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NORTH KERRY LANDFILLS

TIER 3 RISK ASSESSMENT
HISTORIC LANDFILL AT LENAMORE, CO. KERRY

Prepared for: Kerry County Council

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Abstract: This report represents the findings of a Tier 3 risk assessment carried out on Lenamore Historic Landfill site, Co. Kerry, and conducted in accordance with the EPA Code of Practice for unregulated landfill sites following a review of findings from earlier Tier 1 and Tier 2 site investigations and risk assessments.

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 Overview 1

1.2 Tier 1 Risk Classification 1

1.3 Tier 2 Site Investigation 2

1.4 Tier 2 Risk Classification and Tier 2 SPRs 3

1.4.1 Leachate migration through surface water pathway (SPR8) 4

1.4.2 Leachate migration through combined groundwater and surface water pathways (SPR1) 5

2. TIER 3 QUANTITATIVE RISK ASSESSMENT SCOPE OF WORKS 6

2.1 Tier 3 Overview 6

3. DETAILED QUANTITATIVE RISK ASSESSMENT (DQRA) 7

3.1 Detailed Quantitative Risk Assessment 7

3.2 Existing Geological and Hydrogeological Environment 7

3.3 Gurteennacloona Stream 7

3.4 Revised Conceptual Site Model (CSM) 8

3.5 Historic Landfill Contaminants of Concern 10

3.6 Impact of Leachate on Groundwater 10

3.6.1 Potential Leachate Generation 10

3.7 Impact of Leachate on Receiving Groundwater 11

3.7.1 Results – EA UK Remedial Targets Worksheet 13

3.7.2 Discussion of Results 14

3.8 Impact of Leachate on Receiving Surface Water 14

3.8.1 Surface Water Assimilative Capacity Assessment 15

3.8.2 Potential Impacts of Leachate Breakouts on Receiving Surface Waters 15

3.8.3 Mass Balance Assessment 16

3.8.4 Discussion of Results 17

3.9 Landfill Gas assessment – LandGEM 17

3.9.1 Results - LandGEM 19

3.9.2 Discussion of Results 20

4. SUMMARY FINDINGS AND RECOMMENDATIONS 22

4.1 Summary Findings 22

4.1.1 Overview 22
4.1.2 Surface Water..22
4.1.3 Groundwater 23
4.1.4 Landfill Gas 23
4.2 Recommendations..23
5. REMEDIAL ACTION PLAN 25
5.1 Overview of the Risks 25
5.1.1 Summary Findings 25
5.1.2 Surface Water Monitoring Infrastructure 27
5.1.3 Groundwater Monitoring Infrastructure..27
5.1.4 Proposed Groundwater and Surface Water Monitoring Regime..27
5.1.5 Proposed Gas Monitoring Regime 29
5.2 Remediation Cost Estimates..29

LIST OF APPENDICES

Appendix 1: EA UK Remedial Targets Worksheet
Appendix 2: Surface Water Assimilative Capacity Assessment
Appendix 3: LandGEM Model Summary Report

LIST OF FIGURES

Page

Figure 3-1: Revised Conceptual Site Model ... 9
Figure 3-2: LandGEM Landfill Gas Volume Generation Rate ... 20
Figure 5-1: Proposed Surface and Groundwater Monitoring Locations ... 26

LIST OF TABLES

Table 1-1: Tier 1 SPR Linkages (2007) ... 1
Table 1-2: Tier 2 Selected SPR Linkages ... 3
Table 3-1: Modelled Downstream Concentrations (UK EA Remedial Targets Worksheet) ... 11
Table 3-2: Modelled Downstream Concentrations (UK EA Remedial Targets Worksheet) ... 13
Table 3-3 Assimilative Capacity Calculation ... 15
Table 3-4: Mass Balance Calculation ... 16
Table 3-5: Potential Impacts of Leachate Breakouts on Assimilative Capacity of Receiving Downstream Waters ... 16
Table 3-6: Well Gas Monitoring Results October 2019 ... 18
Table 3-7: LandGEM Model Inputs ... 18
Table 3-8: Estimated landfill Gases Generated (2019 and 2029) ... 19
Table 3-9: Estimated gases generated/released per m^3 (2019) ... 20
Table 5-1: Parameters for Monitoring of Groundwater, Surface Water and Leachate ... 28
Table 5-2: Engineers Estimate for Additional Monitoring Infrastructure ... 30

1. INTRODUCTION

1.1 Overview

Fehily Timoney and Company (FT) was appointed by Kerry County Council to carry out and prepare a Tier 3 risk assessment for Lenamore Historical landfill located at Lenamore, Co. Kerry. This Tier 3 makes reference to the:

- Tier 1 risk assessment findings and classifications (2007 and 2013).
- Tier 2 Site investigation, testing and risk assessment (2020).

The Tier 3 assessment was carried out in accordance with the Environmental Protection Agency (EPA) Code of practice (CoP) - Environmental Risk Assessment for Unregulated Waste Disposal Sites guidance document.

1.2 Tier 1 Risk Classification

Kerry County Council prepared a Tier 1 risk assessment in 2007. This risk assessment determined that the site was a moderate (Class B) risk to the receiving environment. Applying the EPA risk assessment tool as per the EPA CoP Risk Assessment for Unregulated Waste Disposal Sites yielded a highest risk score of 50% for source-pathway-receptors (SPR) linkage SPR8. A summary of the risks is presented below in Table 1.1.

The Tier 1 risk assessment was reviewed by KCC in 2013. Risk scores were assessed and recalculated, and the site was reduced from a moderate risk to a low risk. The 2007 and 2013 risk scores are included in Table 1-1.

