Environmental Scientifics Group

ANALYSIS OF ATD TUBES FOR VOCs

Client:	Sean McMahon AWN Consulting The Tecpro Building IDA Business and Technology Park Clonshaugh Dublin 17
Testing Facility:	Environmental Scientifics Group Limited Specialist Chemistry Etwall House Bretby Business Park Ashby Rd Burton-on-Trent DE15 0YZ
Laboratory Reference:	ASC/10885
Customer Reference:	Newcastle West 13/6663
Samples Received:	08 July 2013
Sample Condition:	Good
Analysis Completed:	12 July 2013
Approved by:	M Mullard
Date:	17 JUL 13
Approver's name:	Marya Hubbard
Job Title:	Analyst
Report Date:	17 July 2013

UKAS TESTING 1015

Test Report ASC/10885: Page 1 of 4

Introduction

Three ATD tubes were received for the analysis of VOCs. The samples were received in good condition and stored in a solvent free environment prior to analysis.

Laboratory Reference	Customer Reference	Tube ID	Analysis
ASC/10885.001	Paddy McCoy	Mi013263	VOC Suite
ASC/10885.002	Foinavon	Mi149808	VOC Suite
ASC/10885.003	Shed	Mi001705	VOC Suite

Experimental

Standard preparation and sample measurement was carried out according to UKAS accredited method ASC/SOP/210 Issue 2.
The samples were analysed by thermal desorption-gas chromatography-mass spectrometry on a Markes ATD and an Agilent GC-MS.
Before the samples were ran a calibration was generated for the compounds listed in Table 1. This allowed for positive identification and quantification of these compounds.
Please be aware that values close to the limit of detection (say within an order of magnitude) carry a high uncertainty. The overall uncertainty on those results significantly above the LOD, have been calculated to be ± 25%.
A Quality Control tube with known analyte loading was run with each sequence of samples.

Results

Table 1 shows the results for the amount of VOCs detected on tube (ng) for the samples.
Please note compounds marked with a ~ are not within the scope of our UKAS accreditation. Results which are over calibration range have been marked with a * and should be considered an estimate only. These results are not within the scope of our UKAS accreditation.
Any opinion and interpretation expressed in the report are outside the scope of UKAS accreditation.

1015

ESG Environmental Scientifics Group

Table 1 – Amount of VOCs on tube for samples 001-003 (ng)

Compound	ASC/10885.001	ASC/10885.002	ASC/10885.003
	Mi013263	Mi149808	Mi001705
Ethanol	<10	<10	<10
Acetone	<10	<10	<10
Propan-2-ol	110	61	76
n-Propanol	<10	<10	<10
Ethyl Acetate	<10	<10	<10
n-Butanol	45	44	17
n-Pentane	640	<10	<10
n-Hexane	550	97	160
n-Heptane	480	20	74
n-Octane	190	<10	40
n-Nonane	580	42	43
n-Decane	2000*	54	94
~1,1-Dichloroethene~	<10	<10	<10
Dichloromethane	260	130	170
~Cis-1,2-dichloroethene~	<10	<10	<10
~1,1-Dichloroethane~	<10	<10	<10
Trans-1,2-dichloroethene	<10	<10	<10
~Bromochloromethane~	<10	<10	<10
Chloroform	<10	<10	<10
~2,2-Dichloropropane~	<10	<10	<10
1,2-Dichloroethane	<10	<10	<10
1,1,1-Trichloroethane	<10	<10	<10
~1,1-Dichloropropene~	<10	<10	<10
Benzene	520	<10	51
Carbon Tetrachloride	<10	<10	<10
Dibromomethane	<20	<20	<20
1,2-Dichloropropane	<10	<10	<10
Bromodichloromethane	<10	<10	<10
Trichloroethene	<10	<10	<10
Cis-1,3-dichloropropene	<20	<20	<20
~Trans-1,3-dichloropropene~	<10	<10	<10

~ Indicates compound results not included within UKAS accreditation.
***Results are over calibration and should be considered an estimate. These results are not included within UKAS accreditation.**

UKAS TESTING 1015

ESG Environmental Scientifics Group

Table 1 cont. – Amount of VOCs on tube for samples 001-003 (ng)

Compound	ASC/10885.001	ASC/10885.002	ASC/10885.003
	Mi013263	Mi149808	Mi001705
1,1,2-Trichloroethane	<10	<10	<10
Toluene	7600*	230	940
1,3-Dichloropropane	<10	<10	<10
Dibromochloromethane	<10	<10	<10
1,2-Dibromoethane	<20	<20	<20
Tetrachloroethene	<10	<10	<10
1,1,1,2-Tetrachloroethane	<10	<10	<10
Chlorobenzene	<10	<10	<10
Ethylbenzene	1500*	42	95
m and p-Xylene	5400*	151	360
Styrene	84	17	<10
o-Xylene	2000*	60	120
~1,2,3-Trichloropropane~	<10	<10	<10
Isopropylbenzene	<10	<10	<10
Bromobenzene	<30	<30	<30
2-Chlorotoluene	<10	<10	<10
n-Propylbenzene	220	13	11
4-Chlorotoluene	<10	<10	<10
1,3,5-Trimethylbenzene	410	17	17
tert-butylbenzene	<30	<10	<10
1,2,4-Trimethylbenzene	1400*	56	48
1,3-Dichlorobenzene	<20	<20	<20
1,4-Dichlorobenzene	<20	<20	<20
~sec-Butylbenzene~	44	<10	<10
p-Isopropyltoluene	44	12	<10
1,2-Dichlorobenzene	<20	<20	<20
n-Butylbenzene	<10	<10	<10
~1,2,4-Trichlorobenzene~	<20	<20	<20
Naphthalene	67	17	<10
~1,2,3-Trichlorobenzene~	<20	<20	<20
~Hexachlorobutadiene~	<20	<20	<20

~ Indicates compound results not included within UKAS accreditation.
*** Results are over calibration and should be considered an estimate. These results are not included within UKAS accreditation.**

UKAS TESTING
1015

APPENDIX 3

LABORATORY RESULT SHEET (ACTIVE MONITORING)

Analysis of Charcoal Sorbent Tubes for Volatile Organic Compounds

Customer: Sean McMahon
AWN Consulting
The Tecpro Building
Clonshaugh Business and Technology Park
Dublin 17
Ireland

Testing Facility: Environmental Scientifics Group Limited
Specialist Chemistry
Etwall House
Bretby Business Park
Ashby Road
Burton upon Trent
Staffordshire
DE15 0YZ

Laboratory Reference: ASC/10908

Customer Reference: 13/6663 PO 248

Sample Received: 8th July 2013

Analysis Completed: 14th July 2013

Approved by:

Approver's name: Paul Walker

Job Title: Organic Team Leader

Report Date: 17th July 2013

Test Report: ASC/10908: Page 1 of 3

ESG Environmental Scientifics Group

Introduction

Five charcoal sorbent tubes were received requiring analysis for Volatile Organic Compounds (VOCs).

The tubes were received in good condition and were logged into our system upon receipt.

Samples Received

O/R	Y/R	Sample Description
ASC/10908.001	4504616779	Charcoal Sorbent Tube
ASC/10908.002	4504616776	Charcoal Sorbent Tube
ASC/10908.003	4504616780	Charcoal Sorbent Tube
ASC/10908.004	4504616778	Charcoal Sorbent Tube
ASC/10908.005	4504616774	Charcoal Sorbent Tube

Experimental

The samples were desorbed in Carbon Disulphide (CS_2) and analysed using Gas Chromatography Mass Spectrometry (GC/MS). The top twenty most abundant analytes were tentatively identified by mass spectral data and semi-quantified against the response of the internal standard (Tetradecane). Our detection limit for unknown compounds is in the region of 5ug/ml per analyte.

Results

The results for the samples are detailed in the following tables.

Results

Analytes	ASC/10908.001 4504616779 Front (ug)	ASC/10908.001 4504616779 Back-up (ug)
VOCs	<5	<5

Analytes	ASC/10908.002 4504616776 Front (ug)	ASC/10908.002 4504616776 Back-up (ug)
VOCs	<5	<5

Analytes	ASC/10908.003 4504616780 Front (ug)	ASC/10908.003 4504616780 Back-up (ug)
VOCs	<5	<5

Analytes	ASC/10908.004 4504616778 Front (ug)	ASC/10908.004 4504616778 Back-up (ug)
VOCs	<5	<5

Analytes	ASC/10908.005 4504616774 Front (ug)	ASC/10908.005 4504616774 Back-up (ug)
VOCs	<5	<5

Appendix 8

Environmental Assessment of Receiving Waters

Comhairle Chontae Luimnigh

Environmental Assessment of receiving waters

For

Churchtown Landfill Site

Newcastle West

Co. Limerick

EPA Ref: S22-02465

27th May 2013

Prepared by:

Robert Imbusch

Environment Section

Limerick County Council

Introduction

Limerick County Council intends to apply for a Certification of Authorisation for the historic landfill site located at Churchtown, Newcastlewest, County Limerick in accordance with *Waste Management (Certification of Historic Unlicensed Waste Disposal and Recovery Activity) Regulations 2008 (S.I. No. 524 of 2008)*, As part of this process, Limerick Co Council is required to carry out an environmental assessment of the site in accordance with the EPA **Code of Practice: *Environmental Risk Assessment for Unregulated Waste Disposal Sites.***

There are no direct surface water discharges from the landfill site to any surrounding watercourses. However, in December 2012, Tobin Consulting Engineers carried out a hydrogeological assessment at the site which indicated that the direction of groundwater flow at the site is from the north-east to the south-west in the direction of the River Dooally. The report identified a possible hydraulic groundwater linkage between the site and the River Dooally and that contaminated groundwater from under the landfill site could migrate to the Dooally River.

This report details the results of ecological monitoring carried out on the Dooally River in the vicinity of Churchtown landfill.

The Dooally River is the nearest significant watercourse to the Churchtown landfill site - see Figures 1 and 2. The Dooally River is a tributary of the Deel River and flows 0.5 km to the west of the landfill in a southerly direction. The closest surface water feature to the site is a small drainage channel which flows from a point 450 metres south of the landfill site to the Dooally River, a distance of approximately 500 metres.

Methodology

Since 1971, the EPA has used the Quality Rating System (Q-values) to assess water quality in Irish rivers, primarily on the basis of macroinvertebrate communities in riffle areas of rivers and streams. In the presence of pollution, characteristic and well-documented changes are induced in the flora and fauna of rivers and streams. Particularly well documented are the changes brought about by organic pollution in the macroinvertebrate community, i.e. the immature aquatic stages of aerial insects (mayflies, stoneflies etc.) together with Crustacea (e.g. shrimps), Mollusca (e.g. snails and bivalves), Oligochaeta (worms) and Hirudinea

(leeches). For the purposes of the EPA assessment procedure benthic macroinvertebrates have been divided into five Indicator Groups.
Relationships between water quality and macroinvertebrate community structure are usually described by means of a numerical scale of values. The EPA scheme of Biotic Indices or Quality (Q) Values and its relationship to WFD status is set out in the table.

Q-Value	WFD Status
5,4-5	High
4	Good
3-4	Moderate
3, 2-3	Poor
2, 1-2, 1	Bad

Freshwater benthic macroinvertebrates were sampled at four sampling sites. The location of the sampling sites in relation to the landfill is shown in Figure 2 (see also photos 1-4). Standard two-minute kick samples were taken at each sampling site. The macroinvertebrates were identified on site and the taxa or groups present and relative abundance are shown in Table 1. The invertebrates are grouped according to their sensitivity to organic pollution. A Q-rating and SSRS Score was assigned to each sample (see Table 1). These are biotic indices used to assess the level of pollution and water quality status.

Q-sampling provides a reliable and consistent indication of water quality in rivers and small streams but may be less suitable for small drainage channels which have low, intermittent flows.

Survey Results

Dooally River Main Channel: The main Dooally River was sampled at three locations-see location map. Site 1 is located upstream of the landfill site, sites 2 and 3 are located upstream and downstream of the confluence of the drainage channel with the main channel. All three samples were indicative of a Q4 or unpolluted status. There was no deterioration in water quality up and downstream of the landfill site.

Drainage Channel The landfill drain was sampled close to its conference with the Dooally River at Site 4 (Photo 4). Only pollution tolerant invertebrates were present in the sample giving a Q1-2 rating (see Table 1). There were no other indications of the presence of organic

pollution, such as algae or sewage fungus which would normally be associated with a sample of invertebrates such as this. Dissolved oxygen here was 75% saturation at the time of sampling but the results of the kick sample suggest that more anoxic conditions are typically prevalent. The drain was sampled in 2012 as part of the Tier 2 Investigation and found not to have elevated parameters of contamination associated with landfill leachate – see Appendix 1 for results.

The drainage channel is not considered a suitable habitat for kick sampling due to its low and intermittent flows.

Recommendations

Further biological and chemical sampling on the drainage channel should be incorporated into the ongoing monitoring programme for Churchtown landfill site.

Conclusion

There is no reduction in biological water quality in the main channel of the Dooally River downstream of Churchtown historic landfill site.

_____

Robert Imbusch
Assistant Scientist
Environment Section
Limerick Co Council.

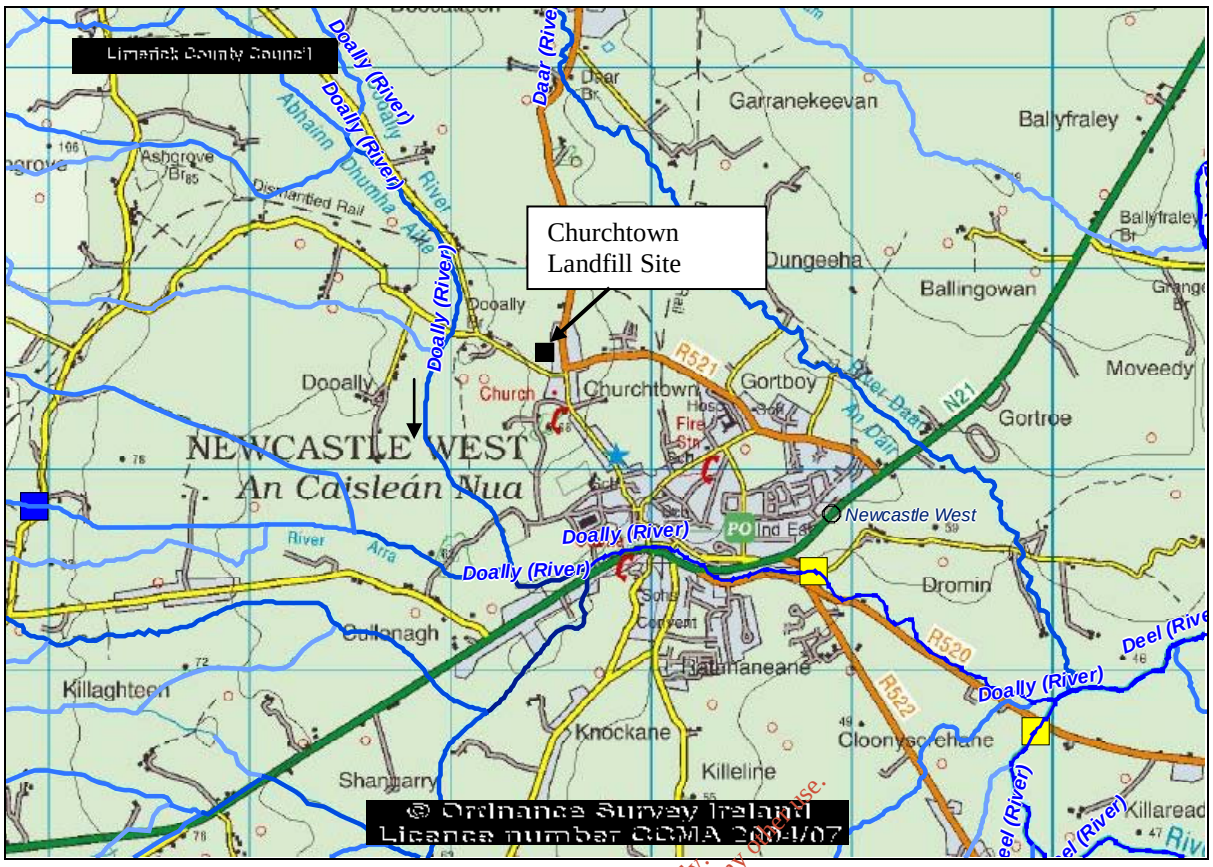


Figure 1. Map of the Churchtown Landfill Site at Newcastlewest, County Limerick.

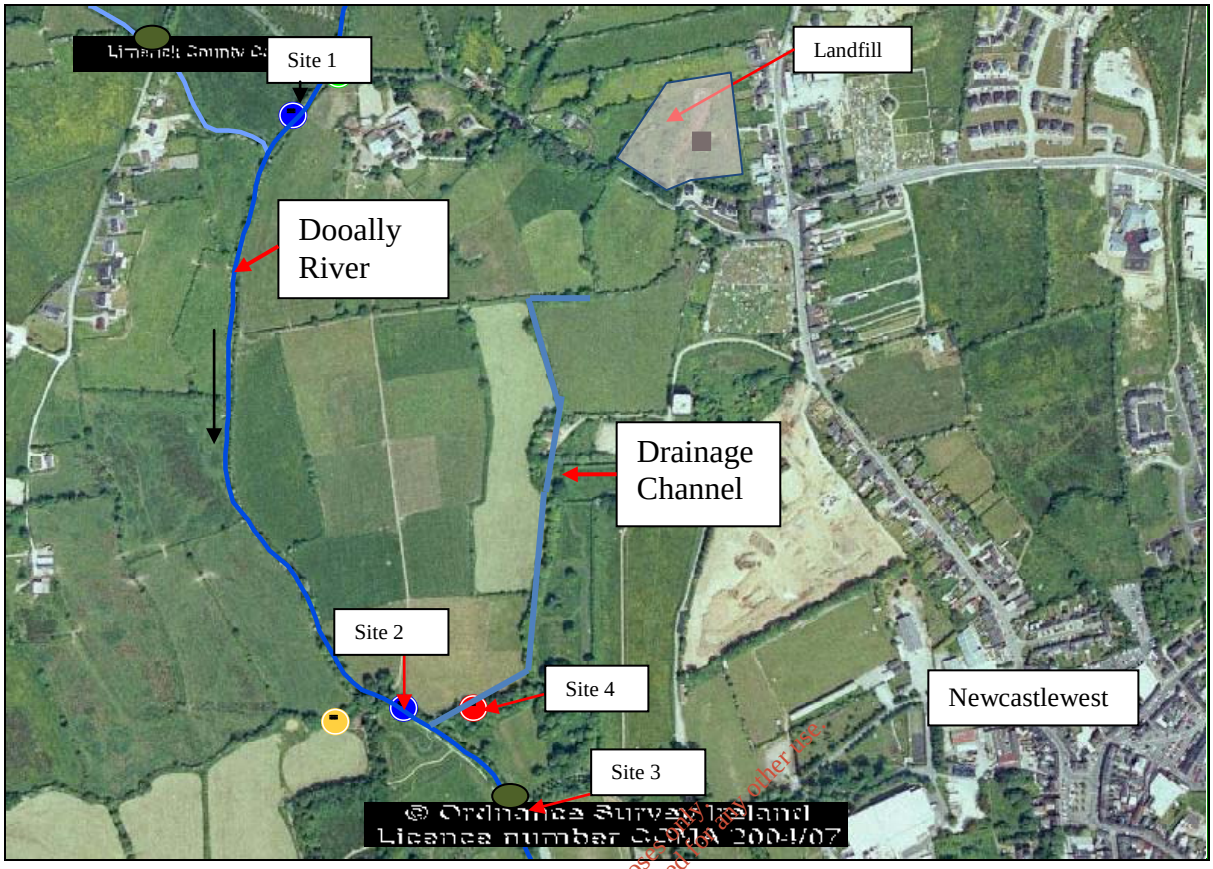


Figure 2. Map of the Churchtown landfill and River Sampling Sites (1-5).

Table 1: Relative Abundance of Macroinvertebrates

	Site 1 Dooally Bridge	Site 2 Dooally River, upstream of drainage channel	Site 3 Dooally River, downstream of drainage channel	Site 4 Landfill Drain
Grid Coordinates	X 126959 Y 134620	X 127095 Y 133884	X 127234 Y 133739	X 127182 Y 133884
Group A (Sensitive)				
Ecdyonurus	Few	Common	Common	
Rhitrogena	Numerous	Numerous	Numerous	
Taenioptergiidae			Few	
Leuctra	Few	Few	Few	
Isoperla		Few		
Group B (Less Sensitive)				
Limnephilidae	Common	Few	Few	
Glossosomatidae	Common			
Goeridae	Common	Few	Few	
Sericostoma	Few	Few	Few	
Ephemerellidae	Common	Common	Common	
Group C (Tolerant)				
Polycentropus	Few	Few		
Hydracarina	Common	Few	Common	
Ancylus	Few	Few	Few	
Potamopyrgus				Few
Gammarus	Dominant	Numerous	Numerous	
Baetis	Dominant	Numerous	Numerous	
Rhyacophila		Few		
Hydropsyche	Few		Few	
Simulidae		Common	Common	
Chironomidae			Common	
Coleoptera	Common	Common	Common	
Limnea	Few			
Group D (Very Tolerant)				
Hirudinea	Few	Few		Few
Asellus	Few			
Sphearriidae				Few
Group E (Most Tolerant)				
Tubificidae	Few	Few	Few	Few
Chironomus				Common
Others:				
Dicranota		Few		
Q-Rating	**4** Unpolluted	**4** Unpolluted	**4** Unpolluted	**1-2** Seriously Polluted
SSRS	8.8 (Probably not at risk)	10.4 (Probably not at Risk)	10.4 (Probably not at Risk)	3.2 (At Risk)

Note: Relative abundance of Benthic Macro-invertebrates sampled in the vicinity of Churchtown Landfill site at Newcastlewest, Co. Limerick. (Few 1-5; Common 6-20; Numerous 21-50; Dominant 51-75).

Photo 1. Sampling Site 1 - Doaally Bridge, Dooally River, Newcastlewest, Co. Limerick.

Photo 2. Site 2 – Dooally River, 30 meters upstream of landfill drain.

Photo 3. Site 3 – Dooally River, 150 meters downstream of landfill drain, Newcastlewest, County Limerick.

Photo 4. Site 4 – Landfill Drain at Churchtown, Newcastlewest, County Limerick.

Appendix 9
Tier 2 Sampling Results

1. **BHP Report**
2. **Alcontrol Laboratories**
3. **City Analysts**

BHP/CEM/23/A

Analysing
Testing
Consulting
Calibrating

TECHNICAL REPORT

Client:

Limerick County Council
Aras an Chontae
Dooradoyle
Co. Limerick

BHP Ref No.: 102502-503-539(2)
Order No.:
Date Received: 14th&16th February 2012
Date Completed: 05th March 2012
Test Specification: Nil

FAO: Finbarr Murphy

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Item: Survey, sampling and analysis of Waste material from Landfill in Churchtown, Newcastle West, Co. Limerick

For and on behalf of BHP Ltd.