Table 1-1 normalised scores for 2007 and 2013. These have been provided for reference purposes and reflect current public records as per the EPA Section 22 register, which as of April 2021 present the 2007 Tier 1 assessment scores.

Table 1-1: Tier 1 SPR Linkages (2007)

SPR No.	Linkage	Normalised Score	Justification
Leachate migration through combined groundwater and surface water pathways			
SPR1	Leachate => surface water	25% (2007) 0% (2013)	SW body within 50m of site boundary
SPR2	Leachate => SWDTE	0% (2007) 0% (2013)	No connection to protected area
Leachate migration through groundwater pathway			
SPR3	Leachate => human presence	6.25% (2007) 6% (2013)	Dwelling house approx. 350m away

SPR No.	Linkage	Normalised Score	Justification
SPR4	Leachate => GWDTE	0% (2007) 0% (2013)	The nearest groundwater source protection zone (SPZ) is located greater than 1 km away from the site boundary.
SPR5	Leachate => Aquifer	11.25% (2007) 11% (2013)	Locally Important Aquifer – Bedrock that is moderately productive in local zones.
SPR6	Leachate => Public Supply	0% (2007) 0% (2013)	Public water source >1km, no karst aquifer
SPR7	Leachate => SWDTE	18.75% (2007) 0% (2013)	High vulnerability, locally important aquifer, SW body within 50m of site boundary.
Leachate migration through surface water pathway			
SPR8	Leachate => Surface Water	50% (2007) 0% (2013)	There is a direct connection between the landfill site and the surface water receptor, through a surface drains.
SPR9	Leachate => SWDTE	0% (2007) 0% (2013)	There is no direct surface water pathway from the site to protected surface water receptors.
Landfill gas migration pathway (lateral & vertical)			
SPR10	Landfill Gas => Human Presence	1.67% (2007) 0% (2013)	Human presence >250m
SPR11	Landfill Gas => Human Presence	0% (2007) 1% (2013)	No dwellings located directly above waste.

1.3 Tier 2 Site Investigation

The Tier 2 site investigation, testing and assessment was carried out in accordance with the EPA CoP Environmental Risk Assessment for Unregulated Waste Disposal Sites guidance document.

Lenamore historic landfill site investigation included the following elements:

- 4 No. Trial pit excavations.
- Installation and monitoring of 1 No. groundwater borehole.
- Groundwater, surface water and landfill gas monitoring.
- Factual reporting.

The Tier 2 site investigations confirmed that the historic landfill contains typically mixed municipal/household waste. A geophysical survey could not be carried out at this location due to the presence of extensive forestry plantings. As such, the findings of the intrusive site investigations were used to interpret the footprint of the waste mass.

The waste footprint was estimated using aerial photography and was found to cover the site over an area of approximately 5,450 m^2.

The depth of waste was estimated from trial pits to be an average thickness of 2.5m. The depth estimate includes capping or natural fill material on top of the main waste body. An initial volume calculation estimates the interred soil/ waste volume to be 13,152 m^3 at the site.

1.4 Tier 2 Risk Classification and Tier 2 SPRs

The Tier 2 risk assessment concluded that the risk rating of the site was Moderate (Class B). The highest single risk rating for the site was calculated to be 50% for SPR (source-pathway-receptor) Linkage 8; Leachate migration through a surface water pathway. The SPR linkages examined in this Tier 3 are presented in Table 1.2 and discussed in further detail below.

Table 1-2: Tier **2** Selected SPR Linkages

SPR No.	Linkage	Normalised Score	Justification
Leachate migration through combined groundwater and surface water pathways			
SPR1	Leachate => surface water	23%	Groundwater vulnerability was identified as being 'Low' and site is underlain by a 'Locally Important Aquifer – Bedrock which is moderately productive in local zones'. The Lower River Shannon SAC is located approximately 2.5 km south of the site. There is a direct connection between the site and the Gurteennacloona stream. Surface water monitoring was conducted at upstream and downstream locations on the River Gurteennacloona as part of the Tier 2 site investigation. Surface water monitoring did not demonstrate any deterioration in water quality between upstream and downstream monitoring locations therefore indicating that the landfill is not having a deleterious effect on the Gurteennacloona stream and connected rivers, as the nearest surface water receptors.
SPR2	Leachate => SWDTE	0%	Aquifer and bedrock present a groundwater pathway however, the surface water monitoring did not demonstrate any deterioration in surface water quality.
Leachate migration through groundwater pathway			
SPR3	Leachate => human presence	5%	One residential dwelling is within 500 m south-west of the site boundary. It is unlikely that this dwelling would be exposed to any subsurface leachate. House drinking water is supplied via mains water supply. There is a farmyard located 250 m north-west of the site and another farmyard located 500 m south-east of the site.

SPR No.	Linkage	Normalised Score	Justification
SPR4	Leachate => GWDTE	0%	The nearest groundwater source protection zone (SPZ) is located greater than 1 km away from the site boundary.
SPR5	Leachate => Aquifer	9%	The Shannon formation is a Locally Important Aquifer – Bedrock that is moderately productive in local zones.
SPR6	Leachate => Public Supply	0%	The nearest groundwater protection zone (outer source protection area) is located greater than 1 km away from the site boundary with no karst aquifer present.
SPR7	Leachate => SWDTE	16%	The Gurteennacloona stream is located directly east of the site. Surface water monitoring did not indicate any deterioration in surface quality attributable to the presence of waste at the historical landfill.
Leachate migration through surface water pathway			
SPR8	Leachate => Surface Water	50%	There is a direct connection between the landfill site and the Gurteennacloona stream surface water receptor, through a surface drain located along the southern boundary of the site. Surface water monitoring did not demonstrate any deterioration in water quality between upstream and downstream monitoring locations therefore indicating that the landfill is not having a deleterious effect on the Gurteennacloona stream, as the nearest surface water receptor.
SPR9	Leachate => SWDTE	0%	There is a direct surface water pathway from the site to surface water receptors. Surface water monitoring did not demonstrate any deterioration in water quality between upstream and downstream monitoring locations.
Landfill gas migration pathway (lateral & vertical)			
SPR10	Landfill Gas => Human Presence	2%	The historic landfill is located within dense forestry with the groundwater vulnerability described as 'Low' and the aquifer as 'Locally Important'. The gas monitoring carried out, indicated that both methane and carbon dioxide levels are below the threshold values.
SPR11	Landfill Gas => Human Presence	0%	The historic landfill is located within dense forestry with the nearest residential dwelling located approximately 500 m south of the site. The gas monitoring carried out, indicated that both methane and carbon dioxide levels are below the threshold values.

1.4.1 Leachate migration through surface water pathway (SPR8)

A risk rating score of 50% was calculated for the SPR8 linkage.

This rating refers to the risk of leachate migration through surface water pathways. There is a direct connection between the historic landfill area and the closest surface water body (the Gurteenacloona stream) via a land drain running adjacent to the waste body. This land drain was a contributing factor when calculating the risk score the historic landfill site poses to surface water contamination.

Two rounds of surface water monitoring were conducted at two locations as part of the Tier 2 site investigation and assessment. Monitoring location SW01 was selected as the upstream location in the Gurteenacloona stream, to the south-east of the historical landfill. Monitoring location SW02 is located further downstream to the south-east within the Gurteenacloona stream.

Elevated concentrations of ammoniacal nitrogen (0.456 mg/l) above the laboratory limit of detection (0.2 mgl) were detected at downstream location SW02 on one occasion. The Tier 2 report states however that, the presence of ammonia at these levels may be an indication of agricultural runoff from the surrounding fields, rather than direct impact from the landfill. Elevated concentrations of Phosphorus were recorded during July 2019 at locations SW1 and SW2 at concentrations of 10.2 to 15.5 µg/l respectively. These are over the EGS limit value of 0.075 µg/l for Phosphorus. An exceedance of the EQS limit value was also recorded at SW1 during the September monitoring round.

1.4.2 Leachate migration through combined groundwater and surface water pathways (SPR1)

Regarding the potential impact of the historical landfill on groundwater quality, elevated concentrations of ammoniacal nitrogen, chloride, manganese and iron were observed to be above groundwater threshold values as per the EPA (IGV) Interim Guideline Values[1] and overall threshold value for groundwater quality within S.I. No. 9 of 2010[2] in groundwater monitoring well BH01, adjacent to the site boundary. This suggests the landfill may be negatively impacting groundwater quality within the locality. The risk of the site on groundwater quality and subsequently surface water was reflected in a calculated risk score of 23% for source-pathway-receptor (SPR1) describing leachate migration through combined surface water and groundwater pathways.

[1] Towards Setting Guideline values For the Protection of Groundwater in Ireland-Interim Report (EPA, 2003)

[2] S.I. No. 9/2010 - European Communities Environmental Objectives (Groundwater) Regulations 2010.

2. TIER 3 QUANTITATIVE RISK ASSESSMENT SCOPE OF WORKS

2.1 Tier 3 Overview

This Tier 3 report further examines the Tier 2 linkages (see Table 1-2) in relation to the following:

- SPR8 leachate migration through a surface water pathway
- SPR1 leachate migration through a combined groundwater and surface water pathway

Based on the outcomes of the quantitative risk assessments (GQRA and or DQRA), suitable remediation measures and associated costs are determined if required.

The Tier 2 assessment concluded that Lenamore historic landfill site presents a **moderate risk** therefore a GQRA or a DQRA is required as part of this Tier 3 assessment.

As part of the Tier 3 assessment, a further review of all previous site investigations and environment risk assessments was conducted. Even though the earlier Tier 1 assessments (2007 and 2013) concluded the site represented a **moderate** and **low** risk, respectively to the environment the Tier 2 assessment, following receipt of review of site investigations, confirmed that the site presented a **moderate risk** to the environment.

This Tier 3 assessment report uses the following DQRAs to further assess the risks to surface waters, groundwater and gas migration:

- Groundwater contaminant dispersion modelling (EA Remedial Targets Worksheet) was undertaken to quantitatively assess the risks posed to the aquifer.
- An assimilative capacity assessment and a mass balance calculation were carried out to predict the potential impact on surface water quality from a leachate discharge to the adjacent stream.
- Predictive landfill gas modelling (LandGEM) was used to assess gas migration risks.

Predictive landfill gas modelling (LandGEM) was used to assess gas migration risks.

Based on the outcomes of the DQRA, suitable remediation measures and associated costs are presented in Section 5 of this report.

3. DETAILED QUANTITATIVE RISK ASSESSMENT (DQRA)

3.1 Detailed Quantitative Risk Assessment

The detailed quantitative risk assessment addressed the following primary risks:

- Leachate migration through a surface water pathway (SPR8).
- Leachate migration through combined groundwater and surface water pathways (SPR1).

The detailed quantitative risk assessments rely on information gathered as part of the Tier 2 investigations. A summary of the relevant environmental characteristics considered in evaluating the site and carrying out this Tier 3 investigation are discussed below.

3.2 Existing Geological and Hydrogeological Environment

An accurate representation and rating of the geological and hydrogeological characteristics of the site and environment are required to determine the primary source-pathway-receptor linkages and potential impacts/risks associated with the site.