Joan McCarthy

Joan McCarthy
Date Issued: 05th April 2012
Supplement to report No. N/A

Content

1.0 EXECUTIVE SUMMARY

An on-site investigation of a historical landfill site located in Churchtown, Newcastle West, Co. Limerick, was conducted on the 14th and 16th February 2012, by BHP Personnel.

This investigation forms part of a Tier 2 Preliminary Investigation carried out carried out in accordance with the *EPA Code of Practice: Environmental Risk Assessment for Unregulated Waste Disposal Sites.*

A walk over survey revealed that the site was closed and covered in bush and scrub. The intrusive investigation that followed showed varying concentrations of municipal waste (EWC 20 03 01) landfilled. On exposure there was a notable decomposition odour indicating that the waste within the landfill is continuing to undergo anaerobic decomposition. Further investigation would be required to determine risks posed to the neighbouring residential area.

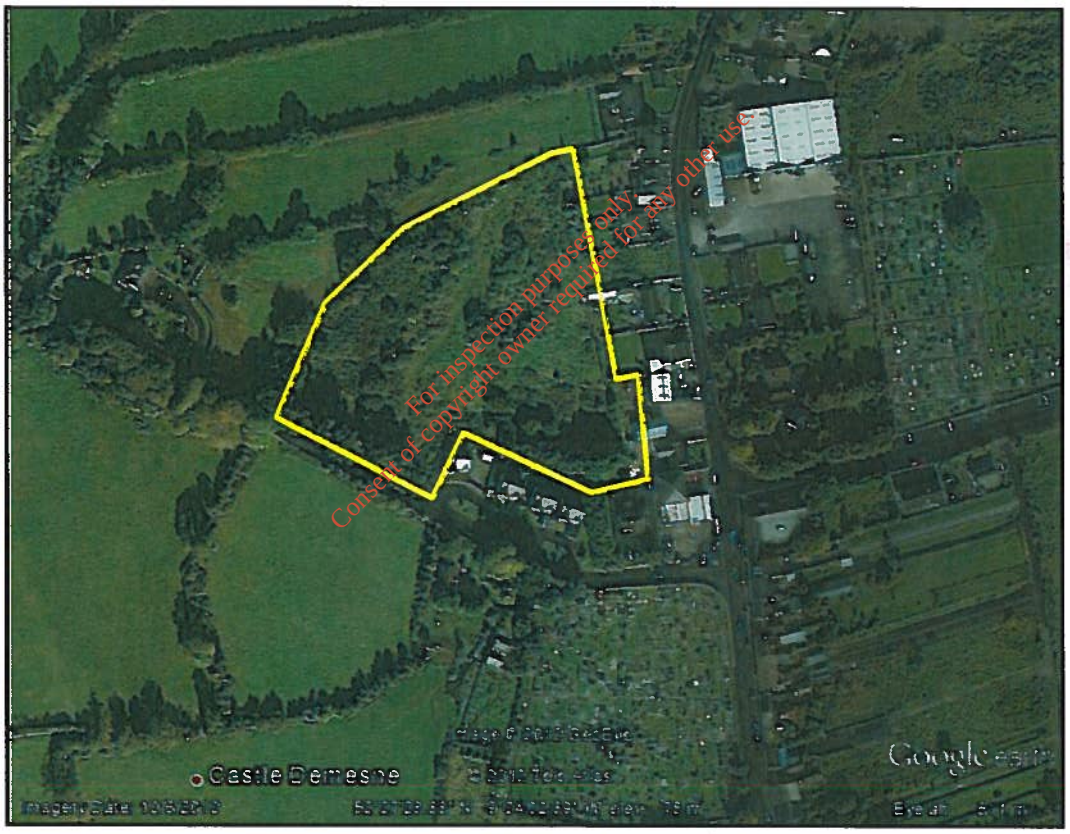
Leachate and landfill gas migration pathways and possible receptors need to be established to quantify risk posed to residents and the environment.

2.0 INTRODUCTION

2.1 Background

At the request of Finbarr Murphy of Limerick County Council, BHP conducted sampling and analysis of waste material from a landfill site located at Churchtown, Newcastle West, Co. Limerick. The purpose of the sampling and analysis program was to classify buried material on site and determine its approximate extent.

The location of the landfill was in the immediate vicinity of a residential area. An aerial photograph of the area under investigation is presented below.



Photograph of the Churchtown site, Newcastle West, showing landfill area under investigation

2.2 Legislation

Arising from the Waste Framework Directive (75/442/EEC), and in particular the European Court of Justice Decision C-494/01, all historic unregulated waste disposal sites need to be identified, and the risks posed to the environment and human health needs to be assessed. The most relevant legislation for historic landfill sites include Waste Management (Certification of Historic Unlicenced Waste Disposal and Recovery Activity) Regulations and the Waste Management Acts 1996 to 2011. Under the Waste Management Acts 1996 to 2011, local authorities were given responsibility for the completion of an inventory and risk assessment of all non-licensed closed landfills. The EPA have produced a Code of Practice to assist Local Authorities in this regard.

Remediation measures chosen for each closed landfill must ensure that there is no significant pollutant linkage remaining after remediation has taken place. Remediation may involve the removal of landfilled material to an appropriate waste disposal facility.

Current legislation governing waste disposal and waste acceptance criteria is set down in Council Decision 2003/33/EC ('*on establishing criteria and procedures for the acceptance of waste at Landfill)*'. This decision lays down uniform waste classification and acceptance procedures according to Annex II to Directive 1999/31/EC on the landfill of waste (the 'Landfill Directive').

3.0 SAMPLING

3.1 Site Survey Observations

Photographs of the historical landfill investigated are presented below:

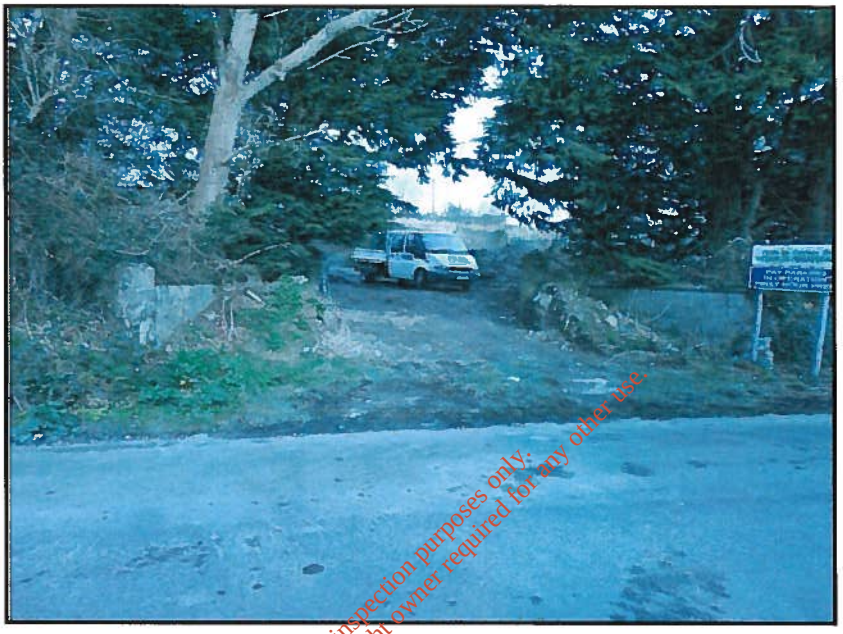


Image of the site entrance

Image A of Site

Image B of Site

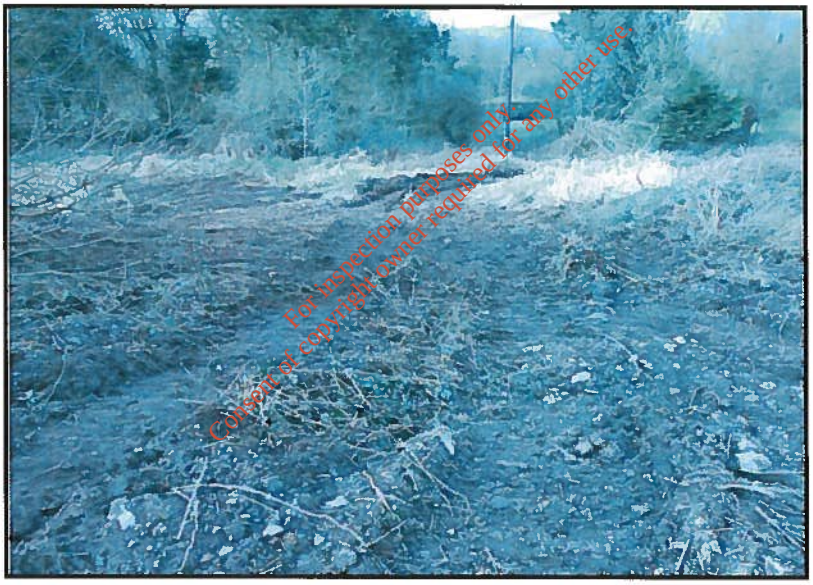


Image C of Site

Image D of Site

Trial holes were excavated at 4 locations across the area under investigation, typically down to approximately 6 metres in depth.

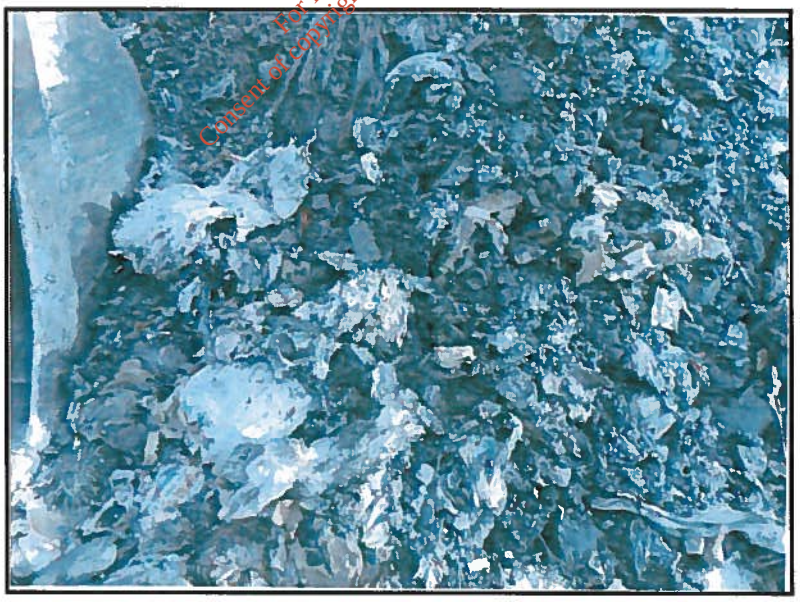
Sampling notes taken during trial hole excavation are given as follows:

Trial Hole	Depth	Description	EWC #
TH2	Surface to 0.50m	Clean Aggregate	-
	0.50m to 6m	Mixed municipal waste	20-03-01
TH3	Surface to 2.5m	Mixed municipal waste	20-03-01
	2.5m to 3.0m	Aggregate	-
	3.0m to 6.0m	Mixed municipal waste	-
TH4	Surface to 0.3m	Topsoil	-
	0.3m to 0.5m	Aggregate	-
	0.5m to 6m	Mixed municipal waste	20-03-01
TH5	0.3m to 4m	Mixed municipal waste	20-03-01
	4m to 5m	Clay	-

Photographs of the excavated material are presented on the following page. This is a typical example of what was encountered for each of the trial holes excavated. The

evidence of municipal waste (EWC 20 03 01) is clear from these photographs. Further photographs taken during trial pit excavation are presented in Appendix 2.

Photograph of TH2 showing municipal waste from just under the surface to the bottom of the pit.



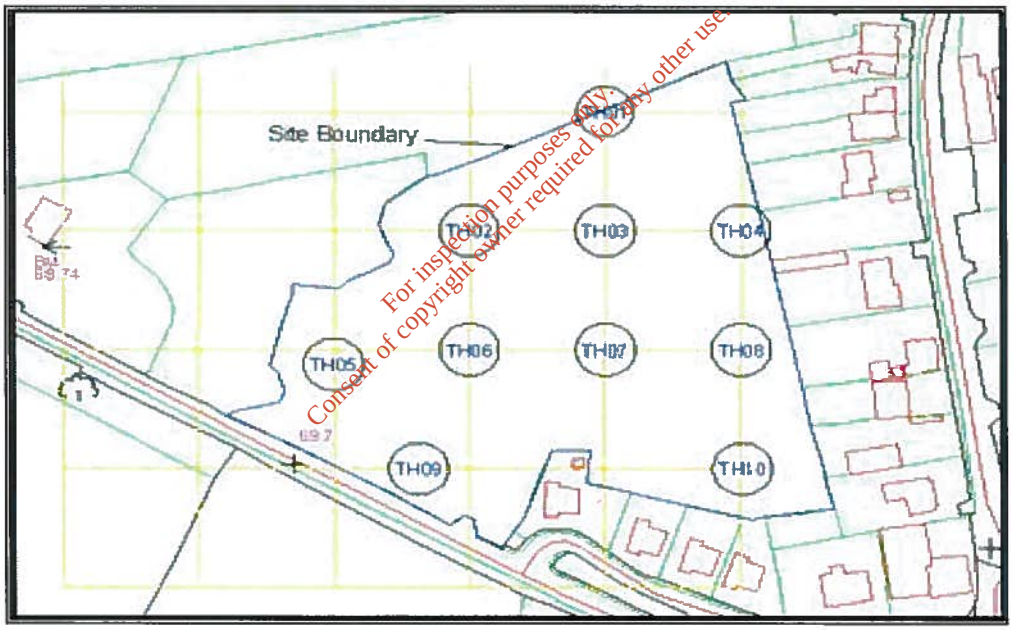
Photograph of excavated material from TH3

3.2 Sampling and Testing of Material

Sampling was carried out on the 14th and 16th February 2012 by Aidan Daffy of BHP Laboratories with the aid of personnel provided by Limerick County Council. Three soil samples and four water samples were taken from the four trial holes excavated. A water sample was also taken from a nearby stream.

The following map illustrates the approximate location of trial holes excavated on site.

The following soil samples were taken from the trial holes and tested against the acceptance criteria for waste at inert landfills.



Sketch of Area surveyed indicating Trial Hole Locations.

TH2 Composite sample taken from a depths 0.5m-6.0m

TH3 Composite sample taken from a depths 0.5m-6.0m

TH4 Composite sample taken from a depths 0.5m-6.0m

TH5 Soil sample taken at between 4.0m and 5.0m

Water ingress into Trial Hole TH2 was noted at a depth of 4.40m. A water sample was taken fromTH2 at this depth.
Water ingress into Trial Hole TH3 was noted at a depth of 2.50m. A water sample was taken fromTH3 at this depth.
Water ingress into Trial Hole TH4 was noted at a depth of 3.80m. A water sample was taken fromTH4 at this depth.
Water ingress into Trial Hole TH5 was noted at a depth of 1.80m. A water sample was taken fromTH5 at this depth.

The soil samples were analysed to determine whether they met acceptance criteria for inert landfills as set down in Council Decision 2003/33/EC.

The water sample was tested to the requirements of SI No. 12/2001 (Water Quality Dangerous Substances Regulations 2001.

4.0 ANALYTICAL RESULTS (SEE APPENDIX 1)

Comprehensive analysis results are presented in Appendix 1. A summary of Analytical Results is presented below.

- Material excavated from all trial holes contains a mixture of soil, aggregate and municipal waste of varying composition.
- The municipal waste is categorised as mixed municipal waste, EWC 20 03 01, according to the European Waste Catalogue and as such is acceptable at landfills for non-hazardous waste according to Council Decision 2003/33/EC Section 2.2.1.
- Leaching limit values for soils taken from all trial holes were within waste acceptance criteria for inert landfills as set down in Council Decision 2003/33/EC (Section 2.1.2.1) due to elevated dissolved organic carbon. Thus was expected due to the presence of paper and cardboard in the samples.
- Total content of organic parameters for soils taken from all trial holes were within waste acceptance criteria for inert landfills as set down in Council Decision 2003/33/EC (Section 2.1.2.2) with the exception of total organic carbon. This was expected due to the presence of paper and cardboard in the samples.
- Dangerous substance concentrations in the water sample meet the standards set down in SI No. 12/2001 'Water Quality (Dangerous Substances) Regulations, 2001.

The material can be classified as non-hazardous in accordance with 2003/33/EU.

5.0 INTERPRETATION

Council Decision of 19 December 2002 *'on establishing criteria and procedures for the acceptance of waste at Landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC'* sets out criteria for the acceptance of waste at landfills. The Acceptance criteria for Inert Landfills and Non-Hazardous Landfills are outlined in Section 2.1 and 2.2 respectively. All material observed and tested can be classified as either Municipal Waste (EWC 20 03 01) or Soil Stone Waste (EWC 17 05 04). As such the material meets waste acceptance criteria as set down in Council Decision 2003/33/EC for **Landfills for Non-Hazardous Waste**.

6.0 CONCLUSIONS

Intrusive site investigations revealed the presence of municipal waste at varying concentrations across the landfill area examined. There is no evidence of lining at this site, the capping layer is of very poor quality.

The waste body is largely decomposed with odour detected in two trial holes. No gas was detected using the gas monitor.

There is no evidence of measures taken to isolate the effects of landfill material, leachate or landfill gas from the surrounding environment.

7.0 RECOMMENDATIONS

Determine the hydrological flow from the site to identify potential receptors and the risks posed by the leachate run-off. Determine the composition of leachate, ground water and surface water in the vicinity of the landfill to assess leachate impact on the environment. The site has been assessed adequately. Additional monitoring and analysis is at the discretion of the client.

Determine the potential migration pathways for landfill gases and the possible receptors due to these pathways. Regular monitoring of landfill gas levels in the possible receptors, to reduce risk from landfill gas migration.

APPENDIX 1

ANALYTICAL RESULTS

APPENDIX 2

QUALITY CONTROL

The Chemical and Environmental Monitoring laboratory (CEM) operates a rigorous approach to quality assurance. The central elements of the quality control system are outlined.

1.1 Chain of Custody and Client Instruction

Every sample received at BHP laboratories is inspected by the laboratory manager Pat O'Sullivan or by site manager Paul O' Sullivan.

A client instruction is required to start analysis.

All samples are then given a unique BHP reference number before storage between 0 and 4°C.

1.2 Training and Competence

All analysts conducting work at BHP are fully trained. Training involves demonstration of accuracy and precision of analysis. All analysts are subject to periodic reviews in their training. All training is fully documented and retrievable.

1.3 Validation

BHP procedures are subjected to a rigorous validation which includes the following;

- Evaluation of instrument detection limits and limits of detection.
- Evaluation of operator characteristics including bias, precision and uncertainty of measurement.
- Demonstration of Linearity.
- Evaluation of the standard error on the mean and evaluation of any systematic biases.
- Evaluation of total uncertainty and uncertainty budgets.
- Evaluation of the uncertainty in measurement at a regulatory limit.
- Demonstration of repeatability.
- Evaluation of Matrix effects.

1.4 Quality Control (Skewhart) Charts

Analysis in the CEM laboratory is monitored using control charts. Each analysis will have at least 3 charts monitoring;

- Certified Reference Material recovery
- Precision of analysis
- Accuracy of analysis

Batches of analyses are rejected if any of the control charts indicate a loss in control.

1.5 Inter-laboratory Testing

The CEM laboratory are members of the W.R.C Aquacheck Scheme. The Laboratory also participates in the Environmental Protection Agency's Intercalibration Programme and is listed on the Agency's Register of Quality Approved Testing Laboratories.

APPENDIX 1

ANALYTICAL RESULTS

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102502.1
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH2 (4.4M)			
Water Level		M	4.40	ISO 5667 - 11
Temperature		°C	11	APHA - 2550 - B
pH		-	6.60	APHA - 4500 - H^+ - B
Conductivity		μScm^{-1}	1942	APHA - 2510 - B
Ammonia (as NH_3-N)		mg/l	64.6	APHA -4500- NH_3-D
Nitrate (as NO_3)		mg/l	1.55	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.1	APHA - 4110 - B
Total Oxidised Nitrogen (as N)		mg/l	0.35	APHA - 4110 - B
BOD		mg/l	11	APHA - 5210 - B
COD		mg/l	158	APHA - 5220 - D
Calcium		mg/l	48.9	APHA - 3120 - B
Magnesium		mg/l	15.6	APHA - 3120 - B
Sodium		mg/l	34.51	APHA - 3120 - B
Potassium		mg/l	32.05	APHA - 3120 - B
Iron		ug/l	560	APHA - 3120 - B
Manganese		ug/l	206	APHA - 3120 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102502.1
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH2 (4.4M)			
Cadmium		ug/l	<0.1	APHA - 3120 - B
Total Chromium		ug/l	<1	APHA - 3120 - B
Copper		ug/l	<1	APHA - 3120 - B
Nickel		ug/l	<1	APHA - 3120 - B
Lead		ug/l	2	APHA - 3120 - B
Zinc		ug/l	12	APHA - 3120 - B
Arsenic		ug/l	<0.9	APHA - 3120 - B
Boron		ug/l	9	APHA - 3120 - B
Mercury		ug/l	<0.2	APHA - 3120 - B
Sulphate		mg/l	6.1	APHA - 4110 - B
Chloride		mg/l	47.8	APHA - 4110 - B
Molybdate Reactive Phosphorus (as P)		mg/l	0.23	APHA - 4500 - P-E
Total Cyanide		mg/l	0.05	APHA - 4500-CN-C
Fluoride		mg/l	0.13	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. O Su

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

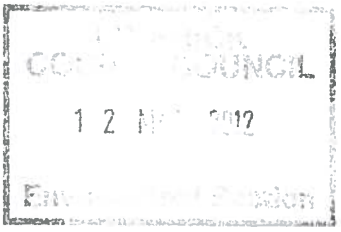
BHP Ref. No.: 102502.1
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH2 (4.4M)			
Atrazine		ug/l	<1	GC-MS
Dichloromethane		ug/l	<1	GC-MS
Simazine		ug/l	<1	GC-MS
Toluene		ug/l	<1	GC-MS
Tributyltin		ug/l	<0.001	GC-MS
Total Xylenes		ug/l	<1	GC-MS

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. O Sullivan
Pat O'Sullivan
Issue Date : 07/03/2012



TEST REPORT

Analysing
Testing
Consulting
Calibrating

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102502.2
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Test	Client Reference	Units	Results	Standard Reference
	TH3 (2.5M)			
Water Level		M	2.50	ISO 5667 - 11
Temperature		°C	11	APHA - 2550 - B
pH		-	6.48	APHA - 4500 - H^+ - B
Conductivity		μScm^{-1}	1667	APHA - 2510 - B
Ammonia (as NH_3-N)		mg/l	75.28	APHA -4500- NH_3-D
Nitrate (as NO_3)		mg/l	0.81	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.1	APHA - 4110 - B
Total Oxidised Nitrogen (as N)		mg/l	0.18	APHA - 4110 - B
BOD		mg/l	9	APHA - 5210 - B
COD		mg/l	437	APHA - 5220 - D
Calcium		mg/l	75.4	APHA - 3120 - B
Magnesium		mg/l	22.49	APHA - 3120 - B
Sodium		mg/l	34.56	APHA - 3120 - B
Potassium		mg/l	21.99	APHA - 3120 - B
Iron		ug/l	453	APHA - 3120 - B
Manganese		ug/l	11	APHA - 3120 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. O Su