The quaternary sediments within the site as 'Cut Over Raised Peat'. Lands immediately surrounding the site are also described as comprising Peat.

The bedrock beneath to be found on a single formation. The entirety of the site and surrounding area are underlain by the Shannon Group formation (CNSHG) which is generally made up of Namurian, undifferentiated mudstone, siltstone and sandstone.

Using GSI Online mapping data sets, an examination of the national bedrock aquifer map classifies the Shannon Group Formation as a 'Locally Important Aquifer – Bedrock which is Moderately Productive Locally' and identifies the vulnerability of groundwater to contamination as 'Low'.

Groundwater recharge is determined to be variable in the region. The annual recharge for the site as 29 mm/yr. The effective rainfall for the area is 731 mm/yr, returning a recharge coefficient of 4%.

3.3 Gurteennacloona Stream

The site is located within the catchment of the Tralee Bay-Feale, sub-catchment Galey and Tarmon Stream river sub-basin. The nearest surface water feature is the Gurteenacloona stream located approximately 30 m south-east of the site. The Gurteenacloona stream flows in a south/south-westerly direction the Lenamore stream. The Lenamore stream eventually meets the River Tyshe c. 2.1 km south-west of the site. The site is surrounded by drainage ditches that are directly linked to the Gurteenacloona stream.

3.4 Revised Conceptual Site Model (CSM)

A revised conceptual site model has been prepared as part of this Tier 3 assessment and is presented in Figure 3.1 below.

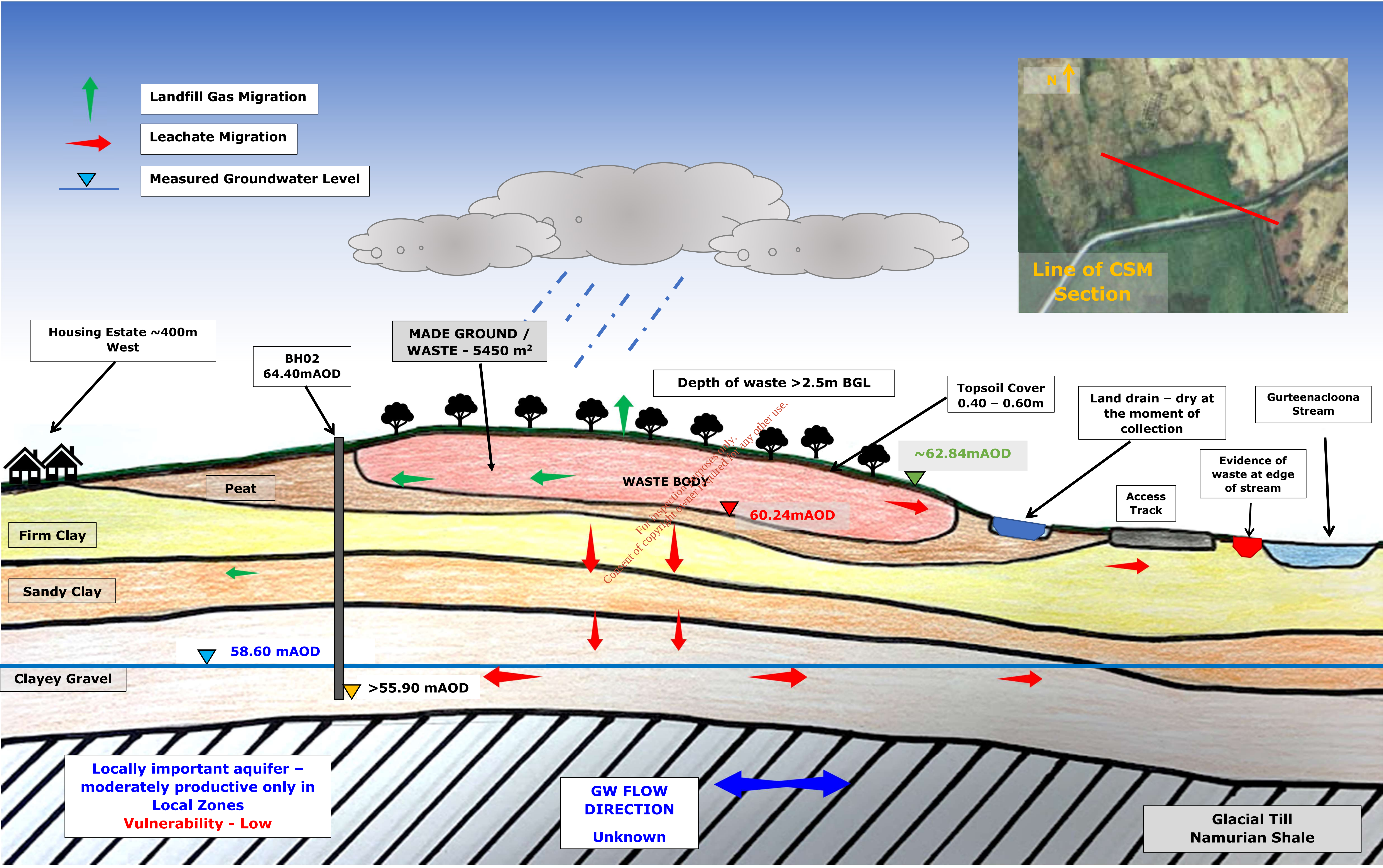

FIGURE 3.1 LENAMORE HISTORIC LANDFILL

CONCEPTUAL SITE MODEL

CROSS SECTION NORTH-WEST/SOUTH-EAST

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3.5 Historic Landfill Contaminants of Concern

Environmental monitoring detected concentrations of ammoniacal nitrogen, chloride, manganese and iron above the groundwater quality threshold values (EPA Interim Guideline Values[1] and Overall Threshold values as per S.I. No. 9 of 2010[2]) within groundwater monitoring well BH01 adjacent to the site boundary. The Tier 2 site investigation identified that the following chemicals in BH01 samples exceed groundwater quality overall threshold values as per the S.I. No. 9 of 2010:

- Ammoniacal Nitrogen as N.
- Chloride.
- Manganese.
- Iron.