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102502.2
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH3 (2.5M)			
Cadmium		ug/l	<0.1	APHA - 3120 - B
Total Chromium		ug/l	<1	APHA - 3120 - B
Copper		ug/l	<1	APHA - 3120 - B
Nickel		ug/l	<1	APHA - 3120 - B
Lead		ug/l	2	APHA - 3120 - B
Zinc		ug/l	12	APHA - 3120 - B
Arsenic		ug/l	<0.9	APHA - 3120 - B
Boron		ug/l	11	APHA - 3120 - B
Mercury		ug/l	<0.2	APHA - 3120 - B
Sulphate		mg/l	19.9	APHA - 4110 - B
Chloride		mg/l	71.7	APHA - 4110 - B
Molybdate Reactive Phosphorus (as P)		mg/l	0.24	APHA - 4500 - P-E
Total Cyanide		mg/l	0.119	APHA - 4500-CN-C
Fluoride		mg/l	<0.05	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. o Sullivan
Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102502.2
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH3 (2.5M)			
Atrazine		ug/l	<1	GC-MS
Dichloromethane		ug/l	<1	GC-MS
Simazine		ug/l	<1	GC-MS
Toluene		ug/l	<1	GC-MS
Tributyltin		ug/l	<0.001	GC-MS
Total Xylenes		ug/l	<1	GC-MS

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. O Sullivan

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102502.3
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH4 (3.8M)			
Water Level		M	3.80	ISO 5667 - 11
Temperature		°C	12.6	APHA - 2550 - B
pH		-	6.40	APHA - 4500 - H^+ - B
Conductivity		μScm^{-1}	1418	APHA - 2510 - B
Ammonia (as NH_3-N)		mg/l	70.73	APHA -4500- NH_3-D
Nitrate (as NO_3)		mg/l	0.9	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.1	APHA - 4110 - B
Total Oxidised Nitrogen (as N)		mg/l	0.2	APHA - 4110 - B
BOD		mg/l	25	APHA - 5210 - B
COD		mg/l	659	APHA - 5220 - D
Calcium		mg/l	82.4	APHA - 3120 - B
Magnesium		mg/l	21.16	APHA - 3120 - B
Sodium		mg/l	36.54	APHA - 3120 - B
Potassium		mg/l	41.87	APHA - 3120 - B
Iron		ug/l	652	APHA - 3120 - B
Manganese		ug/l	24	APHA - 3120 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102502.3
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH4 (3.8M)			
Cadmium		ug/l	<0.1	APHA - 3120 - B
Total Chromium		ug/l	1	APHA - 3120 - B
Copper		ug/l	<1	APHA - 3120 - B
Nickel		ug/l	<1	APHA - 3120 - B
Lead		ug/l	2	APHA - 3120 - B
Zinc		ug/l	13	APHA - 3120 - B
Arsenic		ug/l	<0.9	APHA - 3120 - B
Boron		ug/l	16	APHA - 3120 - B
Mercury		ug/l	<0.2	APHA - 3120 - B
Sulphate		mg/l	5.42	APHA - 4110 - B
Chloride		mg/l	47.5	APHA - 4110 - B
Molybdate Reactive Phosphorus (as P)		mg/l	0.24	APHA - 4500 - P-E
Total Cyanide		mg/l	0.031	APHA - 4500-CN-C
Fluoride		mg/l	<0.05	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102502.3
Order No.:
Date Received: 14/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH4 (3.8M)			
Atrazine		ug/l	<1	GC-MS
Dichloromethane		ug/l	<1	GC-MS
Simazine		ug/l	<1	GC-MS
Toluene		ug/l	<1	GC-MS
Tributyltin		ug/l	<0.001	GC-MS
Total Xylenes		ug/l	<1	GC-MS

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102539.1
Order No.:
Date Received: 16/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Test	Client Reference	Units	Results	Standard Reference
	TH5 (1.8M)			
Water Level		M	1.80	ISO 5667 - 11
Temperature		°C	12.4	APHA - 2550 - B
pH		-	6.76	APHA - 4500 - H^+ - B
Conductivity		μScm^{-1}	681	APHA - 2510 - B
Ammonia (as NH_3-N)		mg/l	63.75	APHA -4500- NH_3-D
Nitrate (as NO_3)		mg/l	2.66	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.1	APHA - 4110 - B
Total Oxidised Nitrogen (as N)		mg/l	0.6	APHA - 4110 - B
BOD		mg/l	28	APHA - 5210 - B
COD		mg/l	84	APHA - 5220 - D
Calcium		mg/l	65.8	APHA - 3120 - B
Magnesium		mg/l	17.86	APHA - 3120 - B
Sodium		mg/l	39.77	APHA - 3120 - B
Potassium		mg/l	44.68	APHA - 3120 - B
Iron		ug/l	893	APHA - 3120 - B
Manganese		ug/l	406	APHA - 3120 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. o Su

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102539.1
Order No.:
Date Received: 16/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	TH5 (1.8M)			
Cadmium		ug/l	<0.1	APHA - 3120 - B
Total Chromium		ug/l	<1	APHA - 3120 - B
Copper		ug/l	<1	APHA - 3120 - B
Nickel		ug/l	<1	APHA - 3120 - B
Lead		ug/l	3	APHA - 3120 - B
Zinc		ug/l	14	APHA - 3120 - B
Arsenic		ug/l	<0.9	APHA - 3120 - B
Boron		ug/l	8	APHA - 3120 - B
Mercury		ug/l	<0.2	APHA - 3120 - B
Sulphate		mg/l	9.63	APHA - 4110 - B
Chloride		mg/l	47.6	APHA - 4110 - B
Molybdate Reactive Phosphorus (as P)		mg/l	0.75	APHA - 4500 - P-E
Total Cyanide		mg/l	0.032	APHA - 4500-CN-C
Fluoride		mg/l	0.14	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

P. O S

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102539.1
Order No.:
Date Received: 16/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Test	Client Reference	Units	Results	Standard Reference
	TH5 (1.8M)			
Atrazine		ug/l	<1	GC-MS
Dichloromethane		ug/l	<1	GC-MS
Simazine		ug/l	<1	GC-MS
Toluene		ug/l	<1	GC-MS
Tributyltin		ug/l	<0.001	GC-MS
Total Xylenes		ug/l	<1	GC-MS

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102539.2
Order No.:
Date Received: 16/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	Leonards Stream			
Water Level		M	n/a	ISO 5667 - 11
Temperature		°C	9.8	APHA - 2550 - B
pH		-	6.68	APHA - 4500 - H^+ - B
Conductivity		μScm^{-1}	429	APHA - 2510 - B
Ammonia (as NH_3-N)		mg/l	0.43	APHA -4500- NH_3-D
Nitrate (as NO_3)		mg/l	0.53	APHA - 4110 - B
Nitrite (as NO_2)		mg/l	<0.1	APHA - 4110 - B
Total Oxidised Nitrogen (as N)		mg/l	0.12	APHA - 4110 - B
BOD		mg/l	3	APHA - 5210 - B
COD		mg/l	44	APHA - 5220 - D
Calcium		mg/l	54.2	APHA - 3120 - B
Magnesium		mg/l	16.83	APHA - 3120 - B
Sodium		mg/l	62.11	APHA - 3120 - B
Potassium		mg/l	34.1	APHA - 3120 - B
Iron		ug/l	<1	APHA - 3120 - B
Manganese		ug/l	759	APHA - 3120 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102539.2
Order No.:
Date Received: 16/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	Leonards Stream			
Cadmium		ug/l	<0.1	APHA - 3120 - B
Total Chromium		ug/l	<1	APHA - 3120 - B
Copper		ug/l	<1	APHA - 3120 - B
Nickel		ug/l	<1	APHA - 3120 - B
Lead		ug/l	3	APHA - 3120 - B
Zinc		ug/l	7	APHA - 3120 - B
Arsenic		ug/l	<0.9	APHA - 3120 - B
Boron		ug/l	12	APHA - 3120 - B
Mercury		ug/l	<0.2	APHA - 3120 - B
Sulphate		mg/l	10.43	APHA - 4110 - B
Chloride		mg/l	51.27	APHA - 4110 - B
Molybdate Reactive Phosphorus (as P)		mg/l	0.15	APHA - 4500 - P-E
Total Cyanide		mg/l	0.015	APHA - 4500-CN-C
Fluoride		mg/l	0.12	APHA - 4110 - B

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 07/03/2012

TEST REPORT

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax + 353 61 455447
E Mail bhpcem2@bhp.ie

Client: Limerick County Council
Aras an Chontae
Dorradoyle
Co.Limerick

FTAO: Finbarr Murphy

BHP Ref. No.: 102539.2
Order No.:
Date Received: 16/02/12
Date Completed: 05/03/12
Test Specification: Nil
Item :See below

Test	Client Reference	Units	Results	Standard Reference
	Leonards Stream			
Atrazine		ug/l	<1	GC-MS
Dichloromethane		ug/l	<1	GC-MS
Simazine		ug/l	<1	GC-MS
Toluene		ug/l	<1	GC-MS
Tributyltin		ug/l	<0.001	GC-MS
Total Xylenes		ug/l	<1	GC-MS

Additional information : All methods are from Standard Methods for the Examination of Water and Wastewater 20th Edition.

For and on behalf of BHP laboratories :

Pat O'Sullivan
Issue Date : 07/03/2012

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 1 of 4) **Description:** L/S = 2 l/kg **Sample: TH2**

Leachate analysis

Parameter	Results (mg/kg dry substance)							Limit values L/S = 2 l/kg mg/kg dry substance	Analysis method / technique
BHP Reference	102503.1						Method Detection Limits		
Product Description	Waste sample								
Arsenic **As**	0.002						0.002	0.1	ICP-MS
Barium **Ba**	0.012						0.01	7	ICP-MS
Cadmium **Cd**	<0.001						0.001	0.03	ICP-MS
Chromium total **Cr**	0.04						0.001	0.2	ICP-MS
Copper **Cu**	0.49						0.001	0.9	ICP-MS
Mercury **Hg**	<0.0002						0.001	0.003	ICP-MS
Molybdenum **Mo**	0.012						0.002	0.3	ICP-MS
Nickel **Ni**	0.18						0.001	0.2	ICP-MS
Lead **Pb**	0.024						0.001	0.2	ICP-MS
Antimony **Sb**	<0.001						0.001	0.02	ICP-MS
Selenium **Se**	0.004						0.002	0.06	ICP-MS
Zinc **Zn**	0.21						0.002	2	ICP-MS
Chloride	18.8						0.1	550	I.C
Fluoride	0.74						0.2	4	I.C
Sulphate	254						0.1	560	I.C
Dissolved Organic Carbon	108						1	240	Photometric
Total Dissolved Solids	378						1	2500	Gravimetric
Phenol Index	0.008						0.001	0.5	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 2 of 4) **Description:** L/S = 10 l/kg **Sample: TH2**

Leachate analysis

Parameter	Results (mg/kg dry substance)							Limit values L/S = 10 l/kg mg/kg dry substance	Analysis method / technique
BHP Reference	102503.1						Method Detection Limits		
Product Description	Waste sample								
Arsenic **As**	<0.001						0.002	0.5	ICP-MS
Barium **Ba**	0.004						0.01	20	ICP-MS
Cadmium **Cd**	0.001						0.001	0.04	ICP-MS
Chromium total **Cr**	0.002						0.001	0.5	ICP-MS
Copper **Cu**	0.027						0.001	2	ICP-MS
Mercury **Hg**	<0.0002						0.001	0.01	ICP-MS
Molybdenum **Mo**	0.001						0.002	0.5	ICP-MS
Nickel **Ni**	0.004						0.001	0.4	ICP-MS
Lead **Pb**	0.011						0.001	0.5	ICP-MS
Antimony **Sb**	<0.001						0.001	0.06	ICP-MS
Selenium **Se**	0.001						0.002	0.1	ICP-MS
Zinc **Zn**	0.014						0.002	4	ICP-MS
Chloride	2.49						0.1	800	I.C
Fluoride	0.16						0.2	10	I.C
Sulphate	24.7						0.1	1000	I.C
Dissolved Organic Carbon	120						1	500	Photometric
Total Dissolved Solids	1012						1	4000	Gravimetric
Phenol Index	0.012						0.001	1	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 3 of 4) **Description:** L/S = 0.1 l/kg C0 (Percolation) **Sample: TH2**

Leachate analysis

Parameter	Results (mg/l)							Limit values L/S = 0.1 l/kg mg/l	Analysis method / technique
BHP Reference	102503.1						Method Detection Limits		
Product Description	Waste sample								
Arsenic **As**	0.002						0.002	0.06	ICP-MS
Barium **Ba**	0.012						0.01	4	ICP-MS
Cadmium **Cd**	0.006						0.001	0.02	ICP-MS
Chromium total **Cr**	0.011						0.001	0.1	ICP-MS
Copper **Cu**	0.096						0.001	0.6	ICP-MS
Mercury **Hg**	<0.002						0.001	0.002	ICP-MS
Molybdenum **Mo**	0.002						0.002	0.2	ICP-MS
Nickel **Ni**	0.027						0.001	0.12	ICP-MS
Lead **Pb**	0.032						0.001	0.15	ICP-MS
Antimony **Sb**	<0.001						0.001	0.1	ICP-MS
Selenium **Se**	0.001						0.002	0.04	ICP-MS
Zinc **Zn**	0.039						0.002	1.2	ICP-MS
Chloride	16.7						0.1	460	I.C
Fluoride	0.52						0.2	2.5	I.C
Sulphate	224.7						0.1	1500	I.C
Dissolved Organic Carbon	510						1	160	Photometric
Total Dissolved Solids								-	Gravimetric
Phenol Index	0.124						0.001	0.3	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 4 of 4) **Description:**_____**Organic Parameters** _____ **Sample: TH2**

Solid analysis

Parameter	**Results (mg/kg)**							**Limit values** mg/kg	**Analysis method / technique**
BHP Reference	102503.1						**Method Detection Limits**		
Product Description	**Waste sample**								
Total Organic Carbon	75000						0.1	30000	Photometric
BTEX	<0.01						0.01	6	GC-FID
PCBs (7 cogeners)	<0.001						0.001	1	GC-MS
Mineral Oil (C10 to C40)	<0.1						0.1	500	GC-FID
PAHs (16)	<0.005						0.005	-	GC-MS

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 1 of 4) **Description:** L/S = 2 l/kg **Sample: TH3**

Leachate analysis

Parameter	Results (mg/kg dry substance)							Limit values L/S = 2 l/kg mg/kg dry substance	Analysis method / technique
BHP Reference	102503.2						Method Detection Limits		
Product Description	Waste sample								
Arsenic **As**	<0.001						0.002	0.1	ICP-MS
Barium **Ba**	0.024						0.01	7	ICP-MS
Cadmium **Cd**	<0.001						0.001	0.03	ICP-MS
Chromium total **Cr**	0.07						0.001	0.2	ICP-MS
Copper **Cu**	0.31						0.001	0.9	ICP-MS
Mercury **Hg**	<0.0002						0.001	0.003	ICP-MS
Molybdenum **Mo**	0.008						0.002	0.3	ICP-MS
Nickel **Ni**	0.039						0.001	0.2	ICP-MS
Lead **Pb**	0.024						0.001	0.2	ICP-MS
Antimony **Sb**	<0.001						0.001	0.02	ICP-MS
Selenium **Se**	0.002						0.002	0.06	ICP-MS
Zinc **Zn**	0.16						0.002	2	ICP-MS
Chloride	98						0.1	550	I.C
Fluoride	0.68						0.2	4	I.C
Sulphate	101						0.1	560	I.C
Dissolved Organic Carbon	82						1	240	Photometric
Total Dissolved Solids	458						1	2500	Gravimetric
Phenol Index	0.122						0.001	0.5	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 2 of 4) **Description:** L/S = 10 l/kg **Sample: TH3**

Leachate analysis

Parameter	**Results (mg/kg dry substance)**							**Limit values L/S = 10 l/kg mg/kg dry substance**	**Analysis method / technique**
BHP Reference	102503.2						**Method Detection Limits**		
Product Description	**Waste sample**								
Arsenic **As**	<0.001						0.002	0.5	ICP-MS
Barium **Ba**	0.006						0.01	20	ICP-MS
Cadmium **Cd**	0.001						0.001	0.04	ICP-MS
Chromium total **Cr**	0.012						0.001	0.5	ICP-MS
Copper **Cu**	0.18						0.001	2	ICP-MS
Mercury **Hg**	<0.0002						0.001	0.01	ICP-MS
Molybdenum **Mo**	0.002						0.002	0.5	ICP-MS
Nickel **Ni**	0.019						0.001	0.4	ICP-MS
Lead **Pb**	0.009						0.001	0.5	ICP-MS
Antimony **Sb**	<0.001						0.001	0.06	ICP-MS
Selenium **Se**	0.001						0.002	0.1	ICP-MS
Zinc **Zn**	0.024						0.002	4	ICP-MS
Chloride	10.7						0.1	800	I.C
Fluoride	0.15						0.2	10	I.C
Sulphate	127						0.1	1000	I.C
Dissolved Organic Carbon	270						1	500	Photometric
Total Dissolved Solids	880						1	4000	Gravimetric
Phenol Index	0.036						0.001	1	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 3 of 4) **Description:** L/S = 0.1 l/kg C0 (Percolation) **Sample: TH3**

Leachate analysis

Parameter	**Results (mg/l)**							**Limit values L/S = 0.1 l/kg mg/l**	**Analysis method / technique**
BHP Reference	102503.2						**Method Detection Limits**		
Product Description	**Waste sample**								
Arsenic **As**	0.001						0.002	0.06	ICP-MS
Barium **Ba**	0.036						0.01	4	ICP-MS
Cadmium **Cd**	0.006						0.001	0.02	ICP-MS
Chromium total **Cr**	0.018						0.001	0.1	ICP-MS
Copper **Cu**	0.049						0.001	0.6	ICP-MS
Mercury **Hg**	<0.002						0.001	0.002	ICP-MS
Molybdenum **Mo**	0.003						0.002	0.2	ICP-MS
Nickel **Ni**	0.054						0.001	0.12	ICP-MS
Lead **Pb**	0.036						0.001	0.15	ICP-MS
Antimony **Sb**	<0.001						0.001	0.1	ICP-MS
Selenium **Se**	0.001						0.002	0.04	ICP-MS
Zinc **Zn**	0.022						0.002	1.2	ICP-MS
Chloride	231						0.1	460	I.C
Fluoride	0.25						0.2	2.5	I.C
Sulphate	459						0.1	1500	I.C
Dissolved Organic Carbon	670						1	160	Photometric
Total Dissolved Solids								-	Gravimetric
Phenol Index	0.212						0.001	0.3	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 4 of 4) **Description:** Organic Parameters **Sample: TH3**

Solid analysis

Parameter	Results (mg/kg)							Limit values mg/kg	Analysis method / technique
BHP Reference	102503.1						Method Detection Limits		
Product Description	Waste sample								
Total Organic Carbon	92500						0.1	30000	Photometric
BTEX	<0.01						0.01	6	GC-FID
PCBs (7 cogeners)	<0.001						0.001	1	GC-MS
Mineral Oil (C10 to C40)	<0.1						0.1	500	GC-FID
PAHs (16)	<0.005						0.005	-	GC-MS

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 1 of 4) **Description:** L/S = 2 l/kg **Sample: TH4**

Leachate analysis

Parameter	Results (mg/kg dry substance)							Limit values L/S = 2 l/kg mg/kg dry substance	Analysis method / technique
BHP Reference	102503.3						Method Detection Limits		
Product Description	Waste sample								
Arsenic **As**	<0.001						0.002	0.1	ICP-MS
Barium **Ba**	0.036						0.01	7	ICP-MS
Cadmium **Cd**	<0.001						0.001	0.03	ICP-MS
Chromium total **Cr**	0.019						0.001	0.2	ICP-MS
Copper **Cu**	0.3						0.001	0.9	ICP-MS
Mercury **Hg**	<0.0002						0.001	0.003	ICP-MS
Molybdenum **Mo**	0.012						0.002	0.3	ICP-MS
Nickel **Ni**	0.043						0.001	0.2	ICP-MS
Lead **Pb**	0.021						0.001	0.2	ICP-MS
Antimony **Sb**	<0.001						0.001	0.02	ICP-MS
Selenium **Se**	0.001						0.002	0.06	ICP-MS
Zinc **Zn**	0.11						0.002	2	ICP-MS
Chloride	80						0.1	550	I.C
Fluoride	0.62						0.2	4	I.C
Sulphate	208						0.1	560	I.C
Dissolved Organic Carbon	360						1	240	Photometric
Total Dissolved Solids	1010						1	2500	Gravimetric
Phenol Index	0.245						0.001	0.5	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 2 of 4) **Description:** L/S = 10 l/kg **Sample: TH4**

Leachate analysis

Parameter	**Results (mg/kg dry substance)**							**Limit values L/S = 10 l/kg mg/kg dry substance**	**Analysis method / technique**
BHP Reference	102503.3						**Method Detection Limits**		
Product Description	**Waste sample**								
Arsenic **As**	<0.001						0.002	0.5	ICP-MS
Barium **Ba**	0.014						0.01	20	ICP-MS
Cadmium **Cd**	0.011						0.001	0.04	ICP-MS
Chromium total **Cr**	0.008						0.001	0.5	ICP-MS
Copper **Cu**	0.21						0.001	2	ICP-MS
Mercury **Hg**	<0.0002						0.001	0.01	ICP-MS
Molybdenum **Mo**	0.001						0.002	0.5	ICP-MS
Nickel **Ni**	0.008						0.001	0.4	ICP-MS
Lead **Pb**	0.006						0.001	0.5	ICP-MS
Antimony **Sb**	<0.001						0.001	0.06	ICP-MS
Selenium **Se**	0.001						0.002	0.1	ICP-MS
Zinc **Zn**	0.036						0.002	4	ICP-MS
Chloride	19.1						0.1	800	I.C
Fluoride	0.6						0.2	10	I.C
Sulphate	19.1						0.1	1000	I.C
Dissolved Organic Carbon	180						1	500	Photometric
Total Dissolved Solids	568						1	4000	Gravimetric
Phenol Index	0.048						0.001	1	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 3 of 4) **Description:** L/S = 0.1 l/kg C0 (Percolation) **Sample: TH4**

Leachate analysis

Parameter	**Results (mg/l)**							**Limit values L/S = 0.1 l/kg mg/l**	**Analysis method / technique**
BHP Reference	102503.3						**Method Detection Limits**		
Product Description	**Waste sample**								
Arsenic **As**	0.002						0.002	0.06	ICP-MS
Barium **Ba**	0.041						0.01	4	ICP-MS
Cadmium **Cd**	0.007						0.001	0.02	ICP-MS
Chromium total **Cr**	0.032						0.001	0.1	ICP-MS
Copper **Cu**	0.049						0.001	0.6	ICP-MS
Mercury **Hg**	<0.002						0.001	0.002	ICP-MS
Molybdenum **Mo**	0.001						0.002	0.2	ICP-MS
Nickel **Ni**	0.054						0.001	0.12	ICP-MS
Lead **Pb**	0.031						0.001	0.15	ICP-MS
Antimony **Sb**	<0.001						0.001	0.1	ICP-MS
Selenium **Se**	0.001						0.002	0.04	ICP-MS
Zinc **Zn**	0.029						0.002	1.2	ICP-MS
Chloride	229						0.1	460	I.C
Fluoride	0.43						0.2	2.5	I.C
Sulphate	295						0.1	1500	I.C
Dissolved Organic Carbon	610						1	160	Photometric
Total Dissolved Solids								-	Gravimetric
Phenol Index	0.185						0.001	0.3	Photometric

Signed for and on behalf of BHP Laboratories Ltd.

Chemical Analysis Report for Limerick County Council

Client:

Address: Churchtown, Adare, Co.Limerick

(Sheet 4 of 4) **Description:** Organic Parameters **Sample: TH4**

Solid analysis

Parameter	Results (mg/kg)							Limit values mg/kg	Analysis method / technique
BHP Reference	102503.3						Method Detection Limits		
Product Description	Waste sample								
Total Organic Carbon	111200						0.1	30000	Photometric
BTEX	<0.01						0.01	6	GC-FID
PCBs (7 cogeners)	<0.001						0.001	1	GC-MS
Mineral Oil (C10 to C40)	<0.1						0.1	500	GC-FID
PAHs (16)	<0.005						0.005	-	GC-MS

Signed for and on behalf of BHP Laboratories Ltd.

TEST REPORT

Analysing
Testing
Consulting
Calibration

Client: Limerick County Council
County Hall
Dooradoyle
Co. Limerick

F.T.A.O.: Mr. Finbarr Murphy

Client Reference: Newcastlewest Landfill Site.

Sampling Certificate Provided: Yes

BHP Ref. No.: 12/02/199
Order No: 400217322
Date Received: 17/02/2012
Date Tested: 06/03/2012
Test Specification: Customer
Item : Clay Liner material

BHP
New road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax +353 61 455447
E Mail
seamusoconnell@bhp.ie

DETERMINATION OF PLASTICITY INDEX TO BS 1377:PART 2:1990

Client Sample Ref.:	:	Sample 1 1
Sample No.	:	1
Date Sampled	:	Not stated
Source	:	Not stated
Location	:	Base of landfill
% Retained on 425µm test sieve	:	9
Method of Test	:	BS 1377:Part 2:1990:Cl.4 & 5
Sample Preparation	:	Wet Sieving
Deviation from Test Method	:	None

Results:

Liquid Limit	:	40
Plastic Limit	:	19
Plasticity Index	:	21

Remarks:
Nil

Seamus O'Connell
Laboratory Technical manager
For and On Behalf of BHP Laboratories

Issue Date: 8th March 2012

Form No.:BHP/AB/390/A/08/01/02

TEST REPORT

Analysing
Testing
Consulting
Calibration

Client: Limerick County Council
County Hall
Dooradoyle
Co. Limerick

F.T.A.O.: Mr. Finbarr Murphy

BHP Ref. No.: 12/02/199
Order No.: 400217322
Date Received: 17/02/2012
Date Tested: 27/02/2012
Test Specification: Customer spec
Item: Clay Liner material

BHP
New road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax +353 61 455447
E Mail
bhpcon2@bhp.ie

Client Reference: Newcastlewest Landfill Site.

Sampling Certificate Provided: No

BS 1377:Part 2:1990

BHP Reference	12/02/199			CLIENT REFERENCE
Client Reference				
Sieve Size (mm)	% Passing	% Passing	% Passing	
125	100			**Customer Ref** Clay liner
100	100			
75	100			**Source:** Base of Landfill
63	100			
50	100			
37.5	100			
28	97			
20	97			
14	97			
10	96			
6.3	95			
5.0	95			
3.35	95			
2.00	94			
1.18	93			
600µm	92			
425µm	91			
300µm	90			
212µm	90			
150µm	89			
63µm	87			
20µm	78			
6µm	64			
2µm	52			

Remarks:
Details of any material not representative of the bulk sample found : None found.

Seamus O'Connell
Laboratory Technical Manager
For and On Behalf of BHP Laboratories

Issue Date: 8th March 2012

Sampling details where supplied are held on file.

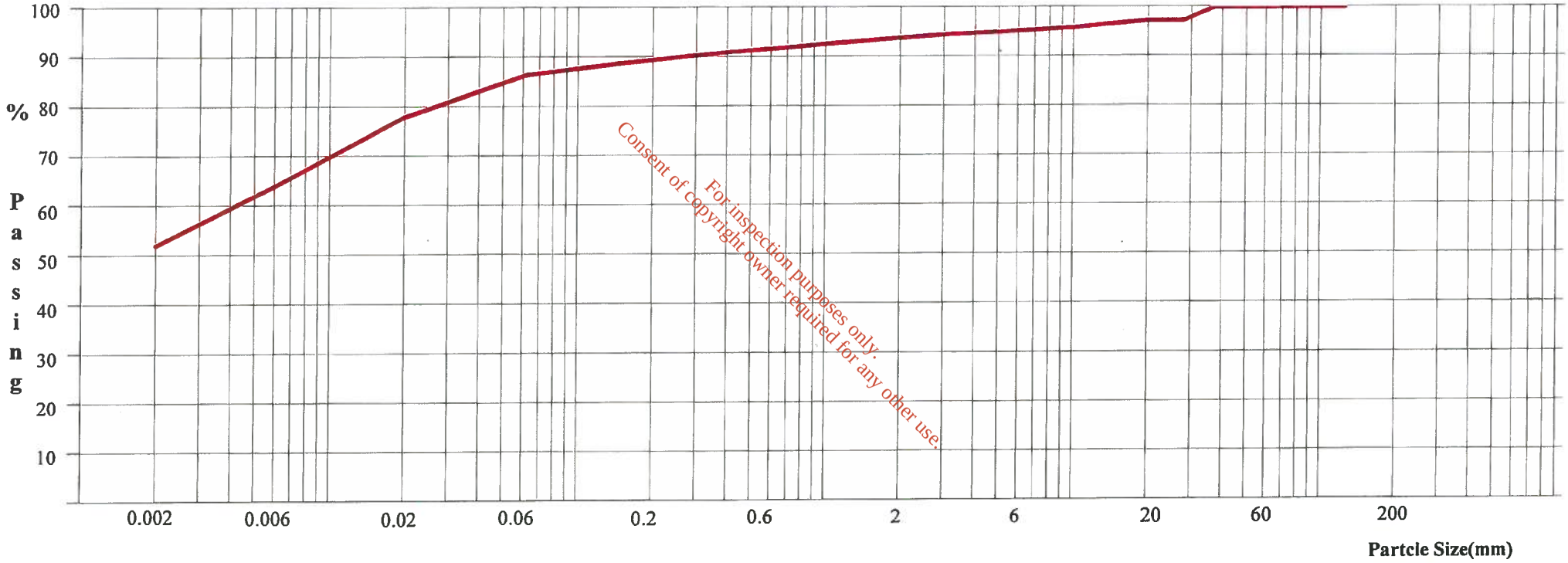
Form No.:BHP/AB/320/A/08/01/02

PARTICLE SIZE DISTRIBUTION

Analysing
Testing
Consulting
Calibrating

BHP
New Road
Thomondgate
Limerick
Ireland

Client:	Limerick County Council	**BHP Ref.:**	12/02/199
Client Reference:	Newcastlewest Landfill Site.	**F.T.A.O.:**	Mr. Finbarr Murphy
Date Received:	17/02/12	**Date Tested:**	27/02/2012
Location:	Base of landfill	**Material Spec:**	Customer spec



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles	Boulders
	Silt			Sand			Gravel				

Seamus O'Connell
Laboratory Technical Manager
For and On Behalf of BHP Laboratories Ltd

Issue Date: 8th March 2012

Sampling details where supplied are held on file.

TEST REPORT

Analysing
Testing
Consulting
Calibration

Client: Limerick County Council
County Hall
Dooradoyle
Co. Limerick.

F.T.A.O.: Mr. Finbarr Murphy

BHP Ref. No.: 12/02/199
Order No: 400217322
Date Received: 17/02/2012
Date Tested: 22/02/2011
Test Spec.: Customer spec
Item : Clay liner material

BHP
New road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax +353 61 455447
E Mail
seamusoconnell@bhp.ie

Client Reference: Newcastlewest Landfill Site.

Sampling Certificate Provided: No

DETERMINATION OF MOISTURE CONTENT TO BS 1377:PART 2:1990

Sample No.	:	1
Time Sampled	:	Not stated
Date Sampled	:	Not stated
Stated Source	:	Not stated
Location	:	Base of landfill
Method of Test	:	Definitive oven drying

Results:

Moisture Content : 22.2%

Remarks:
Nil

Seamus O'Connell
Laboratory Technical Manager
For and On Behalf of BHP Laboratories

Issue Date: 8th March 2012

TEST REPORT

Analysing
Testing
Consulting
Calibration

Client: Limerick County Council
County Hall
Dooradoyle
Co. Limerick
Co. Clare

F.T.A.O.: Mr. Finbar Murphy

Client Ref: Newcastlewest Landfill site.

Sampling Certificate Provided: No

BHP Ref. No.: 12/02/199
Order No: 400217322
Date Received: 17/02/2012
Date Tested: 05/04/2012
Test Spec.: customer spec
Item : Clay liner sample

BHP
New Road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax +353 61 455447
E Mail
seamusoconnell@bhp.ie

DETERMINATION OF THE COEFFICIENT OF PERMEABILITY UNDER CONSTANT HEAD CONDITIONS IN A TRIAXIAL CELL IN ACCORDANCE WITH BS 1377:PART 6 :1990: CLAUSE 6

Sample Ref. : Clay liner - brown silty clay
Method of Test : BS 1377:Part 6:1990

Results:

Sample Condition	:	Remoulded	
Method of Remoulding	:	2.5kg Rammer	
Specimen Details	:	Initial	Final
Diameter	:	101mm	N/A
Height	:	99mm	N/A
Moisture Content	:	24.0%	24.0%
Bulk Density (Mg/m^3)	:	2.040	2.130
Dry Density (Mg/m^3)	:	1.640	1.720

BHP Ref. No.: M12/02/199

Saturation Stage: **Performed in accordance with Clause 5.4.3.**

Initial pore pressure coeficient, B	:	0.86
Final pore pressure coeficient, B	:	0.96
Duration of stage	:	9 days

Consolidation Stage

Effective pressure	:	100 kPa
Duration of stage	:	3 days

Permeability Stage

Pressure difference across specimen (kPa)	:	20
Mean effective stress (kPa)	:	90
Duration of stage	:	2 days

Coefficient of Permeability (k_v) at 20°C = 1.0×10^{-10} m/s

Remarks:
Nil

Seamus O'Connell
Laboratory Technical Manager
For and On Behalf of BHP Laboratories
This test was subcontracted to an approved supplier.

Issue Date: 30th April 2012

TEST REPORT

Analysing
Testing
Consulting
Calibration

BHP
New road
Thomondgate
Limerick
Ireland
Tel +353 61 455399
Fax +353 61 455447
E Mail
seamusoconnell@bhp.ie

Client: Limerick County Council
County Hall
Dooradoyle
Co. Limerick

BHP Ref. No.: 12/02/198
Order No.: 400217322
Date Received: 17/02/2012
Date Tested: 28/02/2012
Test Spec: Customer Spec
Item: Capping material

F.T.A.O.: Mr. Finbar Murphy

Client Ref: Newcastlewest Landfill
Sampling Certificate Provided: No
IS EN 933-1 : 1998 Cl. 7 (Particle Size Distribution)

BHP Reference	12/02/198			SPECIFICATION LIMITS
Client Reference	capping material			
Sieve Size (mm)	% Passing	% Passing	% Passing	
500	100			Not Applicable
125	100			
80	100			
63	100			
45	85			
40	81			
31.5	67			
20	49			
16	41			
14	37			
12.5	35			
10	29			
8	25			
6.3	22			
4	18			
2.80	17			
2	15			
1	13			
500µm	11			
425µm	10			
250µm	9			
125µm	8			
63µm	7.0			

Remarks:

Details of any material not representative of the bulk sample found : None found.

The sample, as supplied is finer than a Cl. 505 Filter Drain material but typical of a Cl. 6F1/6F2 capping material as defined in the Specification for Road Works.

Seamus O'Connell
Laboratory Technical Manager
For and On Behalf of BHP Laboratories

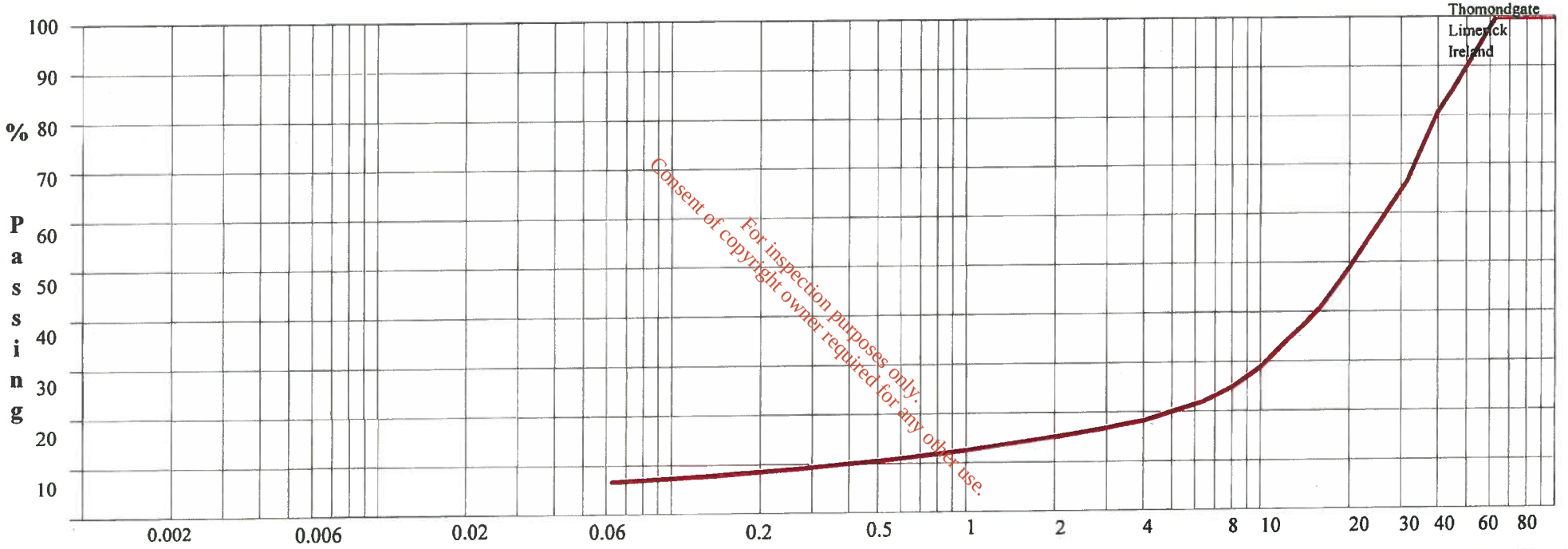
Issue Date: 8th March 2012

PARTICLE SIZE DISTRIBUTION

Analysing
Testing
Consulting
Calibrating

Client:	Limerick County Council	**BHP Ref.:**	12/02/198
Client Reference:	capping material	**F.T.A.O.:**	Mr. Finbar Murphy
Date Received:	17/02/12	**Date Tested:**	28/02/2012

BHP
New Road
Thomondgate
Limerick
Ireland



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	Cobbles	Boulders
	Silt			Sand			Gravel				

Seamus O'Connell
Laboratory Technical Manager
For and On Behalf of BHP Laboratories Ltd

Issue Date: 8th March 2012

Test results relate to the samples, as supplied . This test report shall not be duplicated in full without the permission of the test laboratory.
Sampling details where supplied are held on file.

ALcontrol Laboratories

Unit 18A
Rosemount Business Park
Ballycoolin
Dublin 11
Tel : (0035) 3188 29893

Tobin
Block 10 - 4
Blanchardstown Corporate Park
Dublin

Attention: John Dillon

CERTIFICATE OF ANALYSIS

Date:	08 January 2013
Customer:	D_TOBIN_DUB
Sample Delivery Group (SDG):	121218-40
Your Reference:	2928
Location:	Newcastlewest
Report No:	207714

We received 4 samples on Monday December 17, 2012 and 4 of these samples were scheduled for analysis which was completed on Tuesday January 08, 2013. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

All chemical testing (unless subcontracted) is performed at ALcontrol Hawarden Laboratories.

Approved By:

Sonia McWhan
Operations Manager

ALcontrol Laboratories

CERTIFICATE OF ANALYSIS

Validated

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

LIQUID

Results Legend

X Test

N No Determination Possible

Lab Sample No(s)			6683344	6683343	6683346	6683347
Customer Sample Reference			GW3	GW5	MW1	MW7
AGS Reference						
Depth (m)						
Container			1lplastic (ALE221)	1l green glass bottle	1lplastic (ALE221)	Vial (ALE297)
				1lplastic (ALE221)	H2SO4 (ALE244)	HNO3 Filtered (ALE
				H2SO4 (ALE244)	HNO3 Filtered (ALE	Vial (ALE297)
				HNO3 Filtered (ALE	Vial (ALE297)	1l green glass bottle
				Vial (ALE297)	1l green glass bottle	1lplastic (ALE221)
				1l green glass bottle	1lplastic (ALE221)	H2SO4 (ALE244)
				1lplastic (ALE221)	H2SO4 (ALE244)	HNO3 Filtered (ALE
				H2SO4 (ALE244)	HNO3 Filtered (ALE	Vial (ALE297)
				HNO3 Filtered (ALE	Vial (ALE297)	1l green glass bottle
				Vial (ALE297)	1l green glass bottle	1lplastic (ALE221)
				1l green glass bottle	1lplastic (ALE221)	H2SO4 (ALE244)
				1lplastic (ALE221)	H2SO4 (ALE244)	HNO3 Filtered (ALE
				H2SO4 (ALE244)	HNO3 Filtered (ALE	Vial (ALE297)
Acid Herbicide Suite 1 (W) *	All	NDPs: 0 Tests: 3		X	X	X
Acid Herbicides (W)	All	NDPs: 0 Tests: 3		X	X	X
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 4	X	X	X	X
Anions by Kone (w)	All	NDPs: 0 Tests: 4	X	X	X	X
BOD True Total	All	NDPs: 0 Tests: 4	X	X	X	X
COD Unfiltered	All	NDPs: 0 Tests: 4	X	X	X	X
Conductivity (at 20 deg C)	All	NDPs: 0 Tests: 4	X	X	X	X
Cyanide Comp/Free/Total/Thiocyanate	All	NDPs: 0 Tests: 4	X	X	X	X
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 4	X	X	X	X
Dissolved W, Nb and Zr by ICP-MS	All	NDPs: 0 Tests: 4	X	X	X	X
Fluoride	All	NDPs: 0 Tests: 4	X	X	X	X
Mercury Dissolved	All	NDPs: 1 Tests: 3	N	X	X	X
Metals by iCap-OES Dissolved (W)	All	NDPs: 0 Tests: 4	X	X	X	X
Mineral Oil C10-40 Aqueous (W)	All	NDPs: 0 Tests: 3		X	X	X
Nitrite by Kone (w)	All	NDPs: 0 Tests: 4	X	X	X	X

CERTIFICATE OF ANALYSIS

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

Results Legend	
#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample R	GW3	GW6	MW1	MW7		
			Depth (m)						
			Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)		
			Date Sampled	17/12/2012	17/12/2012	17/12/2012	17/12/2012		
			Sampled Time						
			Date Received	17/12/2012	17/12/2012	17/12/2012	17/12/2012		
			SDG Ref	121218-40	121218-40	121218-40	121218-40		
			Lab Sample No.(s)	6683344	6683343	6683346	6683347		
			AGS Reference						
2,3,6-Trichlorobenzoic acid (2,3,6-TBA)*	<0.02 µg/l	SUB			<0.02	<0.02	<0.02		
Benazolin*	<0.02 µg/l	SUB			<0.02	<0.02	<0.02		
Diclofop*	<0.02 µg/l	SUB			<0.02	<0.02	<0.02		
Flamprop*	<0.02 µg/l	SUB			<0.02	<0.02	<0.02		
Flamprop-isopropyl*	<0.02 µg/l	SUB			<0.02	<0.02	<0.02		
BOD, unfiltered	<1 mg/l	TM045		<2 #	2.38 #	<2 #	<2 #		
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099		<0.2 #	0.206 #	<0.2 #	<0.2 #		
Fluoride	<0.5 mg/l	TM104		<0.5 #	<0.5 #	<0.5 #	<0.5 #		
COD, unfiltered	<7 mg/l	TM107		139 #	34.5 #	13.5 #	19 #		
Conductivity @ 20 deg.C	<0.005 mS/cm	TM120		0.54 #	1.5 #	0.847 #	0.715 #		
Silicon (diss.filt)	<0.05 mg/l	TM129		3.13	10.8	3.56	3.61		
Antimony (diss.filt)	<0.16 µg/l	TM152		0.68 #	1.98 #	0.779 #	1.73 #		
Arsenic (diss.filt)	<0.12 µg/l	TM152		0.614 #	1.05 #	0.498 #	0.579 #		
Barium (diss.filt)	<0.03 µg/l	TM152		87.5 #	56.8 #	56.9 #	58.5 #		
Beryllium (diss.filt)	<0.07 µg/l	TM152		<0.07 #	<0.07 #	<0.07 #	<0.07 #		
Boron (diss.filt)	<9.4 µg/l	TM152		17.1 #	575 #	138 #	134 #		
Cadmium (diss.filt)	<0.1 µg/l	TM152		<0.1 #	0.703 #	0.189 #	0.207 #		
Chromium (diss.filt)	<0.22 µg/l	TM152		3.15 #	3.04 #	1.9 #	2.18 #		
Cobalt (diss.filt)	<0.06 µg/l	TM152		0.273 #	1.48 #	0.474 #	0.499 #		
Copper (diss.filt)	<0.85 µg/l	TM152		1.33 #	5.87 #	2.32 #	2.49 #		
Lead (diss.filt)	<0.02 µg/l	TM152		0.059 #	0.277 #	0.063 #	0.097 #		
Manganese (diss.filt)	<0.04 µg/l	TM152		1.22 #	265 #	55.5 #	55.5 #		
Molybdenum (diss.filt)	<0.24 µg/l	TM152		0.429 #	1.07 #	0.457 #	0.688 #		
Nickel (diss.filt)	<0.15 µg/l	TM152		2.77 #	23.5 #	7.93 #	8.24 #		
Phosphorus (diss.filt)	<6.3 µg/l	TM152		46.8 #	17.7 #	14.5 #	18.1 #		
Selenium (diss.filt)	<0.39 µg/l	TM152		4.3 #	6.29 #	1.71 #	1.82 #		
Tellurium (diss.filt)	<2 µg/l	TM152		<2	<2	<2	<2		
Thallium (diss.filt)	<0.96 µg/l	TM152		<0.96	<0.96	<0.96	<0.96		
Tin (diss.filt)	<0.36 µg/l	TM152		<0.36 #	<0.36 #	<0.36 #	0.401 #		
Uranium (diss.filt)	<1.5 µg/l	TM152		<1.5	1.87	1.5	1.62		
Titanium (diss.filt)	<1.5 µg/l	TM152		<1.5 #	2.58 #	<1.5 #	<1.5 #		
Vanadium (diss.filt)	<0.24 µg/l	TM152		0.86 #	0.804 #	0.467 #	0.627 #		