Accordingly, groundwater quality and surface water quality are at risk of becoming contaminated.

3.6 Impact of Leachate on Groundwater

The site location is underlain by a 'Locally Important Aquifer – Moderately productive in local zones'. The Gurteenacloona stream is located along the eastern boundary of the site and is directly connected to the historic landfill site by a surface drain that runs along the southern boundary of the site and discharges into the stream.

3.6.1 Potential Leachate Generation

In quantifying the potential impact that the leachate generated at the historical landfill may have on the underlying groundwater aquifer and on the Gurteenacloona stream, it is important to estimate the potential quantity of leachate generated at the site. A higher volume of leachate generation and migration of contaminants is more likely to have a greater impact on the receiving environment. At Lenamore, it is unclear as to whether the groundwater table transects the waste body laterally (See Figure 3.1).

The vertical infiltration of rainfall to the underlying groundwater aquifer is determined by the groundwater recharge rate at this site. The recharge rate at the site is estimated to be 485 mm/year with an effective rainfall rate of 2,154 mm/year resulting in a recharge co-efficient of 22.5%. The approximate aquifer recharge volume within the site boundary has been calculated below.

Rainfall Aquifer Recharge

4% x 731 mm/year = 29.24 mm/year or 0.02924 m/year (available rainfall for recharge over the landfill area)

Aquifer Recharge Volume = Recharge x Area of Landfill

Aquifer Recharge Volume = 0.029 m/year x 5,450 m²

Aquifer Recharge Volume (over the landfill area) = ***159.4 m³/year [0.44 m³/day]***

The underlying groundwater aquifer is not used for public water supplies within the area.

Based on the calculation above and taking the flow rate of the Gurteenacloona stream into account, it is likely that there is a very low potential impact from leachate generated at the historical landfill site on the quality of the groundwater and surface water body in the area.

3.7 Impact of Leachate on Receiving Groundwater

To confirm the potential downstream concentration of leachate generated at the site and the potential risk leachate migration may pose to groundwater downgradient of the site, a hydrogeological model developed by the UK Environment Agency's Science Group was utilised.

This model is generally utilised to develop remediation targets in soil or groundwaters to ensure a desired downstream concentration at a point e.g., a well or other receptor downstream. The model allows the user to predict at what point in time and distance that the desired groundwater concentration will be met.

This assessment tool was utilised to predict the potential groundwater concentration for select parameters downstream of the site. The model relies on the following (simplified) inputs:

- Source characteristics (i.e., Leachate species concentration, retardation, half-life).
- Aquifer characteristics (permeability, porosity, hydraulic gradient).

The UK EA worksheet relies on the input of single values and it was therefore necessary to make several assumptions based on available site-specific data, and typical values obtained from literature and understanding of the site.

The input values used in the model are outlined in Table 3.1 below:

Table 3-1: Modelled Downstream Concentrations (UK EA Remedial Targets Worksheet)

Input Parameter	Unit	Ammoniacal Nitrogen	Chloride	Manganese	Iron	Source
Target Concentration	*mg/l*	0.175	30	0.05	0.2	S.I No. 9 of 2016 and EPA IGV
Initial contaminant concentration in groundwater at plume core	*mg/l*	0.262	48.6	4.29	0.405	Maximum BH01 groundwater monitoring well concentration (2019)
Half-life for degradation of contaminant in water	*days*	$1x10^9$				Assumed high value (no degradation)
Width of plume in aquifer at source	*m*	50				Approximate width of site/waste

Input Parameter	Unit	Ammoniacal Nitrogen	Chloride	Manganese	Iron	Source
(perpendicular to flow)						extent based on Site Investigation
Plume thickness at source	*m*	2.5				Assumed thickness based on site investigation
Saturated aquifer thickness	*m*	10				Average aquifer thickness minimum thickness of locally important aquifer
Bulk density of aquifer materials	*g/cm3*	2.6				Assumed sandstone bulk density
Effective porosity of aquifer	*fraction*	0.275				Median value of assumed porosity referenced in Environmental Agency Landsim manual
Hydraulic gradient	*fraction*	0.01				Assumed hydraulic gradient based on BH01 data and online available data
Hydraulic conductivity of aquifer	*m/d*	0.5184				Assumed single conductivity based on permeability of aquifer
Distance to compliance point	*m*	1000				Distance from site to nearest downstream residential dwelling
Time Since Pollutant entered groundwater	*days*	25, 50, 100, 500 and 1000 years [9,125, 18,250, 36,500, 182,500, 365,000 days]				Time intervals selected
Soil Water Partition Co-efficient	*l/kg*	1.25	0	0	0	Assumed - based on values referenced in Environmental Agency Landsim manual

3.7.1 Results – EA UK Remedial Targets Worksheet

The EA UK Remedial Targets Worksheet model was used to estimate the downstream dispersion concentrations of: ammoniacal nitrogen, chloride, manganese, and iron. The groundwater concentrations at a range of distances from the source at different time intervals are presented in Table 3.2.

The range of distances are automatically generated by the model based on the percentages of the compliance point distance (1000m) i.e., 50m [5%], 200m [20%], 400m [40%] and 1000m [100%].

Table 3-2: Modelled Downstream Concentrations (UK EA Remedial Targets Worksheet)

Ammoniacal Nitrogen (mg/l)			*Groundwater threshold Value (GTV) = 0.175 mg/l*		
Years of Dispersion	**Initial Plume Concentration (mg/l)**	***Conc.at 50m (mg/l)***	***Conc. at 200 m (mg/l)***	***Conc. at 400m (mg/l)***	***Conc. at 1000 m (mg/l)***
25	0.262	0.03	0.008	0.004	0.0016
50	0.262	0.03	0.008	0.004	0.0016
100	0.262	0.03	0.008	0.004	0.0016
500	0.262	0.03	0.008	0.004	0.0016
1000	0.262	0.03	0.008	0.004	0.0016
Chloride (mg/l)			***Groundwater threshold Value (GTV) = 30 mg/l***		
Years of Dispersion	**Initial Plume Concentration (mg/l)**	***Conc.at 50m (mg/l)***	***Conc. at 200m (mg/l)***	***Conc. at 400m (mg/l)***	***Conc. at 1000m (mg/l)***
25	48.6	5.48	1.49	0.75	0.3
50	48.6	5.48	1.49	0.75	0.3
100	48.6	5.48	1.49	0.75	0.3
500	48.6	5.48	1.49	0.75	0.3
1000	48.6	5.48	1.49	0.75	0.3
Manganese (mg/l)			***Groundwater threshold Value (GTV) = 0.05 mg/l***		
Years of Dispersion	**Initial Plume Concentration (mg/l)**	***Conc.at 50m (mg/l)***	***Conc. at 200m (mg/l)***	***Conc. at 400m (mg/l)***	***Conc. at 1000m (mg/l)***
25	4.29	0.48	0.13	0.07	0.03
50	4.29	0.48	0.13	0.07	0.03
100	4.29	0.48	0.13	0.07	0.03
500	4.29	0.48	0.13	0.07	0.03
1000	4.29	0.48	0.13	0.07	0.03

Iron (mg/l)			*Groundwater threshold Value (GTV) = 0.2 mg/l*		
Years of Dispersion	Initial Plume Concentration (mg/l)	*Conc.at 50m (mg/l)*	*Conc. At 200m (mg/l)*	*Conc. at 400m (mg/l)*	*Conc. at 1000m (mg/l)*
25	0.405	0.046	0.012	0.006	0.003
50	0.405	0.046	0.012	0.006	0.003
100	0.405	0.046	0.012	0.006	0.003
500	0.405	0.046	0.012	0.006	0.003
1000	0.405	0.046	0.012	0.006	0.003

3.7.2 Discussion of Results

The model was used to predict downgradient concentrations of the identified pollutants (ammoniacal nitrogen, chloride, manganese, and iron) at 50 m, 200 m,400 m and 1,000 m downstream of the site after the stated number of years of dispersion (25, 50, 100, 500 and 1,000 years).

The model conservatively assumes a worst-case scenario of a non-depleting source concentration, i.e., it assumes that flushing will not reduce the source concentration over time. The source concentrations applied in the model used groundwater sampling concentrations obtained during the Tier 2 site investigation at groundwater monitoring well BH01.

This modelling scenario represented a worse-case scenario given that dilution and dispersion of leachate since the closure of the site, and over the modelled time periods i.e., 25 years, 50 years, 100 years etc. will have reduced leachate source concentrations from continued dilution and dispersion. The model assumes that the initial leachate concentration remains constant.

With respect to all contaminants, over time, flushing will reduce concentrations below the threshold values and these concentrations will also decrease further away from the source.

Overall, it is estimated that after 50 years, no pollutants of concern will at a local level negatively impact the groundwater quality of either the underlying aquifer or the Gurteennacloona stream surface water body. As leachate dispersion is not predicted to negatively impact on groundwater quality locally, it is therefore not likely to impact on groundwater quality further downgradient of the site, due to increased dilution.

The full EA UK Remedial Targets Worksheet is included in Appendix 1 of this report.

3.8 Impact of Leachate on Receiving Surface Water

The potential impact of leachate emissions to the adjacent stream along the eastern boundary of the site was identified as being a risk associated with the site. Ammonia concentrations detected in the groundwater monitoring borehole installed at the site were shown to slightly exceed the relevant groundwater quality threshold, ammonia is a commonly occurring pollutant associated with landfills which may pose a risk to surface waters, where a pathway exists.

The potential impact of the site on this receiving waterbody was assessed by conducting an assimilative capacity assessment and mass balance calculations with ammonia chosen as a representative potential pollutant. A copy of the assimilative capacity and mass balance calculations are included in Appendix 2 of this report.

3.8.1 Surface Water Assimilative Capacity Assessment

Table 3-3 shows the assimilative capacity of receiving surface waters in relation to Ammonia is **0.36 kg/day**.

Table 3-3 Assimilative Capacity Calculation

Assimilative capacity = (C_{max} – C_{back}) x F95 x 86.4 kg/day		
Where:	Value	Source
C_{max} = maximum permissible concentration (EQS – 95%ile value) (mg/l)	0.14	95%-ile 'good' status threshold as per S.I No. 77 of 2019 - European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019
C_{back} = background upstream concentration (mg/l mean value)	0.035	Assumed background concentration
F95 = the 95%ile flow in the river (m^3/s)	0.04	Obtained from online EPA Hydrotool for river segment adjacent to site.
Assimilative Capacity kg/day	0.36	**(0.14 - 0.035) x 0.04 x 86 .4 = 0.36 Kg/day**

3.8.2 Potential Impacts of Leachate Breakouts on Receiving Surface Waters

To determine potential impacts that leachate surface breakouts from the landfill may have on the assimilative capacity of the receiving water body, the mass of ammonia discharging from the site is calculated applying the equation below.