CERTIFICATE OF ANALYSIS

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

Results Legend	
#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4&+$@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample R	GW3	GW6	MW1	MW7		
			Depth (m)						
			Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)		
			Date Sampled	17/12/2012	17/12/2012	17/12/2012	17/12/2012		
			Sampled Time						
			Date Received	17/12/2012	17/12/2012	17/12/2012	17/12/2012		
			SDG Ref	121218-40	121218-40	121218-40	121218-40		
			Lab Sample No.(s)	6683344	6683343	6683346	6683347		
			AGS Reference						
Cyanide, Free	<0.05 mg/l	TM227		<0.05 #	<0.05 #	<0.05 #	<0.05 #		
Calcium (diss.filt)	<0.012 mg/l	TM228		151 #	361 #	218 #	222 #		
Sodium (diss.filt)	<0.076 mg/l	TM228		7.23 #	35.5 #	10.9 #	11.3 #		
Magnesium (diss.filt)	<0.036 mg/l	TM228		6.22 #	38.5 #	16.9 #	16.7 #		
Potassium (diss.filt)	<2.335 mg/l	TM228		<2.34 #	23.7 #	4.49 #	4.85 #		
Iron (diss.filt)	<0.019 mg/l	TM228		<0.019 #	<0.019 #	<0.019 #	<0.019 #		
pH	<1 pH Units	TM256		7.98 #	7.7 #	7.71 #	7.74 #		
Silver (diss.filt)	<1.5 µg/l	TM283		<1.5 #	<1.5 #	<1.5 #	<1.5 #		
Dibutyl tin	<5 ng/l	TM328			<5	<5	<5		
Tributyl tin	<1 ng/l	TM328			<1	<1	<1		
Tetrabutyl tin	<2 ng/l	TM328			<2	<2	<2		
Triphenyl tin	<1 ng/l	TM328			<1	<1	<1		
Surrogate	%	TM328			50	67	92		

CERTIFICATE OF ANALYSIS

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

OC, OP Pesticides and Triazine Herb

Results Legend	
#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4&+$@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample R	GW6	MW1	MW7			
			Depth (m)						
			Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)			
			Date Sampled	17/12/2012	17/12/2012	17/12/2012			
			Sampled Time						
			Date Received	17/12/2012	17/12/2012	17/12/2012			
			SDG Ref	121218-40	121218-40	121218-40			
			Lab Sample No.(s)	6683343	6683346	6683347			
			AGS Reference						
Atrazine	<1 µg/l	TM231		<1	<1	<1			
Simazine	<1 µg/l	TM231		<1	<1	<1			
Dichlorvos	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Mevinphos	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Hexachlorobenzene	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
alpha-Hexachlorocyclohexane (HCH / Lindane)	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Diazinon	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
gamma-Hexachlorocyclohexane (HCH / Lindane)	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Propetamphos	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Dimethoate	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Chlorothalonil	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Heptachlor	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Pirimiphos-methyl	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Aldrin	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Isodrin	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
beta-Hexachlorocyclohexane (HCH / Lindane)	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Fenthion	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Methyl parathion	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Pendimethalin	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Chlorfenvinphos	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Malathion	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
o,p-DDE	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Fenitrothion	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Heptachlor epoxide	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
o,p-TDE (DDD)	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
o,p-DDT	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Parathion	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Endosulphan I	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
o,p-Methoxychlor	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
Carbophenothion	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			
p,p-DDE	<0.01 µg/l	TM231		<0.01	<0.01	<0.01			
Triazophos	<0.1 µg/l	TM231		<0.1	<0.1	<0.1			

CERTIFICATE OF ANALYSIS

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

OC, OP Pesticides and Triazine Herb

Results Legend		Customer Sample R	GW6	MW1	MW7			
#	ISO17025 accredited.							
M	mCERTS accredited.							
aq	Aqueous / settled sample.	Depth (m)						
diss.filt	Dissolved / filtered sample.	Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)			
tot.unfilt	Total / unfiltered sample.	Date Sampled	17/12/2012	17/12/2012	17/12/2012			
*	Subcontracted test.	Sampled Time						
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery	Date Received	17/12/2012	17/12/2012	17/12/2012			
		SDG Ref	121218-40	121218-40	121218-40			
(F)	Trigger breach confirmed	Lab Sample No.(s)	6683343	6683346	6683347			
1-4&+§@	Sample deviation (see appendix)	AGS Reference						

Component	LOD/Units	Method						
Methacriphos	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Tributylphosphate	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Sulfotep	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Phorate	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Fonofos	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Phosphamidon I	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Disulfoton	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Phosphamidon II	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Chlorpyriphos methyl	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Triphenylphosphate	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Phosmet	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
o-ethyl 4-nitrophenyl phosphonothioate (EPN)	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
Coumaphos	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			
cis-Heptachlor epoxide	<0.1 µg/l	TM231	<0.1	<0.1	<0.1			

CERTIFICATE OF ANALYSIS

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

SVOC MS (W) - Aqueous

Results Legend	
#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4&+$@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample R	GW6	MW1	MW7			
			Depth (m)						
			Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)			
			Date Sampled	17/12/2012	17/12/2012	17/12/2012			
			Sampled Time						
			Date Received	17/12/2012	17/12/2012	17/12/2012			
			SDG Ref	121218-40	121218-40	121218-40			
			Lab Sample No.(s)	6683343	6683346	6683347			
			AGS Reference						
1,2,4-Trichlorobenzene (aq)	<1 µg/l	TM176		<1	<1	<1			
1,2-Dichlorobenzene (aq)	<1 µg/l	TM176		<1	<1	<1			
1,3-Dichlorobenzene (aq)	<1 µg/l	TM176		<1	<1	<1			
1,4-Dichlorobenzene (aq)	<1 µg/l	TM176		<1	<1	<1			
2,4,5-Trichlorophenol (aq)	<1 µg/l	TM176		<1	<1	<1			
2,4,6-Trichlorophenol (aq)	<1 µg/l	TM176		<1	<1	<1			
2,4-Dichlorophenol (aq)	<1 µg/l	TM176		<1	<1	<1			
2,4-Dimethylphenol (aq)	<1 µg/l	TM176		<1	<1	<1			
2,4-Dinitrotoluene (aq)	<1 µg/l	TM176		<1	<1	<1			
2,6-Dinitrotoluene (aq)	<1 µg/l	TM176		<1	<1	<1			
2-Chloronaphthalene (aq)	<1 µg/l	TM176		<1	<1	<1			
2-Chlorophenol (aq)	<1 µg/l	TM176		<1	<1	<1			
2-Methylnaphthalene (aq)	<1 µg/l	TM176		<1	<1	<1			
2-Methylphenol (aq)	<1 µg/l	TM176		<1	<1	<1			
2-Nitroaniline (aq)	<1 µg/l	TM176		<1	<1	<1			
2-Nitrophenol (aq)	<1 µg/l	TM176		<1	<1	<1			
3-Nitroaniline (aq)	<1 µg/l	TM176		<1	<1	<1			
4-Bromophenylphenylether (aq)	<1 µg/l	TM176		<1	<1	<1			
4-Chloro-3-methylphenol (aq)	<1 µg/l	TM176		<1	<1	<1			
4-Chloroaniline (aq)	<1 µg/l	TM176		<1	<1	<1			
4-Chlorophenylphenylether (aq)	<1 µg/l	TM176		<1	<1	<1			
4-Methylphenol (aq)	<1 µg/l	TM176		<1	<1	<1			
4-Nitrophenol (aq)	<1 µg/l	TM176		<1	<1	<1			
4-Nitroaniline (aq)	<1 µg/l	TM176		<1	<1	<1			
Azobenzene (aq)	<1 µg/l	TM176		<1	<1	<1			
bis(2-Chloroethyl)ether (aq)	<1 µg/l	TM176		<1	<1	<1			
bis(2-Chloroethoxy)methane (aq)	<1 µg/l	TM176		<1	<1	<1			
bis(2-Ethylhexyl) phthalate (aq)	<2 µg/l	TM176		<2	<2	<2			
Butylbenzyl phthalate (aq)	<1 µg/l	TM176		<1	<1	<1			
Benzo(k)fluoranthene (aq)	<1 µg/l	TM176		<1	<1	<1			
Carbazole (aq)	<1 µg/l	TM176		<1	<1	<1			
Dibenzofuran (aq)	<1 µg/l	TM176		<1	<1	<1			

CERTIFICATE OF ANALYSIS

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

VOC MS (W)

Results Legend

#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4&+$@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample R	GW3	GW6	MW1	MW7		
			Depth (m)						
			Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)		
			Date Sampled	17/12/2012	17/12/2012	17/12/2012	17/12/2012		
			Sampled Time						
			Date Received	17/12/2012	17/12/2012	17/12/2012	17/12/2012		
			SDG Ref	121218-40	121218-40	121218-40	121218-40		
			Lab Sample No.(s)	6683344	6683343	6683346	6683347		
			AGS Reference						
Dibromofluoromethane**	%	TM208		110 1	109	107	108		
Toluene-d8**	%	TM208		100 1	100	100	101		
4-Bromofluorobenzene**	%	TM208		99 1	98.6	98.7	99.7		
Dichlorodifluoromethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Chloromethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Vinyl chloride	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Bromomethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Chloroethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Trichlorofluoromethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
1,1-Dichloroethene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Carbon disulphide	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Dichloromethane	<3 µg/l	TM208		<3 1 #	<3 #	<3 #	<3 #		
Methyl tertiary butyl ether (MTBE)	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
trans-1,2-Dichloroethene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
1,1-Dichloroethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
cis-1,2-Dichloroethene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
2,2-Dichloropropane	<1 µg/l	TM208		<1 1	<1	<1	<1		
Bromochloromethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Chloroform	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
1,1,1-Trichloroethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
1,1-Dichloropropene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Carbontetrachloride	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
1,2-Dichloroethane	<1 µg/l	TM208		<1 1	<1	<1	<1		
Benzene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Trichloroethene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
1,2-Dichloropropane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Dibromomethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Bromodichloromethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
cis-1,3-Dichloropropene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
Toluene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
trans-1,3-Dichloropropene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
1,1,2-Trichloroethane	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		

CERTIFICATE OF ANALYSIS

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

VOC MS (W)

Results Legend	
#	ISO17025 accredited.
M	mCERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-4&+$@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample R	GW3	GW6	MW1	MW7		
			Depth (m)						
			Sample Type	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)	Water(GW/SW)		
			Date Sampled	17/12/2012	17/12/2012	17/12/2012	17/12/2012		
			Sampled Time						
			Date Received	17/12/2012	17/12/2012	17/12/2012	17/12/2012		
			SDG Ref	121218-40	121218-40	121218-40	121218-40		
			Lab Sample No.(s)	6683344	6683343	6683346	6683347		
			AGS Reference						
1,2,3-Trichlorobenzene	<1 µg/l	TM208		<1 1 #	<1 #	<1 #	<1 #		
1,3,5-Trichlorobenzene	<1 µg/l	TM208		<1 1	<1	<1	<1		

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

Table of Results - Appendix

Method No	Reference	Description	Wet/Dry Sample [1]	Surrogate Corrected
SUB		Subcontracted Test		
TM045	MEWAM BOD5 2nd Ed.HMSO 1988 / Method 5210B, AWWA/APHA, 20th Ed., 1999; SCA Blue Book 130	Determination of BOD5 (ATU) Filtered by Oxygen Meter on liquids		
TM061	Method for the Determination of EPH,Massachusetts Dept.of EP, 1998	Determination of Extractable Petroleum Hydrocarbons by GC-FID (C10-C40)		
TM099	BS 2690: Part 7:1968 / BS 6068: Part2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser		
TM104	Method 4500F, AWWA/APHA, 20th Ed., 1999	Determination of Fluoride using the Kone Analyser		
TM107	ISO 6060-1989	Determination of Chemical Oxygen Demand using COD Dr Lange Kit		
TM120	Method 2510B, AWWA/APHA, 20th Ed., 1999 / BS 2690: Part 9:1970	Determination of Electrical Conductivity using a Conductivity Meter		
TM129	Method 3120B, AWWA/APHA, 20th Ed., 1999 / Modified: US EPA Method 3050B	Determination of Metal Cations by IRIS Emission Spectrometer		
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS		
TM172	Analysis of Petroleum Hydrocarbons in Environmental Media – Total Petroleum Hydrocarbon Criteria	EPH in Waters		
TM176	EPA 8270D Semi-Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)	Determination of SVOCs in Water by GCMS		
TM178	Modified: US EPA Method 8100	Determination of Polynuclear Aromatic Hydrocarbons (PAH) by GC-MS in Waters		
TM183	BS EN 23506:2002, (BS 6068-2.74:2002) ISBN 0 580 38924 3	Determination of Trace Level Mercury in Waters and Leachates by PSA Cold Vapour Atomic Fluorescence Spectrometry		
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers		
TM186	Determination of Acidic Herbicides in Groundwater and Potable Water by LC/MSD Using Selective Ion Monitoring. Agilent Technologies Inc. Application Note 5988-5882EN.	The Determination of Acid Herbicides in Environmental Water Samples and Leachates by LC/MS QQQ.		
TM191	Standard Methods for the examination of waters and wastewaters 16th Edition, ALPHA, Washington DC, USA. ISBN 0-87553-131-8.	Determination of Unfiltered Metals in Water Matrices by ICP-MS		
TM205		Determination of Phenols in Waste Waters using Solid Phase Extraction, Acetylation, Gas Chromatography and Mass Selective Detection		
TM208	Modified: US EPA Method 8260b & 624	Determination of Volatile Organic Compounds by Headspace / GC-MS in Waters		
TM227	Standard methods for the examination of waters and wastewaters 20th Edition, AWWA/ARHA Method 4500.	Determination of Total Cyanide, Free (Easily Liberatable) Cyanide and Thiocyanate		
TM228	US EPA Method 6010B	Determination of Major Cations in Water by iCap 6500 Duo ICP-OES		
TM231	Agilent 6890 Gas Chromatograph system using an Agilent 5973 Mass Selective Detector (MSD)	Determination of Organochlorine and Organophosphorus Pesticides and Triazine Herbicides by GCMS		
TM256	The measurement of Electrical Conductivity and the Laboratory determination of pH Value of Natural, Treated and Wastewaters. HMSO, 1978. ISBN 011 751428 4.	Determination of pH in Water and Leachate using the GLpH pH Meter		
TM283		Determination of Dissolved Niobium, Tungsten, and Zirconium in Water Matrices by ICP-MS		
TM328				

[1] Applies to Solid samples only. DRY indicates samples have been dried at 35°C. NA = not applicable.

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

Chromatogram

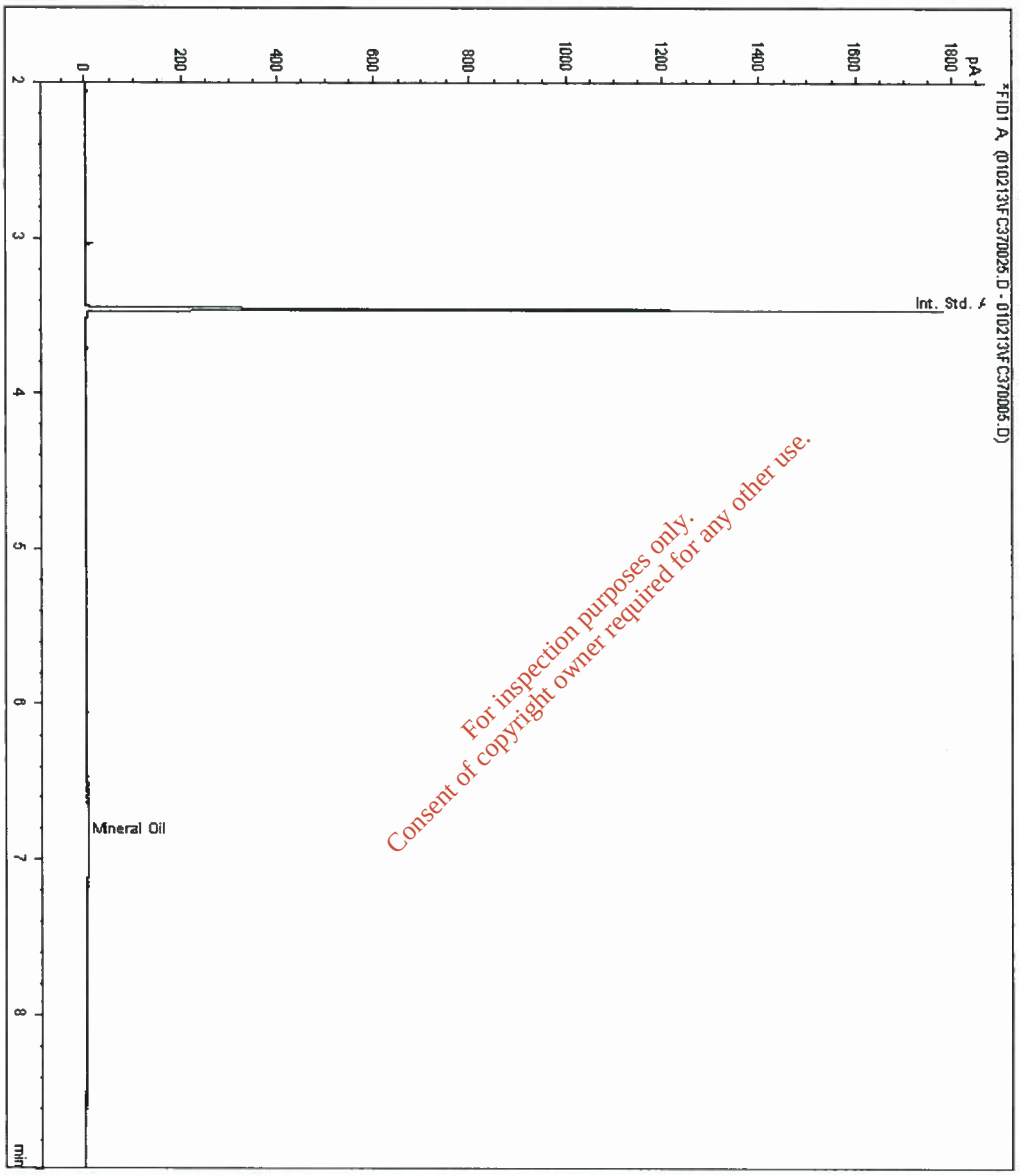
Analysis: Mineral Oil C10-40 Aqueous (W)

Sample No : 6685765
Sample ID : MW1

Depth :

Alcontrol Analytical Services
Mineral Oil Range Organics (C10 - C40)

Sample Identity: 6453679-6685765
Date Acquired : 03/01/13 02:16:17 PM
Units : mg/L
Sample Volume: 0 ml's
Dilution:



CERTIFICATE OF ANALYSIS

SDG:	121218-40	**Location:**	Newcastlewest	**Order Number:**	
Job:	D_TOBIN_DUB-86	**Customer:**	Tobin	**Report Number:**	207714
Client Reference:	2928	**Attention:**	John Dillon	**Superseded Report:**	

Chromatogram

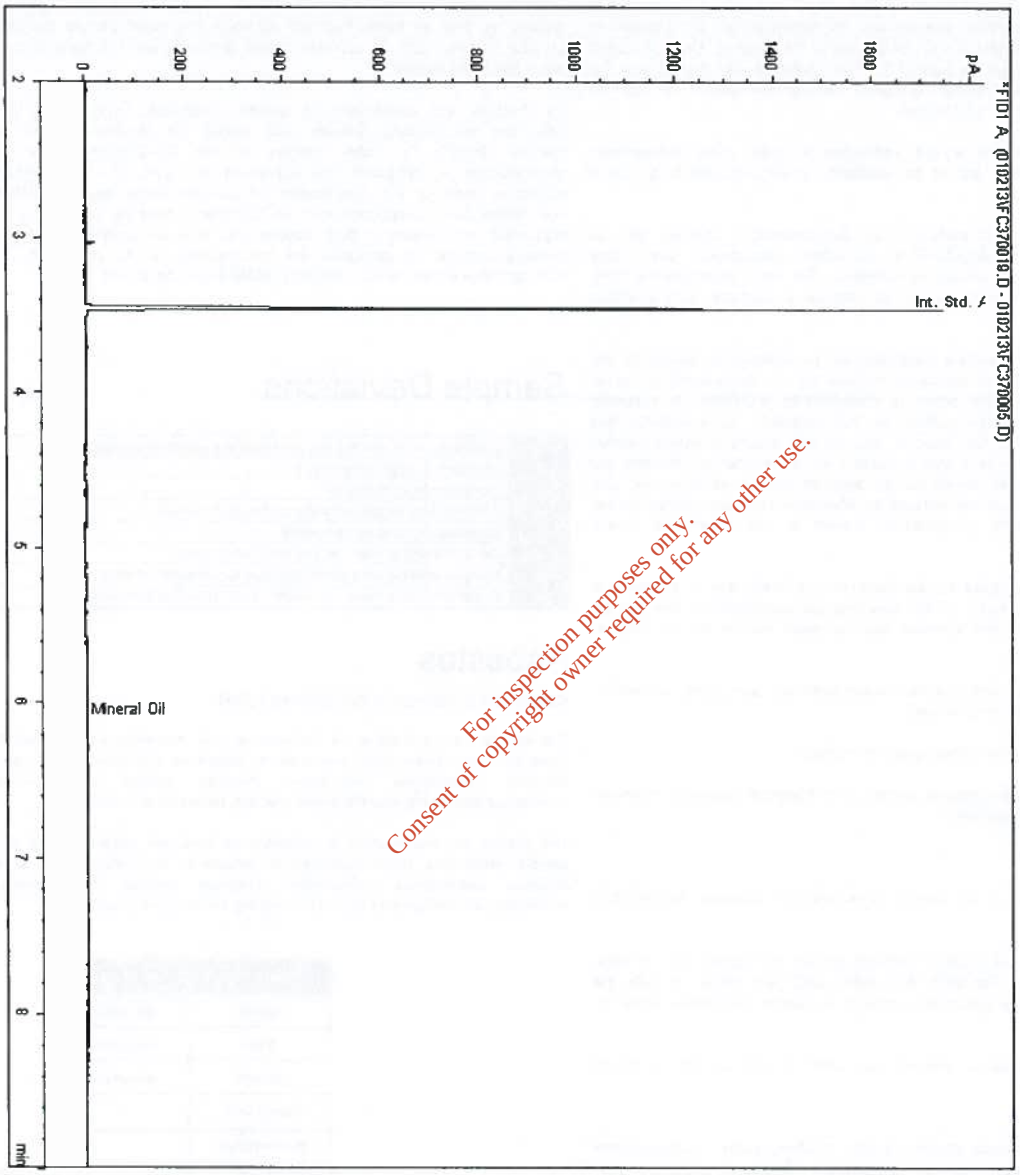
Analysis: Mineral Oil C10-40 Aqueous (W)

Sample No : 6686090
Sample ID : GW6

Depth :

Alcontrol Analytical Services
Mineral Oil Range Organics (C10 - C40)

Sample Identity: 6453577-6686090
Date Acquired : 02/01/13 23:57:35 PM
Units : mg/L
Sample Volume: 0 ml's
Dilution:



City Analysts Limited
Environmental Laboratories

City Analysts Limited,
Pigeon House Road,
Ringsend,
Dublin 4.

Tel:(01) 613 6003 /6 /9
Fax:(01) 613 6008
Email:info@cityanalysts.ie

www.cityanalysts.ie

Certificate of Analysis

Customer Contact: John Dillon

Customer: Tobin Consulting Engineers,

Customer Address: Block 10-4.,
Blanchardstown Corporate Park,
Blanchardstown,
Dublin 15

Report Reference: 13-02062-
Report Version: 1
Date Received: 19/04/2013

ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO. 138T

Sample Description: BH 9
Sample Type: Ground Water
Date Sampled: 19/04/2013
Lab Reference Number: 150554

Site/Method Ref.	Analysis Start Date	Parameter	Result	Units	PV Value	Accreditation Status
D/3000	19/04/2013	Ammonia as N	0.11	mg/l	-	INAB
SUB C		Dissolved Methane	<0.05	mg/l	-	NON

Note:

NAC & ATC - No abnormal change and acceptable to customers.
TVC - Total Viable Count
PV Value is the parametric value, taken from European Communities, (Drinking Water) (No. 2) Regulations, 2007. S.I. No. 278 of 2007, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Limerick

City Analysts Limited
Environmental Laboratories

City Analysts Limited,
Pigeon House Road,
Ringsend,
Dublin 4.

Tel:(01) 613 6003 /6 /9
Fax:(01) 613 6008
Email:info@cityanalysts.ie

www.cityanalysts.ie

Certificate of Analysis

Customer Contact: John Dillon

Customer: Tobin Consulting Engineers,

Customer Address: Block 10-4.,
Blanchardstown Corporate Park,
Blanchardstown,
Dublin 15

Report Reference: 13-02062-
Report Version: 1
Date Received: 19/04/2013

Sample Description: SW 3
Sample Type: Surface Water
Date Sampled: 19/04/2013
Lab Reference Number: 150552

Site/Method Ref.	Analysis Start Date	Parameter	Result	Units	PV Value	Accreditation Status
D/3000	19/04/2013	Ammonia as N	0.96	mg/l	-	INAB

Note:
NAC & ATC - No abnormal change and acceptable to customers.
TVC - Total Viable Count
PV Value is the parametric value, taken from European Communities, (Drinking Water) (No. 2) Regulations, 2007. S.I. No. 278 of 2007, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Limerick

City Analysts Limited
Environmental Laboratories

City Analysts Limited,
Pigeon House Road,
Ringsend,
Dublin 4.

Tel:(01) 613 6003 /6 /9
Fax:(01) 613 6008
Email:info@cityanalysts.ie

www.cityanalysts.ie

Certificate of Analysis

Customer Contact: John Dillon

Customer: Tobin Consulting Engineers,

Customer Address: Block 10-4.,
Blanchardstown Corporate Park,
Blanchardstown,
Dublin 15

Report Reference: 13-02062-
Report Version: 1
Date Received: 19/04/2013

ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO. 138T

Sample Description: SW 1
Sample Type: Surface Water
Date Sampled: 19/04/2013
Lab Reference Number: 150550

Site/Method Ref.	Analysis Start Date	Parameter	Result	Units	PV Value	Accreditation Status
D/3000	19/04/2013	Ammonia as N	0.06	mg/l	-	INAB

Note:

NAC & ATC - No abnormal change and acceptable to customers.
TVC - Total Viable Count
PV Value is the parametric value, taken from European Communities, (Drinking Water) (No. 2) Regulations, 2007. S.I. No. 278 of 2007, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Limerick

Appendix 10

Historic Sampling Analysis from Pump House

Landfill
Leachate

Navcastle West

Date 12 – 11 . 2001

3.67 ✓

✓ FAR

Location	Code	B.O.D. mg/l	C.O.D. mg/l	pH	Temp DegC	NH4-N mg/l	Cond uS/cm	Chloride mg/l	Iron mg/l	Manganese mg/l	Total Alkalinity mg/l	T.O.N. NO_3-N mg/l	Suspended Solids mg/l
From Landfill old	2317	7.99 ✓	64 ✓	~~7.8~~ ✓	—	3.55 ✓	452 ✓	17.95 ✓	~~2640~~	0.153 ✓	200 ✓	0.56 ✓	—
AT				7.5									
NCW													

O.L.A.

Ca	Cd	Cr	Cu	Hg	Pb	Mg	Ni	K	Na	SO4	Zn	T.O.C.
↓						↓		↓	↓	↓		
mg/l 2317 61						8.45		28.73	11.24	14.5		

Ions:

SO_4 = 2.7[redacted] mg/l. ✓

Ca = 66.3 mg/l ✓

Mg = 25.35 mg/l. ✓

K = 22.38 mg/l ✓

Na = 26.54 mg/l ✓

mth.

Landfill
Leachate

Date 3/9/01

Location	Code	B.O.D. mg/l	C.O.D. mg/l	pH	Temp DegC	NH4-N mg/l	Cond uS/cm	Chloride mg/l	Iron mg/l	Manganese mg/l	Total Alkalinity mg/l	T.O.N. NO_3-N mg/l	Suspended Solids mg/l
NCWS	2002	20.5	54	7.7	13.3	8.77	727	29.09	0.58	0.11	390	1.27 [redacted]	71.
Leachate Sump.													

O.L.A.

~~Ca~~ Cd Cr Cu Hg Pb ~~Mg~~ Ni ~~K~~ ~~Na~~ ~~SO4~~ Zn T.O.C.

P.O. 4→38522.

QRN 5→39864.

EURO environmental services

Environmental Science & Management
Water, Soil & Air Testing

Southbank House,
Southbank Ind. Est.,
Drogheda,
Co Louth.

Tel: 041 9845440
Fax: 041 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer Name	Cait Gleeson	*Lab Report Ref. No.*	1880/006/05
Company	Limerick County Council	*Date of Receipt*	05/09/02
Address	County Council Laboratory	*Date Testing Commenced*	05/09/02
	Ballykeeffe	*Received or Collected*	Collected
	Limerick	*Condition on Receipt*	Acceptable
	Ireland	*Date of Report*	30/09/02

CERTIFICATE OF ANALYSIS

ClientRef: 02LK 2002

Lab Ref: 1880/006/05

Test Parameter	Method of Analysis		Analytical Technique	Result	Units
Cadmium *	SOP	0	I.C.P.	<0.003	mg/L
Chromium	SOP	129	Atomic Absorption	0.02	mg/L as Cr
Copper	SOP	128	Atomic Absorption	0.02	mg/L as Cu
Lead *	SOP	0	I.C.P.	<0.049	mg/L
Mercury *	SOP	0	Cold Vapour AA	<0.0005	mg/L
Nickel	SOP	132	Atomic Absorption	0.02	mg/L as Ni
Total Organic Carbon *	SOP	0	IR	17	mg/L
Zinc	SOP	123	Atomic Absorption	0.04	mg/L as Zn

Signed : _____ *Date :* 30.9.02

Mark Jacob - Technical Quality Manager

Results contained in this report relate only to the samples tested
* Indicates test which has been subcontracted

Landfill
Leachate

Date 30/11/03

Location	Code	B.O.D. mg/l	C.O.D. mg/l	pH	Temp DegC	NH4-N mg/l	Cond uS/cm	Chloride mg/l	Iron mg/l	Manganese mg/l	Total Alkalinity mg/l	T.O.N. mg/l	Suspended Solids mg/l
Landfill	NCW	250	201	35	7.2	9.2	—	846	45.41	1.3	0.199	373	6.54	43.
	[redacted]												

O.L.A.

Ca Cd Cr Cu Hg Pb Mg Ni K Na SO4 Zn T.O.C.

Landfill Leachate Monitoring.

Sampling Date: 30/1/03.

Calcium Magnes Potassium Sodium Sulphate

Sample	Code	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	SO_4 mg/l		
Date of analysis			5/2/03.			6/2/03.		
New leachate	250.	99.3	27.14	28.08	25.57	30.08.		

EURO environmental services

Environmental Science & Management
Water, Soil & Air Testing

Southbank House,
Southbank Ind. Est.,
Drogheda,
Co Louth,
Ireland.

Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer Name	Cait Gleeson	*Lab Report Ref. No.*	1880/027/01
Company	Limerick County Council	*Date of Receipt*	31/01/03
Address	County Council Laboratory Ballykeeffe	*Date Testing Commenced*	31/01/03
		Received or Collected	Collected
	Limerick	*Condition on Receipt*	Acceptable
CustomerPO	400046354	*Date of Report*	17/02/03

Environmental Laboratory
27 MAR 2003
Limerick County Council

CERTIFICATE OF ANALYSIS

lon 311

Newcastle West

ClientRef: 03LK 250

Lab Ref: 1880/027/01

Test Parameter	Method of Analysis		Analytical Technique	Result	Units
Cadmium	SOP	0	ICPMS	<0.1 ✓	ug/L
Chromium	SOP	129	ICPMS	<0.001 ✓	mg/L as Cr
Copper	SOP	128	ICPMS	<0.001 ✓	mg/L as Cu
Lead	SOP	0	ICPMS	<0.1 ✓	ug/L
Mercury	SOP	0	ICPMS	<0.01 ✓	ug/L
Nickel	SOP	132	ICPMS	<0.001 ✓	mg/L as Ni
Total Organic Carbon *	SOP	0	IR	17 ✓	mg/L
Zinc	SOP	127	ICPMS	<0.001 ✓	mg/L as Zn

20 FEB 2003

Environmental Section

Signed : _____

Mark Jacob- Technical Quality Manager

Date : 17-2-03

Results shall not be reproduced, except in full, without the approval of EURO envoirnmental services
Results contained in this report relate only to the samples tested
* Indicates test which has been subcontracted

Landfill
Leachate

Date 1/14/03

Location	Code	B.O.D. mg/l	C.O.D. mg/l	pH	Temp DegC	NH4-N mg/l	Cond úS/cm	Chloride mg/l	Iron mg/l	Manganese mg/l	Total Alkalinity mg/l	T.O.N. mg/l	Suspended Solids mg/l
NCW.	918	10.08	67	7.4	7.7	5.24	733	40.52	—	—	343	40.09	16
leachate													
IN enclosed													
Sump													
1/14/03													
51	921												
DOWN	stream	White	River										5
56	922.												
up stream	White	River											8

S.S. only

O.L.A.

Ca	Cd	Cr	Cu	Hg	Pb	Mg	Ni	K	Na	SO4	Zn	T.O.C.

~~HCSP~~

Landfill Leachate Monitoring.

Sampling Date: 14/4/03

Sample	Code	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	SO_4 mg/l		
Date of analysis			30/4/03			17/4		
	918	81.6	*	*	26.49	11.04		

F:\Laboratory Forms etc\Results sheets\Urban Waste Waters.doc

* Sample was over range for Mg ++ CS

EURO environmental services

Environmental Science & Management
Water, Soil & Air Testing

Southbank House,
Southbank Ind. Est.,
Drogheda,
Co Louth,
Ireland.

Tel: +353 41 9845440
Fax: +353 41 9846171
Web: www.euroenv.ie
email: info@euroenv.ie

Customer Name	Cait Gleeson	*Lab Report Ref. No.*	1880/040/18
Company	Limerick County Council	*Date of Receipt*	17/04/03
Address	County Council Laboratory	*Date Testing Commenced*	17/04/03
	Ballykeeffe	*Received or Collected*	Collected
	Limerick	*Condition on Receipt*	Acceptable
CustomerPO	400060194	*Date of Report*	30/04/03

CERTIFICATE OF ANALYSIS

ClientRef: 03 Lk 918
Lab Ref: 1880/040/18

Test Parameter	Method of Analysis	Analytical Technique	Result	Units
Cadmium	SOP 177	ICPMS	<0.1	ug/L
Chromium	SOP 177	ICPMS	0.397	ug/L
Copper	SOP 177	ICPMS	0.078	ug/L
Cyanide	SOP 145	Colorimetry	18	ug/L
Lead	SOP 177	ICPMS	<0.1	ug/L
Mercury	SOP 178	ICPMS	0.55	ug/L
Nickel	SOP 177	ICPMS	<0.001	ug/L
Zinc	SOP 177	ICPMS	<0.001	ug/L

Environmental Laboratory
01 MAY 2003
Limerick County Council

Signed : _____ *Date :* 30-4-03

Mark Jacob - Technical Quality Manager

* Indicates test which has been subcontracted

Landfill
Leachate

Date 15/7/03

Location	Code	B.O.D. mg/l	C.O.D. mg/l	pH	Temp DegC	NH4-N mg/l	Cond uS/cm	Chloride mg/l	Iron mg/l	Manganese mg/l	Total Alkalinity mg/l	~~T.O.N.~~ TOC mg/l	Suspended Solids mg/l
			17-07-03										17-07
NCW	1852	14.6	75	7.9	13	8.96	710	33.98	1.26 ~~1260~~	0.29	358	5.05	49
Landfill													

O.L.A.

Ca	Cd	Cr	Cu	Hg	Pb	Mg	Ni	K	Na	SO4	Zn	T.O.C.

Landfill Leachate Monitoring.

Sampling Date: 15/7/10.

Sample	Code	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	SO_4 mg/l		
Date of analysis		- 23/7/10				15/7		
	1852	32.5	21.14	-	24.26	1.47		

Landfill
Leachate

Date 10-09-03

Location	Code	B.O.D. mg/l	C.O.D. mg/l	pH	Temp DegC	NH4-N mg/l	Cond uS/cm	Chloride mg/l	Iron mg/l	Manganese mg/l	Total Alkalinity mg/l	T.O.N. NO3-N mg/l	Suspended Solids mg/l
Nexcastle West	2612.	37.5	82	7.8	16.5	4.55	674	27.68	9.05	0.154	326.5	0.95	26.

O.L.A.

Ca Cd Cr Cu Hg Pb Mg Ni K Na SO4 Zn T.O.C.

moh

Appendix 11

LFG Model for Churchtown Landfill Site

1.1 GAS SIM Modeling of LFG Production

In order to look at the LFG production from Churchtown landfill over time, *TOBIN* were commissioned by Limerick County Council to run a model using *GasSim (Version 2.00.0078)*, for which *Tobin* have a licence and are appropriately trained. The GasSim software was developed by *Golders Associates* for the *Environment Agency of England and Wales* and is the recognised accepted software package for LFG modeling.

This model was run in April 2012, with the model inputs and results discussed below.

1.2 Model Input Data & Assumptions

The full data inputted to the GasSim software for Churchtown landfill is summarised on the GasSim 2.0 Model - Project Details Printout, attached in **Appendix 1**.

The GasSim 2.00.0078 model studied the landfill as one phase – 'Waste Body'.

The model uses information on waste composition and quantity, landfill engineering, and landfill gas management techniques, to estimate the quantity of landfill gas generated from the landfill.

Table 1 lists the years of waste deposition associated with the Waste Body, the quantities of waste deposited per year and the waste breakdown per year, all of which were inputted to the GasSim Model.

Table 1: Waste Deposition 1935 to 1986

MODELLED PHASES	YEARS OF WASTE DEPOSITION	QUANTITIES OF WASTE DEPOSITED	WASTE BREAKDOWN
Waste Body	1935 - 1969	2,500 tonnes/year	Household – 33.5% Commercial – 33.5% Inert (including C&D) - 33%
	1970 - 1979	5,000 tonnes/year	Household – 33.5% Commercial – 33.5% Inert (including C&D) - 33%
	1980 - 1986	10,000 tonnes/year	Household – 33.5% Commercial – 33.5% Inert (including C&D) - 33%

Table 2 below presents additional information inputted to the GasSim Model for Churchtown Landfill.

Table 3 Further Information Inputted to the GasSim Model

Operational Period	52 Years
Simulation period	150 Years
Iterations	201
Waste Composition: **1935 – 1986**	England 2000-2010 Waste Streams (Included in Modelling Software)
Uncapped Infiltration	400 – 450mm/yr
Waste Moisture Content	Dry
Waste Density	0.7 t/m3
Leachate Head	1 – 1.5m
Temporary Cap: **Cap Thickness** **Cap Hydraulic Conductivity**	 0.25 – 0.35m 1e-5m/s
Permanent Cap:	NONE
Liner:	NONE
Geosphere Moisture Content	2 – 8% v/v
Geosphere Porosity	15 – 49% v/v
Proportion of CH4:CO2	50%:50% (Default)
Biological Methane Oxidation	10% (Default)

1.3 Model Results

The GasSim model results for Churchtown Landfill are presented on a graph and a table of 'Total Bulk LFG Produced Per Year', which are attached in **Appendix 1**

The results show a peak in LFG production for the landfill facility in 1987 (53.83 m^3/hr). A total bulk LFG of 20.93m^3/hr was predicted for 2012.

BALLYDONAGH LANDFILL
TOTAL LFG PRODUCED PER YEAR (m3/Hour)

	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953
5% Less Than	0	1.198228	2.335917	3.41677	4.444245	5.421573	6.35177	7.237658	8.081873	8.88688	9.654982	10.38834	11.08896	11.75873	12.39943	13.01271	13.6001	14.16307	14.70297
10% Less Than	0	1.198233	2.335928	3.416785	4.444265	5.421596	6.351797	7.237689	8.081907	8.886917	9.655022	10.38838	11.089	11.75878	12.39948	13.01276	13.60015	14.16312	14.70303
25% Less Than	0	1.198239	2.335939	3.416802	4.444286	5.421622	6.351828	7.237723	8.081945	8.886958	9.655066	10.38842	11.08905	11.75883	12.39954	13.01281	13.60021	14.16318	14.70309
50% Less Than	0	1.19825	2.335959	3.416831	4.444324	5.421668	6.35188	7.237782	8.08201	8.887029	9.655142	10.38851	11.08914	11.75892	12.39963	13.01291	13.60031	14.16329	14.70319
75% Less Than	0	1.198262	2.335982	3.416864	4.444367	5.421719	6.35194	7.237849	8.082084	8.887109	9.655229	10.3886	11.08923	11.75903	12.39974	13.01302	13.60043	14.16341	14.70332
90% Less Than	0	1.198271	2.336	3.416889	4.444399	5.421758	6.351984	7.2379	8.08214	8.88717	9.655294	10.38867	11.08931	11.7591	12.39982	13.0131	13.60051	14.16349	14.70341
95% Less Than	0	1.198276	2.33601	3.416904	4.444418	5.421781	6.352011	7.23793	8.082173	8.887206	9.655332	10.38871	11.08935	11.75915	12.39986	13.01315	13.60056	14.16355	14.70346

	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
5% Less Than	15.22108	15.71858	16.19661	16.6562	17.09834	17.52396	17.93393	18.32906	18.71011	19.0778	19.43282	19.77579	20.10731	20.42794	20.73822	21.03864	21.32967	22.80999	24.22123
10% Less Than	15.22113	15.71864	16.19667	16.65626	17.0984	17.52403	17.93399	18.32912	18.71017	19.07787	19.43288	19.77585	20.10738	20.42801	20.73829	21.03871	21.32974	22.81006	24.22131
25% Less Than	15.2212	15.7187	16.19673	16.65633	17.09847	17.5241	17.93406	18.32919	18.71025	19.07794	19.43296	19.77593	20.10745	20.42809	20.73837	21.03879	21.32982	22.81014	24.2214
50% Less Than	15.22131	15.71882	16.19685	16.65644	17.09859	17.52422	17.93419	18.32932	18.71037	19.07807	19.43308	19.77606	20.10758	20.42822	20.7385	21.03892	21.32995	22.81029	24.22155
75% Less Than	15.22143	15.71894	16.19697	16.65657	17.09872	17.52435	17.93432	18.32946	18.71051	19.07821	19.43323	19.7762	20.10773	20.42837	20.73865	21.03907	21.33011	22.81045	24.22173
90% Less Than	15.22152	15.71904	16.19707	16.65667	17.09883	17.52446	17.93443	18.32956	18.71062	19.07832	19.43334	19.77631	20.10784	20.42848	20.73876	21.03918	21.33022	22.81058	24.22186
95% Less Than	15.22158	15.7191	16.19713	16.65673	17.09889	17.52452	17.93449	18.32962	18.71068	19.07838	19.4334	19.77638	20.1079	20.42854	20.73883	21.03925	21.33029	22.81065	24.22194

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
5% Less Than	25.56749	26.85261	28.08017	29.2535	30.37575	31.44983	32.47851	33.46433	36.80616	39.98873	43.02154	45.91348	48.67287	51.30749	53.8246	51.43809	49.1894	47.06966	45.07062
10% Less Than	25.56758	26.8527	28.08026	29.2536	30.37585	31.44994	32.47862	33.46444	36.80629	39.98887	43.02169	45.91364	48.67305	51.30767	53.82479	51.43827	49.18956	47.06981	45.07076
25% Less Than	25.56767	26.8528	28.08037	29.25371	30.37596	31.45006	32.47874	33.46457	36.80643	39.98902	43.02185	45.91382	48.67323	51.30787	53.825	51.43846	49.18974	47.06998	45.07091
50% Less Than	25.56784	26.85298	28.08055	29.2539	30.37616	31.45026	32.47894	33.46478	36.80667	39.98929	43.02214	45.91413	48.67356	51.30822	53.82536	51.4388	49.19005	47.07027	45.07118
75% Less Than	25.56803	26.85317	28.08075	29.25411	30.37638	31.45049	32.47918	33.46502	36.80694	39.98959	43.02247	45.91448	48.67394	51.30861	53.82577	51.43918	49.1904	47.07059	45.07149
90% Less Than	25.56817	26.85332	28.08091	29.25427	30.37655	31.45066	32.47936	33.46521	36.80715	39.98981	43.02271	45.91474	48.67422	51.30891	53.82608	51.43947	49.19067	47.07084	45.07171
95% Less Than	25.56825	26.85341	28.081	29.25437	30.37665	31.45077	32.47947	33.46532	36.80727	39.98995	43.02286	45.9149	48.67438	51.30908	53.82627	51.43964	49.19083	47.07099	45.07185