Mass Emission (kg/day) = Discharge Flow (m^3/day) x Concentration (mg/l) /1000

Assumed criteria:

- *Flow range of assumed leachate breakouts:* 1-5 l/s
- *Concentration of ammonia in leachate:* 0.262 mg/l NH_4 based on BH01 observations
- *Significant pollution threshold if:* > S.I. No. 77 of 2019 ('Good' status mean 0.065 mg/l) or > S.I. No. 77 of 2019 ('Good' status 95%-ile 0.140 mg/l)

A range of assumed discharge flows (1 - 5 litres/second) was applied and the percentage of the assimilative capacity removed following discharge to the receiving water was also calculated (Daily Mass Emission ÷ Assimilative Capacity). A discharge ammonia concentration of 0.262 mg/l (highest ammonia observation from groundwater BH01) was assumed for this calculation. The calculated mass emissions and the impacts on the assimilative capacity, for a range of assumed discharge rates, of the receiving water are shown in Table 3-5.

3.8.3 Mass Balance Assessment

A mass balance calculation was used to determine the potential change in ammonia concentration within the receiving water downstream of the discharge. The following calculation as shown in Table 3-4 was applied.

Table 3-4: Mass Balance Calculation

T = (FC + fc)/(F + f)		
Where:		*Source*
F is the river flow upstream of the discharge (95%ile flow m^3/sec);	0.04	Obtained from online EPA Hydrotool for river segment adjacent to site.
C is the concentration of pollutant in the river upstream of the discharge (mean concentration in mg/l);	0.035	Assumed background concentration
f is the flow of the discharge (m^3/sec);	0.001 to 0.005	Assumed discharge rate
c is the maximum concentration of pollutant in the discharge (mg/l);	0.262	Maximum concentration of ammonia (NH_4) detected in BH01
T is the concentration of pollutant downstream of the discharge.	Varies 1-5 l/s	Predicted ammonia concentration in receiving water downstream of discharge
Water Quality Standard (mg/l)	0.140	'Good' Status 95%-ile as per S.I No. 77 of 2019
	0.065	'Good' Status Mean as per S.I No. 77 of 2019

Table 3-5: Potential Impacts of Leachate Breakouts on Assimilative Capacity of Receiving Downstream Waters

Assumed Leachate Breakout Flow (l/s)	Assumed Leachate Breakout Flow (m^3/day)	Daily Mass Emission (kg/day) assuming NH_4 concentration 0.262 mg/l	% Impact Breakout has on of Assimilative Capacity (see Note 3)	Estimated Downstream Concentration NH_4 (mg/l)
1	86	0.023	6%	0.041
2	173	0.045	12%	0.047
3	259	0.068	19%	0.053
4	346	0.091	25%	0.058
5	432	0.113	31%	0.063

Note 1: Water quality standard as per S.I. No. 77 of 2019 ('Good' status 95%-ile 0.140 mg/l).

Note 2: Water quality standard as per S.I. No. 77 of 2019 ('Good' status mean 0.065 mg/l).

Note 3: Assimilative capacity assumed to be 0.69 kg/day ammonia (Table 3-3).

Table 3-5 results show that leachate discharge flow rates of:

- 1, 2, 3, 4 and 5 litres/s (86, 173, 259, 346 and 432 m^3/day) downstream concentrations will be compliant with both S.I. No. 77 of 2019 'Good' status 95%-ile 0.140 mg/l and S.I. No. 77 of 2019 'Good' status mean concentration of 0.065 mg/l NH_4.

At discharge rates of 1, 2, 3, 4 and 5 litres/s (86, 173, 259, 346 and 432 m^3/day) the discharges to surface waters will consume 6%, 12%, 19%, 25% and 31% respectively, of the assimilative capacity of the river, with respect to ammonia.

Tables 3-4 and 3-5 mass balance calculations predict that leachate breakouts containing of 0.262 mg/l NH_4 will cause downstream concentrations of ammonia 0.041 mg/l to 0.063 mg/l for leachate breakout flow rates between 1 and 5 l/s.

3.8.4 Discussion of Results

Overall, the above assessment shows that:

- For leachate breakout flow rates (1 to 5 l/s) the downstream surface water assimilative capacity will be able to accommodate leachate breakouts containing up to 0.262 mg/l NH_4. Under these flow rates the risk of ammonia contaminating receiving surface waters is low for 95%-ile flows.

On the basis of visual site observations during the site walkover the leachate breakout flow rates were estimated to be below 5 l/s. Accordingly modelling assumed leachate breakouts between 1 and 5 l/s. In the absence of detailed breakout flow rate information being available, the CoP requires a conservative approach to be adopted. Results show that leachate breakouts have low potential to negatively impact receiving surface waters, accordingly, only minimal measures will be required to manage the risk of leachate breakouts contaminating receiving surface waters.

3.9 Landfill Gas assessment – LandGEM

LandGEM is an excel based screening model developed by the US EPA for estimating the quantity of landfill gases generated during both the operational phase of a landfill and post-closure of the landfill. The model applies a first-order decomposition rate equation to estimate the quantity of landfill gases being produced from decomposing waste present in a landfill.

The model relies on a limited number of inputs, some of which are supplied within the model as a variety of default values and site-specific information provided by the user. A summary of the model inputs used for this Tier 3 assessment are presented in Table 3-6 below.