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5% Less Than	43.18458	41.40436	39.72326	38.13503	36.63382	35.2142	33.87109	32.59974	31.39571	30.25486	29.17333	28.14751	27.17402	26.24969	25.37158	24.53693	23.74315	22.98784	22.26872
10% Less Than	43.18471	41.40448	39.72337	38.13513	36.63392	35.21429	33.87117	32.59981	31.39578	30.25493	29.1734	28.14757	27.17407	26.24974	25.37163	24.53697	23.74319	22.98787	22.26876
25% Less Than	43.18486	41.40462	39.72349	38.13524	36.63402	35.21439	33.87126	32.5999	31.39585	30.255	29.17346	28.14763	27.17413	26.24979	25.37167	24.53702	23.74324	22.98791	22.26879
50% Less Than	43.1851	41.40485	39.72371	38.13544	36.63421	35.21456	33.87142	32.60004	31.39599	30.25512	29.17358	28.14774	27.17423	26.24988	25.37176	24.5371	23.74331	22.98798	22.26886
75% Less Than	43.18538	41.40511	39.72395	38.13566	36.63441	35.21475	33.8716	32.60021	31.39614	30.25527	29.17371	28.14786	27.17434	26.24999	25.37186	24.53719	23.74339	22.98806	22.26893
90% Less Than	43.1856	41.4053	39.72413	38.13583	36.63457	35.2149	33.87173	32.60033	31.39626	30.25537	29.17381	28.14795	27.17442	26.25007	25.37193	24.53725	23.74345	22.98812	22.26898
95% Less Than	43.18572	41.40542	39.72424	38.13593	36.63466	35.21498	33.87181	32.60041	31.39633	30.25544	29.17387	28.14801	27.17447	26.25011	25.37197	24.53729	23.74349	22.98815	22.26901

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
5% Less Than	21.58369	20.93076	20.30809	19.71392	19.14664	18.60472	18.08673	17.59132	17.11726	16.66335	16.22849	15.81164	15.41182	15.02813	14.6597	14.30573	13.96546	13.63816	13.32318
10% Less Than	21.58372	20.93079	20.30811	19.71394	19.14666	18.60474	18.08674	17.59134	17.11727	16.66336	16.2285	15.81165	15.41183	15.02814	14.65971	14.30574	13.96546	13.63817	13.32319
25% Less Than	21.58376	20.93082	20.30814	19.71397	19.14669	18.60476	18.08677	17.59136	17.11729	16.66338	16.22852	15.81166	15.41185	15.02816	14.65973	14.30575	13.96547	13.63818	13.3232
50% Less Than	21.58382	20.93088	20.30819	19.71402	19.14673	18.6048	18.0868	17.5914	17.11733	16.66341	16.22854	15.81169	15.41187	15.02818	14.65975	14.30577	13.96549	13.6382	13.32322
75% Less Than	21.58388	20.93094	20.30825	19.71407	19.14678	18.60485	18.08685	17.59144	17.11736	16.66344	16.22857	15.81172	15.4119	15.0282	14.65977	14.30579	13.96551	13.63822	13.32323
90% Less Than	21.58393	20.93099	20.30829	19.71411	19.14681	18.60488	18.08688	17.59147	17.11739	16.66347	16.2286	15.81174	15.41192	15.02822	14.65979	14.30581	13.96553	13.63823	13.32325
95% Less Than	21.58396	20.93101	20.30832	19.71413	19.14684	18.6049	18.0869	17.59148	17.1174	16.66348	16.22861	15.81175	15.41193	15.02823	14.6598	14.30582	13.96554	13.63824	13.32325

	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048
5% Less Than	13.01989	12.72768	12.446	12.17432	11.91216	11.65903	11.41451	11.17817	10.94963	10.72852	10.51449	10.30721	10.10637	9.911683	9.722867	9.539662	9.36182	9.189108	9.021306
10% Less Than	13.01989	12.72768	12.44601	12.17433	11.91216	11.65904	11.41451	11.17818	10.94964	10.72852	10.51449	10.30721	10.10637	9.911686	9.722869	9.539664	9.361822	9.18911	9.021307
25% Less Than	13.0199	12.72769	12.44601	12.17434	11.91217	11.65904	11.41452	11.17818	10.94964	10.72853	10.5145	10.30722	10.10638	9.911689	9.722872	9.539666	9.361825	9.189113	9.021309
50% Less Than	13.01992	12.7277	12.44602	12.17435	11.91218	11.65905	11.41453	11.17819	10.94965	10.72853	10.5145	10.30722	10.10638	9.911694	9.722877	9.539671	9.361829	9.189116	9.021313
75% Less Than	13.01993	12.72772	12.44604	12.17436	11.91219	11.65906	11.41454	11.1782	10.94966	10.72854	10.51451	10.30723	10.10639	9.9117	9.722882	9.539676	9.361833	9.189121	9.021317
90% Less Than	13.01994	12.72773	12.44605	12.17437	11.9122	11.65907	11.41454	11.1782	10.94966	10.72855	10.51452	10.30723	10.10639	9.911704	9.722886	9.53968	9.361837	9.189124	9.02132
95% Less Than	13.01995	12.72774	12.44605	12.17437	11.9122	11.65907	11.41455	11.17821	10.94967	10.72855	10.51452	10.30724	10.1064	9.911707	9.722889	9.539682	9.361839	9.189126	9.021322

	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067
5% Less Than	8.858202	8.6996	8.545311	8.395157	8.24897	8.106591	7.967866	7.832653	7.700815	7.572223	7.446752	7.324286	7.204713	7.087928	6.97383	6.862324	6.753317	6.646723	6.542459
10% Less Than	8.858204	8.699601	8.545312	8.395158	8.248972	8.106592	7.967867	7.832654	7.700816	7.572223	7.446752	7.324286	7.204714	7.087929	6.973831	6.862324	6.753317	6.646723	6.542459
25% Less Than	8.858206	8.699603	8.545314	8.39516	8.248973	8.106593	7.967869	7.832656	7.700817	7.572224	7.446753	7.324287	7.204715	7.08793	6.973832	6.862325	6.753318	6.646724	6.542459
50% Less Than	8.858209	8.699606	8.545316	8.395162	8.248975	8.106595	7.967871	7.832657	7.700819	7.572226	7.446755	7.324289	7.204716	7.087931	6.973833	6.862326	6.753319	6.646725	6.54246
75% Less Than	8.858213	8.699609	8.54532	8.395165	8.248978	8.106598	7.967873	7.83266	7.700821	7.572228	7.446757	7.32429	7.204717	7.087932	6.973834	6.862327	6.75332	6.646726	6.542461
90% Less Than	8.858215	8.699612	8.545322	8.395168	8.24898	8.1066	7.967875	7.832661	7.700823	7.572229	7.446758	7.324291	7.204719	7.087933	6.973835	6.862328	6.753321	6.646726	6.542462
95% Less Than	8.858217	8.699614	8.545323	8.395169	8.248981	8.106601	7.967876	7.832662	7.700824	7.57223	7.446759	7.324292	7.204719	7.087934	6.973836	6.862329	6.753321	6.646727	6.542462

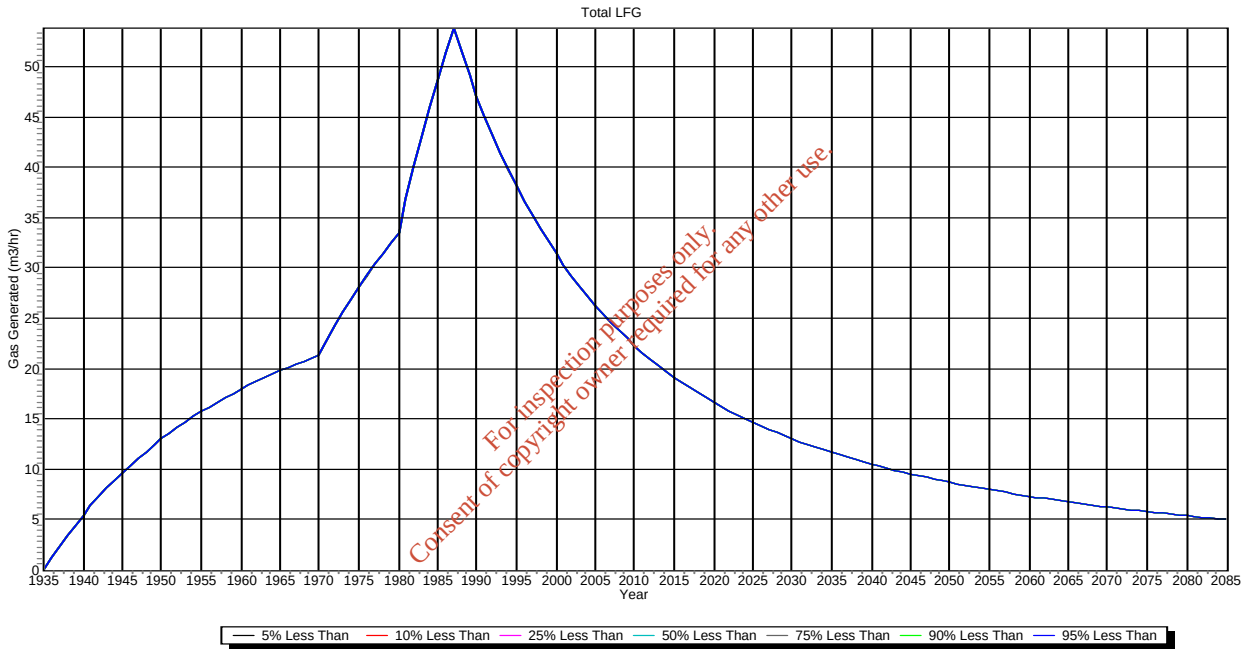
	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085
5% Less Than	6.440445	6.340608	6.242874	6.147176	6.053448	5.961626	5.871652	5.783469	5.697021	5.612256	5.529124	5.447578	5.367572	5.289061	5.212003	5.136358	5.062087	4.989153
10% Less Than	6.440446	6.340608	6.242875	6.147176	6.053448	5.961626	5.871653	5.783469	5.697021	5.612256	5.529125	5.447579	5.367572	5.289061	5.212003	5.136358	5.062088	4.989153
25% Less Than	6.440446	6.340609	6.242875	6.147177	6.053448	5.961627	5.871653	5.783469	5.697021	5.612256	5.529125	5.447579	5.367572	5.289061	5.212003	5.136359	5.062088	4.989154
50% Less Than	6.440447	6.34061	6.242876	6.147177	6.053449	5.961627	5.871653	5.78347	5.697021	5.612257	5.529125	5.447579	5.367573	5.289061	5.212004	5.136359	5.062088	4.989154
75% Less Than	6.440448	6.34061	6.242877	6.147178	6.053449	5.961628	5.871654	5.78347	5.697022	5.612257	5.529126	5.44758	5.367573	5.289062	5.212004	5.136359	5.062088	4.989154
90% Less Than	6.440449	6.340611	6.242877	6.147179	6.05345	5.961628	5.871654	5.78347	5.697022	5.612257	5.529126	5.44758	5.367573	5.289062	5.212004	5.136359	5.062088	4.989154
95% Less Than	6.440449	6.340611	6.242878	6.147179	6.05345	5.961629	5.871655	5.783471	5.697022	5.612258	5.529126	5.44758	5.367573	5.289062	5.212004	5.136359	5.062088	4.989154

GasSim Version V 2.00

Project Name: LFG Model for Churchtown Landfill Site

Project Client: Limerick County Council

Total: Total Bulk LFG Produced



CHURCHTOWN LANDFILL.gss 26/04/2012 14:34:58

ProjectDetails

Project Name	LFG Model for Churchtown Landfill Site
Client	Limerick County Council
Model	C:\Program Files\Golder Associates\GasSim2\churchtown landfill\CHURCHTOWN LANDFILL.gss
Model Date	26/04/2012 14:34:58
Comments	
Start Year	1935
Operation Period	52
Simulation Period	150
Iterations	201

Confined Migration Pathway

Waste Composition

Year	Composition
1935	England 2000-2010 waste streams
Newspapers	
Water (%)	SINGLE(30.0)
Cellulose (%)	SINGLE(48.5)
Hemi-Cellulose (%)	SINGLE(9.0)
Decomposition (%)	SINGLE(35.0)
Magazines	
Water (%)	SINGLE(30.0)
Cellulose (%)	SINGLE(42.3)
Hemi-Cellulose (%)	SINGLE(9.4)
Decomposition (%)	SINGLE(46.0)
Other paper	
Domestic	SINGLE(19.8)
Civic Amenity	SINGLE(3.3)
Commercial	SINGLE(28.8)
Industrial	SINGLE(8.8)
Water (%)	SINGLE(30.0)
Cellulose (%)	SINGLE(87.4)
Hemi-Cellulose (%)	SINGLE(8.4)
Decomposition (%)	SINGLE(98.0)
Liquid cartons	
Water (%)	SINGLE(30.0)
Cellulose (%)	SINGLE(57.3)
Hemi-Cellulose (%)	SINGLE(9.9)
Decomposition (%)	SINGLE(64.0)
Card packaging	
Water (%)	SINGLE(30.0)
Cellulose (%)	SINGLE(57.3)
Hemi-Cellulose (%)	SINGLE(9.9)
Decomposition (%)	SINGLE(64.0)
Other card	
Water (%)	SINGLE(30.0)
Cellulose (%)	SINGLE(57.3)
Hemi-Cellulose (%)	SINGLE(9.9)
Decomposition (%)	SINGLE(64.0)
Wood	
Domestic	SINGLE(3.0)
Civic Amenity	SINGLE(11.2)
Commercial	SINGLE(3.3)
Industrial	SINGLE(5.0)
Water (%)	SINGLE(20.0)
Cellulose (%)	SINGLE(21.0)
Hemi-Cellulose (%)	SINGLE(11.0)
Decomposition (%)	SINGLE(75.0)
Textiles	
Domestic	SINGLE(3.3)
Civic Amenity	SINGLE(2.3)
Commercial	SINGLE(1.1)
Industrial	SINGLE(0.3)
Water (%)	SINGLE(25.0)
Cellulose (%)	SINGLE(20.0)
Hemi-Cellulose (%)	SINGLE(20.0)
Decomposition (%)	SINGLE(50.0)
Disposable nappies	
Domestic	SINGLE(3.3)
Civic Amenity	SINGLE(2.9)
Water (%)	SINGLE(20.0)
Cellulose (%)	SINGLE(25.0)
Hemi-Cellulose (%)	SINGLE(25.0)
Decomposition (%)	SINGLE(50.0)
Other misc. combustibles	
Domestic	SINGLE(0.3)
Civic Amenity	SINGLE(4.2)

Commercial	SINGLE(10.4)
Industrial	SINGLE(17.7)
Water (%)	SINGLE(20.0)
Cellulose (%)	SINGLE(25.0)
Hemi-Cellulose (%)	SINGLE(25.0)
Decomposition (%)	SINGLE(50.0)
Garden waste	
Domestic	SINGLE(16.0)
Civic Amenity	SINGLE(32.1)
Commercial	SINGLE(9.8)
Industrial	SINGLE(4.7)
Water (%)	SINGLE(65.0)
Cellulose (%)	SINGLE(25.7)
Hemi-Cellulose (%)	SINGLE(13.0)
Decomposition (%)	SINGLE(62.0)
Other putrescible	
Domestic	SINGLE(25.6)
Civic Amenity	SINGLE(14.8)
Commercial	SINGLE(10.4)
Industrial	SINGLE(6.8)
Water (%)	SINGLE(65.0)
Cellulose (%)	SINGLE(55.4)
Hemi-Cellulose (%)	SINGLE(7.2)
Decomposition (%)	SINGLE(76.0)
10mm fines	
Domestic	SINGLE(4.1)
Civic Amenity	SINGLE(1.2)
Commercial	SINGLE(1.9)
Industrial	SINGLE(0.5)
Water (%)	SINGLE(40.0)
Cellulose (%)	SINGLE(25.0)
Hemi-Cellulose (%)	SINGLE(25.0)
Decomposition (%)	SINGLE(50.0)
Sewage sludge	
Sewage Sludge	SINGLE(100.0)
Water (%)	SINGLE(70.0)
Cellulose (%)	SINGLE(14.0)
Hemi-Cellulose (%)	SINGLE(14.0)
Decomposition (%)	SINGLE(75.0)
Composted organic material	
Composted Organic Material	SINGLE(100.0)
Water (%)	SINGLE(30.0)
Cellulose (%)	UNIFORM(7.47, 9.59)
Hemi-Cellulose (%)	UNIFORM(7.47, 9.59)
Decomposition (%)	SINGLE(57.0)
Incinerator ash	
Commercial	SINGLE(0.2)
Industrial	SINGLE(25.5)
Incinerator Ash	SINGLE(100.0)
Water (%)	SINGLE(30.0)
Cellulose (%)	TRIANGULAR(0.5, 0.7, 1.5)
Hemi-Cellulose (%)	TRIANGULAR(0.5, 0.7, 1.5)
Decomposition (%)	SINGLE(57.0)
Non degradable	
Domestic	SINGLE(24.6)
Civic Amenity	SINGLE(28.0)
Commercial	SINGLE(34.1)
Industrial	SINGLE(30.7)
Inert	SINGLE(100.0)
Water (%)	SINGLE(0.0)
Cellulose (%)	SINGLE(0.0)
Hemi-Cellulose (%)	SINGLE(0.0)
Decomposition (%)	SINGLE(0.0)
Calcium Sulphate (%)	
Domestic	TRIANGULAR(0.2, 0.35, 2.3)
Civic Amenity	TRIANGULAR(0.2, 0.35, 2.3)
Composted Organic Material	TRIANGULAR(0.2, 0.35, 2.3)
Incinerator Ash	TRIANGULAR(0.2, 0.35, 2.3)
Residues from MRF	TRIANGULAR(0.2, 0.35, 2.3)
Recycling Schemes	TRIANGULAR(0.2, 0.35, 2.3)
Chemical Sludge	TRIANGULAR(0.2, 0.35, 2.3)
Industrial Liquid Waste	TRIANGULAR(0.2, 0.35, 2.3)
Iron (%)	
Domestic	TRIANGULAR(0.3, 4.8, 8.2)
Civic Amenity	TRIANGULAR(0.3, 4.8, 8.2)
Commercial	TRIANGULAR(0.3, 4.8, 8.2)
Industrial	TRIANGULAR(0.3, 4.8, 8.2)
Inert	TRIANGULAR(0.3, 4.8, 8.2)
Liquid Inert	TRIANGULAR(0.3, 4.8, 8.2)
Sewage Sludge	TRIANGULAR(0.3, 4.8, 8.2)
Composted Organic Material	TRIANGULAR(0.3, 4.8, 8.2)

Incinerator Ash		TRIANGULAR(0.3, 4.8, 8.2)
Residues from MRF		TRIANGULAR(0.3, 4.8, 8.2)
Recycling Schemes		TRIANGULAR(0.3, 4.8, 8.2)
Chemical Sludge		TRIANGULAR(0.3, 4.8, 8.2)
Industrial Liquid Waste		TRIANGULAR(0.3, 4.8, 8.2)
User Defined 1		TRIANGULAR(0.3, 4.8, 8.2)
User Defined 2		TRIANGULAR(0.3, 4.8, 8.2)
User Defined 3		TRIANGULAR(0.3, 4.8, 8.2)
1936		England 2000-2010 waste streams
1937		England 2000-2010 waste streams
1938		England 2000-2010 waste streams
1939		England 2000-2010 waste streams
1940		England 2000-2010 waste streams
1941		England 2000-2010 waste streams
1942		England 2000-2010 waste streams
1943		England 2000-2010 waste streams
1944		England 2000-2010 waste streams
1945		England 2000-2010 waste streams
1946		England 2000-2010 waste streams
1947		England 2000-2010 waste streams
1948		England 2000-2010 waste streams
1949		England 2000-2010 waste streams
1950		England 2000-2010 waste streams
1951		England 2000-2010 waste streams
1952		England 2000-2010 waste streams
1953		England 2000-2010 waste streams
1954		England 2000-2010 waste streams
1955		England 2000-2010 waste streams
1956		England 2000-2010 waste streams
1957		England 2000-2010 waste streams
1958		England 2000-2010 waste streams
1959		England 2000-2010 waste streams
1960		England 2000-2010 waste streams
1961		England 2000-2010 waste streams
1962		England 2000-2010 waste streams
1963		England 2000-2010 waste streams
1964		England 2000-2010 waste streams
1965		England 2000-2010 waste streams
1966		England 2000-2010 waste streams
1967		England 2000-2010 waste streams
1968		England 2000-2010 waste streams
1969		England 2000-2010 waste streams
1970		England 2000-2010 waste streams
1971		England 2000-2010 waste streams
1972		England 2000-2010 waste streams
1973		England 2000-2010 waste streams
1974		England 2000-2010 waste streams
1975		England 2000-2010 waste streams
1976		England 2000-2010 waste streams
1977		England 2000-2010 waste streams
1978		England 2000-2010 waste streams
1979		England 2000-2010 waste streams
1980		England 2000-2010 waste streams
1981		England 2000-2010 waste streams
1982		England 2000-2010 waste streams
1983		England 2000-2010 waste streams
1984		England 2000-2010 waste streams
1985		England 2000-2010 waste streams
1986		England 2000-2010 waste streams
Justification:	[Default]	Default Value

Trace Gases

No Combustion Products Selected

Waste Body

Infiltration		UNIFORM(400.0, 450.0)
Justification:	[Changed]	Not Justified

Waste Input

Year	AmountDepositied (t)
1935	SINGLE(2.50E+03)
1936	SINGLE(2.50E+03)
1937	SINGLE(2.50E+03)
1938	SINGLE(2.50E+03)
1939	SINGLE(2.50E+03)
1940	SINGLE(2.50E+03)
1941	SINGLE(2.50E+03)
1942	SINGLE(2.50E+03)
1943	SINGLE(2.50E+03)
1944	SINGLE(2.50E+03)
1945	SINGLE(2.50E+03)

1946		SINGLE(2.50E+03)
1947		SINGLE(2.50E+03)
1948		SINGLE(2.50E+03)
1949		SINGLE(2.50E+03)
1950		SINGLE(2.50E+03)
1951		SINGLE(2.50E+03)
1952		SINGLE(2.50E+03)
1953		SINGLE(2.50E+03)
1954		SINGLE(2.50E+03)
1955		SINGLE(2.50E+03)
1956		SINGLE(2.50E+03)
1957		SINGLE(2.50E+03)
1958		SINGLE(2.50E+03)
1959		SINGLE(2.50E+03)
1960		SINGLE(2.50E+03)
1961		SINGLE(2.50E+03)
1962		SINGLE(2.50E+03)
1963		SINGLE(2.50E+03)
1964		SINGLE(2.50E+03)
1965		SINGLE(2.50E+03)
1966		SINGLE(2.50E+03)
1967		SINGLE(2.50E+03)
1968		SINGLE(2.50E+03)
1969		SINGLE(2.50E+03)
1970		SINGLE(5.00E+03)
1971		SINGLE(5.00E+03)
1972		SINGLE(5.00E+03)
1973		SINGLE(5.00E+03)
1974		SINGLE(5.00E+03)
1975		SINGLE(5.00E+03)
1976		SINGLE(5.00E+03)
1977		SINGLE(5.00E+03)
1978		SINGLE(5.00E+03)
1979		SINGLE(5.00E+03)
1980		SINGLE(1.00E+04)
1981		SINGLE(1.00E+04)
1982		SINGLE(1.00E+04)
1983		SINGLE(1.00E+04)
1984		SINGLE(1.00E+04)
1985		SINGLE(1.00E+04)
1986		SINGLE(1.00E+04)
Justification:	[Changed]	Not Justified

Waste Breakdown

1935		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1936		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1937		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1938		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1939		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1940		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1941		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1942		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1943		
Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
1944		
Domestic		SINGLE(33.5)

Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1945	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1946	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1947	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1948	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1949	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1950	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1951	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1952	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1953	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1954	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1955	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1956	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1957	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1958	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1959	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1960	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1961	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1962	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1963	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1964	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)

Inert	SINGLE(33.0)
1965	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1966	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1967	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1968	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1969	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1970	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1971	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1972	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1973	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1974	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1975	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1976	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1977	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1978	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1979	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1980	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1981	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1982	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1983	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)
1984	
Domestic	SINGLE(33.5)
Commercial	SINGLE(33.5)
Inert	SINGLE(33.0)

1985

Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)

1986

Domestic		SINGLE(33.5)
Commercial		SINGLE(33.5)
Inert		SINGLE(33.0)
Justification:	[Default]	Default Value

Trace Gases

No Trace Gases Selected

Waste Moisture Content

Moisture Content		Dry
Justification:	[Changed]	Not Justified
Waste Density		SINGLE(0.7)
Justification:	[Changed]	Not Justified
Leachate Head		UNIFORM(1.0, 1.5)
Justification:	[Changed]	Not Justified
Hydraulic Conductivity		LOGUNIFORM(1.00E-09, 1.00E-05)
Justification:	[Default]	Default Value

Engineered Controls

Cap		None
Justifications		
Cap	[Changed]	Not Justified
Cap Thickness	[Changed]	Not Justified
Cap Hydraulic Conductivity	[Changed]	Not Justified
liner		None
Justifications		
Liner	[Default]	Default Value
Liner Thickness	[Changed]	Not Justified
Liner Hydraulic Conductivit	[Changed]	Not Justified
Justification:	[Default]	Default Value
Methane Oxidation %		SINGLE(10.0)
Justification:	[Default]	Default Value
Land Raise Depth		#UNDEFINED?

Geosphere

Ground Surface (mAOD)	70
Water Table (mAOD)	66
Geosphere Moisture Content	UNIFORM(2.0, 8.0)
Geosphere Porosity	UNIFORM(14.0, 49.0)

Site Characteristics

Proportion to CO2 [%]		SINGLE(50.0)
Justification:	[Default]	Default Value
Proportion to CH4 [%]		SINGLE(50.0)
Justification:	[Default]	Default Value

Cellulose Decay Rates

		Dry	Average	Wet
Slow		SINGLE(0.013)	SINGLE(0.046)	SINGLE(0.076)
Moderate		SINGLE(0.046)	SINGLE(0.076)	SINGLE(0.116)
Fast		SINGLE(0.076)	SINGLE(0.116)	SINGLE(0.694)
Justification:	[Default]	Default Value		

Gas Plant

No Flares/Engines in use

Engine/Flare Order	[Changed]	Not Justified

Trace Gas Plant

No Trace Gases Selected

Justification:	[Default]	Default Value

Global Impact

Bulk Gases

Global Warming Potential		
Carbon Dioxide [t]:		1
Methane [t carbon dioxoide]:		25
Hydrogen [t carbon dioxide]:		0
Justification:	[Default]	Default Value
Ozone Depletion Potential		
Carbon Dioxide [t trichlorofluoromethane]		0
Methane [t trichlorofluoromethane]:		0
Hydrogen [t trichlorofluoromethane]:		0
Justification:	[Default]	Default Value

Lateral Migration

Bulk Gases

Air Diffusion Coefficients	
CO2 Dispersivity	SINGLE(0.1613)

CH4 Dispersivity		SINGLE(0.2192)
H2 Dispersivity		#UNDEFINED?
Justification:	[Default]	Default Value
Geosphere		
Cell		Waste Body
Geosphere Moisture Content		UNIFORM(2.0, 8.0)
Geosphere Porosity		UNIFORM(14.0, 49.0)
Justification:	[Changed]	Not Justified

Exposure

Scenario:	Residential without Plant Uptake
Year:	1935
Distance from boundary [m]:	0
Direction:	North East
Emissions to model:	1,1,1,2-Tetrafluorochloroethane
Gas Viscosity [N.hr/m2]:	0.000000005
Henry's law constant:	0
Soil Type:	Loam
Soil Organic Matter [%]:	5
Wind speed above ground surface in ambient mixing zone [cm/s]:	12
Depth below ground to contaminated source zone [cm]:	1
Building Characteristics	
Area of walls in living space [m2]:	186
Area of windows [m2]:	20
Area of floor [m2]:	74.1
Height of Living space [m]:	5.4
Air exchange rate (total exchanges per hour)	1
Perimeter of building [m]:	34.4
Air pressure inside house [Pa]:	101321.5
Area of house walls in cellar [m2]:	6.88
Height of subfloor void [m]:	0.5
Air pressure inside subfloor void [Pa]:	101325
Temperature inside house [C]:	565
Floor resistance [NH/m3]:	27.8
Average height of all openings [m]:	2

Building Materials

Material	Total Porosity [cm3/cm3]	Air-filled porosity [cm3/cm3]	Thickness [m]
Hardcore	0.5	0.25	0.1
Blinding Sand	0.5	0.5	0.05
Concrete	0.068	0.034	0.1
Insulating layer (floors)	0.9	0.9	0.05
Brick (external walls)	0.5	0.25	0.1
Lightweight block (walls)	0.068	0.068	0.1
Insulating layer (walls)	0.9	0.9	0.055
Plasterboard (ceiling)	0.068	0.068	0.0125
Insulating layer (roof)	0.9	0.9	0.1
Screed (over beam/block floor)	0.068	0.068	0.05
Suspended timber floor	0.2	0.2	0.03
Justification: [Default]	Default Value		

Appendix 12

Appropriate Assessment

Limerick County Council

Limerick County Council.

Churchtown Landfill Remediation Works.

Appropriate Assessment: Screening Document.

February 2013.

Appropriate Assessment Screening –Churchtown Land Fill

The Appropriate Assessment Screening Document is for the remedial works at the old Churchtown Landfill Newcastlewest Co. Limerick. Included with this screening report is an ecological survey which was carried out in December 2012. Though outside the optimum season for vegetation and wildlife surveys, it was possible to identify plants species vegetatively.

The overall conclusion of the screening is that a full Appropriate Assessment **is not required** due to limited nature of the works involved i.e. only 1 ha. in area and the distance from Natura 2000 sites. In addition as the works are remedial measures designed to deal with leachate from a disused land fill it is expected that local environmental improvements will take place. The works are outlined below.

The screening is in accordance with the requirements of Article 6(3) of the EU Habitats Directive (92/43/EEC). The principal consideration for an Appropriate Assessment would be if the remedial works were likely to have significant effects on a Natura 2000 site – Special Areas of Conservation and Special Protection Areas (SACs and SPAs) are Natura sites. The screening should be read with the Geophysical Survey of March 12th 2012 to hand. The ecological report drawn up following site visits in December 2012 is included in Appendix 1.

The first site in question is the Lower River Shannon Special Area of Conservation Site (002165), the closest part of which is the Galey River which is 7.2km distant. The landfill also lies within 4km of the Mullaghreirks Mountains, West Limerick hills and Mount Eagle SPA (004161) which is composed of a number of upland habitats forestry at different stages of growth, open moorland rough grassland and some unplanted peat based habitats. These provide foraging and nesting sites for the hen harrier for which the site has been designated. Due to the very specific and localised works to be carried out to the old landfill site it is considered that the works will have no effects on the Special Protection Area. The works are described in the next section.

Screening Matrix

Brief description of the project:
The proposed works are remedial works on the Churchtown land fill. These works involve the diversion of leachate and run off from the old waste body to a sump on the lowest part of the site. This is then pumped to the Newcastlewest Waste Water Treatment Plant. Additional works involve the arrangement of covering materials over the waste body and the installation of water sampling and monitoring points on site.
Brief description of the Natura 2000 sites:
The water based site closest to the landfill is the Lower River Shannon SAC site, designated for a range of riparian habitats and species. The Galey River is one of the tributaries within the Feale catchment area, which is an important component of the Lower River Shannon site. The overall ecological quality of the site is heavily dependant on good water quality. The site has variety of habitats and is important for spawning salomonids and lamprey. The site is within 4km of the Mullaghreirks Mountains, West Limerick hills and Mount Eagle SPA (004161)

which is composed of a number of upland habitats, forestry at different stages of growth, open moor land rough grassland and some unplanted peat based habitats. These provide foraging and nesting sites for the hen harrier for which the SPA site has been designated.

Describe the individual elements of the project (either alone or in combination with other plans or projects) likely to give rise to impacts on the Natura 2000 site:

The works are not likely to cause any effects on the Natura 2000 sites due to distance from the sites and the limited nature of the works involved. By dealing with contaminants from the landfill it is expected that local environmental improvements will result.

The main way in which impacts could be created on the SAC site is through the introduction of pollutants or sediments which would have an effect on water quality but as outlined above the works are designed to deal with the issue of leachate from the old waste body.

Describe any likely direct, indirect or secondary impacts of the project (either alone or in combination with other plans or projects) on the Natura 2000 site by virtue of:

- **Size and scale;**

  The area taken in by works and machinery traversing and activities on site is expected to be in the region of 1 ha. The site is outside designated sites and is 4km distance from the nearest Natura 2000 site.

- **Land-take;**

  No land take implications- see above.

- **Distance from Natura 2000 site or key features of the site;**

The land fill is 4km from the SPA site and 7.2km from the SAC site.

- **Resource requirements (water abstraction etc);**

There are no resource implications. It is not anticipated that any extraction of material –rock etc or soil or abstraction of water would take place from any designated site. Stone may be used in the remedial works but will be taken from quarries that have planning permission or have consent under S261 or S261A. In this case the stones will be from established and licensed quarries. These quarries are governed by planning permissions or conditions laid down under the quarry registration process.

- **Emission (disposal to land, water or air);**

There is the risk of sediment or pollutants being released to ground water. Kiely (1997, p. 221) indicates that ground water pollution events tend to be localised and due to high levels of re-charge (through rainfall) tend to be of short term duration. Given the distance from the landfill to the SAC site the risk is further minimised. Two sets of water sample results, the latest from Jan 2013, indicate that the pollutant levels are not a cause for concern as they are not in concentrations which will have an effect on the Lower River Shannon SAC site. It also seems to be the case that pollutant emissions seem to be particularly dilute as the waste body has been in place for many years- see Geophysical Report. In addition there are no permanent water courses on the site which futher reduces the chances of transmission of pollutants. Inspection of nearby land drains in December 2013, down-slope from the land fill, did not show any indications of leachate escaping from the site.

- **Excavation requirements;**

Any excavation that may take place within the land fill would be at a distance from the SAC site. Most works will consist of the re-arrangement of material to better cap the landfill, rather than excavation of the land fill waste body itself. This will minimise the disturbance to the residual waste thereby lessening any leakage of contaminants. The clearing of channels to divert any leachate to a sump and thence to the Waste Water Treatment Plant has been mentioned above. Sediment traps in these channels would also help to control run off of sediment.

Transportation requirements;

Plant and trucks will be involved in bringing the material to the site and removal of material. With traffic movement confined to the roads there will not be transport effects on the water courses or drainage features nearby.

- **Duration of construction, operation, decommissioning, etc;**

18 months- monitoring will be on going.

- **Other**

Not applicable.

Describe any likely changes to the site arising as a result of :

- **reduction of habitat area:**

None- the works are to a previously existing landfill and will not result in any further development outside the existing foot print of the Churchtown landfill.

- **habitat or species fragmentation;**

Given the location of the works-on the old land fill site and 7 km from the Lower River Shannon Sac site and 4.2km from the SPA no effects on these sites are likely.

- **reduction in species density;**

Not applicable in that the landfill is outside and at a distance from Natura 2000 sites and would have any ex-situ effects as the scale of works is limited and measures are in place to reduce run off from the site.

- **changes in key indicators of conservation value**

None-see point above.

.

- **Climate change:**

No implications for climate change due to limited scale of the works.

Describe any likely impacts on the Natura 2000 site as a whole in terms of:

- **interference with the key relationships that define the structure of the site;**

None, the land fill lies outside the SPA and SAC the works are limited in scale. In relation to the SAC site, both the limited scope of the works allied to distance and mitigation measures (diversion and treatment of leachate) are expected to ensure that there will not be any significant effects on the SAC site.

- **interference with key relationships that define the function of the site;**

See above.

Provide indicators of significance as a result of the identification of effects set out above in terms of:

- **loss;**

Not applicable.

- **Fragmentation;**

Not applicable.

- **Disruption;**

Not applicable.

- **Disturbance;**

Not applicable.

- **change to key elements of the site (e.g. water quality etc);**

Not applicable. The mitigation measures mentioned above, treatment of leachate.

Describe from the above those elements of the project or plan, or combination of elements, where the above impacts are likely to be significant or where the scale or magnitude of impacts are not known.

It is not likely that any combination of elements will have effects as the landfill is outside the Special Protection Area and SAC site. The small scale of works is not likely to have any effects on the Lower River Shannon as they are confined to the landfill itself. It is considered that a full Appropriate Assessment is not required. The works are designed to rehabilitate an old land fill which by reducing pollution risk would lessen chances of ecological damage.

Finding of No Significant Effects Matrix

Name of Project:	Remedial works on disused land fill at Churchtown Newcastlewest. .
Name and location of Natura 2000 sites:	Mullaghreirks Mountains, West Limerick hills and Mount Eagle SPA (004161) within 4km. Lower River Shannon SAC site 002165, the bridge is located within the SAC site.
Description of the Project or Plan	The proposed works are remedial works on the Churchtown land fill. These works involve the diversion of leachate and run off from the old waste body to a sump on the lowest part of the site. This is then pumped to the Newcastlewest Waste Water Treatment Plant. Additional works involve the arrangement of covering materials over the waste body and the installation of water sampling and monitoring points on site.
Is the Project or Plan directly connected with or necessary to the management of the site (provide details) ?	No, but the works will lessen the chances of local pollution to ground water.
Are there other projects or plans that together with the project of plan being assessed could affect the site (provide details)?	There are no other projects current on the land fill.
The Assessment of Significance of Effects	
Describe how the project or plan (alone or in combination) is likely to affect the Natura 2000 sites:	Unlikely to have any effects as the works involve the rehabilitation of an old land fill site, directing run off to the local WWTP and re-arrangement of the cover material on the site.
Explain why these effects are not considered significant:	See report above. Main factors are distance from the Natura 2000 sites and the limited scale of the works, the treatment of the leachate and the lack of surface water drainage features which would carry pollutants to the SAC site.
List of Agencies Consulted: Provide contact name and telephone or email address:	*The Manager, Development Applications Unit DoEHLG* *Newtown Road, Wexford.*

	(T: 053 9117382)
Response to consultation	*Awaited.*

Data Collected to Carry out the Assessment			
Who carried out the Assessment?	**Sources of Data**	**Level of assessment Completed**	**Where can the full results of the assessment be accessed and viewed**
Heritage Officer, Forward Planning Section, Limerick County Council.	*Existing NPWS Site Synopses* *Site visits and site surveys. .*	*Desktop study, site visits*	*The conclusions are included in the screening document and the site report is attached in an Appendix to this document.*

Appendix One: Site report.

CHURCHTOWN LAND FILL ECOLOGICAL SURVEY

TO: B MURPHY SEE

FROM: T O NEILL HO

SUBJECT: AS ABOVE

SITE VISIT: 11/12/12.

DATE: 8/2/2013.

Site description and location: the site is a disused land fill which ceased operation in 1986 after operating for approximately 30 years. Prior to this it was limestone quarry which ceased operations about 1930. It is 1.7ha in extent and slopes from the NE to the SW. The on site vegetation has been largely disturbed by machinery which has bored monitoring wells on site. It is located to the north west of Newcastlewest immediately outside the boundary of the LAP.

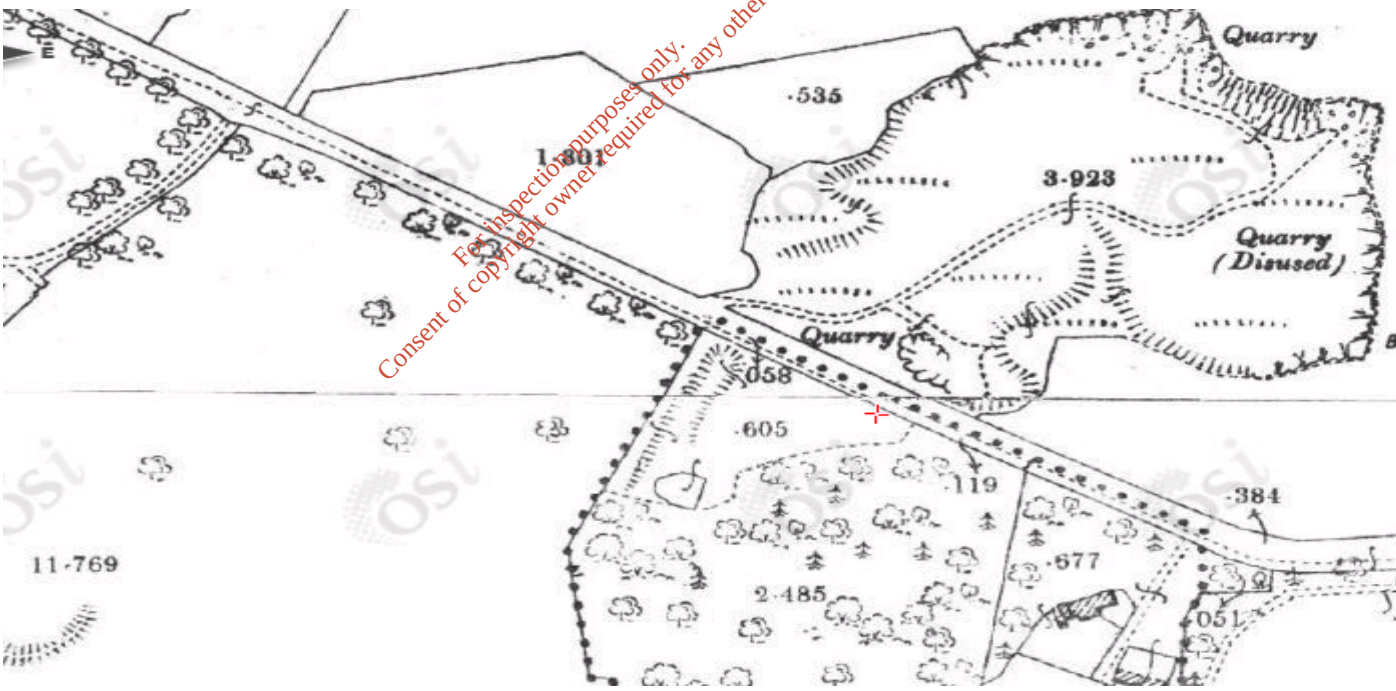


Figure 1: 1890 25 inch map of the quarry.

Drainage: there are a small number of surface drainage ditches on site. The most important are those to the south west boundary of the site as much of the site drains to this area. There is a sump constructed in this area to which water and leachate can drain which is then pumped to a foul sewer for treatment. Due to the levels in the drainage ditches no liquid was draining off the site at the time of the site visit-see Figure 1 below.

There are locally wet spots in the land fill, these are located for the most part on the western sides of the site and occur where the soil layer does not allow water to percolate down wards. These areas are used by snipe as feeding areas.

One other drain occurs at the rear of the houses to east of the entrance gateway, this is a shallow drain and is partially filled with water. The drains and wet spots are notable in what is an elevated and well drained site. They are seasonal and would be likely to dry up in summer. The drains do not look as if they contained leachate. Examination of nearby farm drains down slope and outside the e Land fill did not show the presence of leachate.

On site vegetation: much of the site has been cleared due to works which include the construction of bore holes to monitor ground water. The remainder of the site has covering of ruderal vegetation with high proportion of nettles (*Urtica dioica*) reflecting the nutrient rich mature of the soil covering. The site has been used for grazing by horses. Thistles (*Cirsium arvense*) and Rosebay Willow Herb (*Chamerion angustifolium*) were also present on the site, with soft rush (*Juncus effuses*) in the wetter locations mentioned above. Some patches of scrub remain composed of mixes of Ash (*Fraxinus excelsior),* Rusty Willow (*Salix cinera* subsp. *Oleifolia*) and Sycamore (*Acer pseudoplatanus*). These remain towards the centre and east of the site.

Grasses had also colonised the site with common species such as Cocksfoot (*Dactylis glomerata*) while in the wetter areas with rushes and smaller amounts of Reed Canary grass (*Phalaris arundinaceae*) present. Photographs of the site prior to works showed it to be fully vegetated with species such as Angelica (*Angelica Sylvestris*) on damper parts of the site with Docks *(Rumex crispus*), Ragworth *(Senecio jacobea*) and Plantains

Figure 2: the outlet from the site is shown in the top centre of the photo. The fall in the drain is back towards the site itself and towards a sump constructed in the western boundary area of the landfill.

Soils: The site has a covering of mineral soil of varying depth of between 4 and 10 cm. Beneath this there is layer of stone which had been used as covering material over the waste body. The underlying geology of the land fill site is described as

On site birds: Birds on site were snipe, blackbird, jackdaw and robin and wood pigeon which overflying the site. No nests were seen in any tree or shrub within the site. Rooks nests were seen on nearby trees outside the site to the south.

Adjacent land: land to the north and west is improved grassland used for grazing by horses. The southern boundary is a roadway, while to the east is housing with gardens backing onto the site.

Ground layer: beneath the tree lined hedges the ground layer was ivy (*Hedera helix*) and Brambles (*Rubus fruticosus*) which formed an impenetrable layer in parts.

Trees/hedgerows: the Southern boundary is a mature tree line with Cypress forming the tree layer with an understory of whitethorn. The road side bank is covered with ivy. Mixed with the Cypress are Ash and Sycamore. To the east of the entrance gate timber panelling provides a boundary which farther east leads to row of Cypress, with sycamore and willow present in side them.

The eastern boundary is a mix of garden fencing and open space, while the northern boundary is an open boundary with limited growth of Whitethorn. The eastern boundary consists of mature cypress tress with a drain on the inside.

On site habitats: presently the predominant habitat is presently disturbed ground (Spoil and Bare Ground ED2) while on the fringes of the site, towards the roadside edge. The cypress from a treeline (WL2). There are isolated patches of Scrub with willow present (Salix Spp.) These would correspond with habitat category WS1. Drainage ditches are also present (FW4).

Local Habitat Importance of the site: none of the on site habitats have any links with annex habitats and are of types that are available in the wider countryside. Despite this the presence of an area which if allowed to regenerate naturally and would have a local seed bank with a low intensity management regime would be beneficial and of local importance particularly on the outskirts of an urban area.

Additional comments: the site has been heavily disturbed with large areas of bare soil caused by machinery traffic. Some of the scrub growth on the site had been cleared way during works. No signs of badgers or other animal dwellings were found on site. The surrounding fields to the north and west were also checked for signs of badgers e.g. tracks or latrines or feeding signs, none were found.

Recommendation: following remedial works that vegetation be allowed to regenerate naturally on site. When the grass land layer has developed it would be possible to allow limited grazing, which prevent regeneration of scrub but would also allow structural diversity in the sward which would be useful for invertebrates and small mammals. .

_____

T O Neill HO.