The results of this model aid in informing what, if any, remedial measures or control measures should be put in place to mitigate or monitor that risk.

Monitoring for landfill gas emissions from perimeter well (BH01) was conducted in October 2019 as part of the Tier 2 site investigation. This well yielded trace quantities of methane at 0.1% and carbon dioxide concentrations of 0.2%.

In accordance with the EPA CoP the trigger level for methane outside the waste body is 1.0% v/v and 1.5% v/v for carbon dioxide.

Table 3-6: Well Gas Monitoring Results October 2019

Date: 23/10/19						
Sample Station	CH_4	CO_2	O_2	Atmospheric Pressure	Staff Member	Weather
	(% v/v)	(% v/v)	(% v/v)	(mbar)		
BH01	0.1	0.2	22.3	1005	Emily Archer	Overcast, heavy rain showers, 10-14°C

Table 3-7: LandGEM Model Inputs

Landfill Characteristics	Input	Source
Landfill Open Year	1986	Exact timeframe of landfill operation is unknown. Assumed site to be operational through the late 1980s, based on Tier 1 report. Start of filling operations assumed.
Landfill Closure Year	1998	Anecdotal evidence suggests landfilling activities ceased c.1998.
Have Model Closure Calculate Closure Year	Yes	
Waste Design Capacity (megagrams/tonnes)	16,000	Mass based on estimated waste volume determined as part of Tier 2 assessment and site investigation.
Determining Model Parameters		
Methane Generation Rate, k (year^{-1})	CAA Conventional – 0.05	Default value – maximum values applied as a conservative worst-case scenario approach
Potential Methane Generation Capacity, L_0 (m^3/Mg)	CAA Conventional – 1070	
NMOC Concentration (ppmv as hexane)	CAA – 4,000	

Landfill Characteristics	Input	Source
Methane Content (% by volume)	CAA – 50% by volume	
Select Gases/pollutants		
Gas/Pollutant #1	Total Landfill Gas	Standard – No other specific gases of concern
Gas/Pollutant #2	Methane	
Gas/Pollutant #3	Carbon Dioxide	
Gas/Pollutant #4	NMOC	
Enter Waste Acceptance Rates (Mg/year)		
1986 - 1998	1333	Exact waste acceptance quantities per year are unknown. Worst case assumed waste design capacity was filled equally over 1986 to 1998 (12 year) period

3.9.1 Results - LandGEM

Modelling landfill gas generation in LandGEM generates a series of graphs illustrating the production rate of respective specified pollutants.

As an output, LandGEM produces a report on the model inputs and outputs. This report is included in Appendix 3 of this report. LandGEM estimates the mass and volume of landfill gases generated both during the operational/filling phase of the landfill and beyond. The estimated quantity of gas generated for the current year (2019) and after 10 years of further degradation (2029) are presented in Table 3-8. The model predicted that the site is currently generating 8.19 m^3/hr of total landfill gas across the entire site area. This will reduce to 4.97 m^3/hr by 2029. This gas production flow rate is very low and the tree rooting zone may be acting as a natural biological filter. There is however no evidence that methane is being oxidised.

Table 3-8: Estimated landfill Gases Generated (2019 and 2029)

Gas/Pollutant	Tonnes/year		m^3/year		tonnes/hour		m^3/hour	
	2019	2029	2019	2029	2019	2029	2019	2029
Total Landfill Gas	89.62	54.36	71,760	43,530	0.002	0.001	8.19	4.97
Methane	23.94	14.52	35,880	21,760	0.001	0.000	4.09	2.5
Carbon dioxide	65.68	39.84	35,880	21,760	0.001	0.001	4.09	2.5
NMOC	1.03	0.62	287	174	0.000	0.000	0.03	0.01

The approximate maximum waste deposition footprint was estimated to be 5,450m^2. The estimated volume and mass of landfill gas generated and potentially released per m^2 of the total landfill area are presented in Table 3-9.

Table 3-9: Estimated gases generated/released per m² (2019)

Gas/Pollutant	Tonnes/year/m²	m³/year/m²	tonnes/hour/m²	m³/hour/m²
Total Landfill Gas	0.016	13.17	0.000	0.002
Methane	0.004	6.58	0.000	0.0008
Carbon dioxide	0.012	6.58	0.000	0.0008
NMOC	0.0001	0.053	0.000	0.00

3.9.2 Discussion of Results

The outcome of the LandGEM model predicts a moderate rate of landfill gas generation in the 2019 (8.19 m³/hr). The EPA guidance document, 'Management of Low Levels of Landfill Gas' prepared by Golder Associates Ireland Ltd outlines readily available flaring technologies that meet EPA requirements on temperature and retention specifications. These technologies generally require gas flow rates ranging from 40-2,500+ m³/hr with methane contents ranging from 10 to 50 percent. The lowest methane content referring to Low-CV (Calorific value) flare technology.

As shown in Table 3-9, LandGEM estimated that in the current year (2019) a small quantity of 8.19 m³/hour of landfill gas from the whole site is generated 50% percent of which is assumed to be methane (4.09 m³) and 50 % of which is carbon dioxide. Landfill gas monitoring of groundwater wells conducted in 2019 yielded only trace amounts of methane. The LandGEM model using estimated waste inputs, predicts that methane production is still occurring at low flow rates and that this will continue for a number of years. Figure 3-2 below shows the estimated landfill gas generation rates per year during the assumed operational phase (c.1986 to 1998) and predicted generation rates from 1998 onwards following closure of the site. The model assumes equal production rates for both methane and carbon dioxide and are represented by the pink trendline.

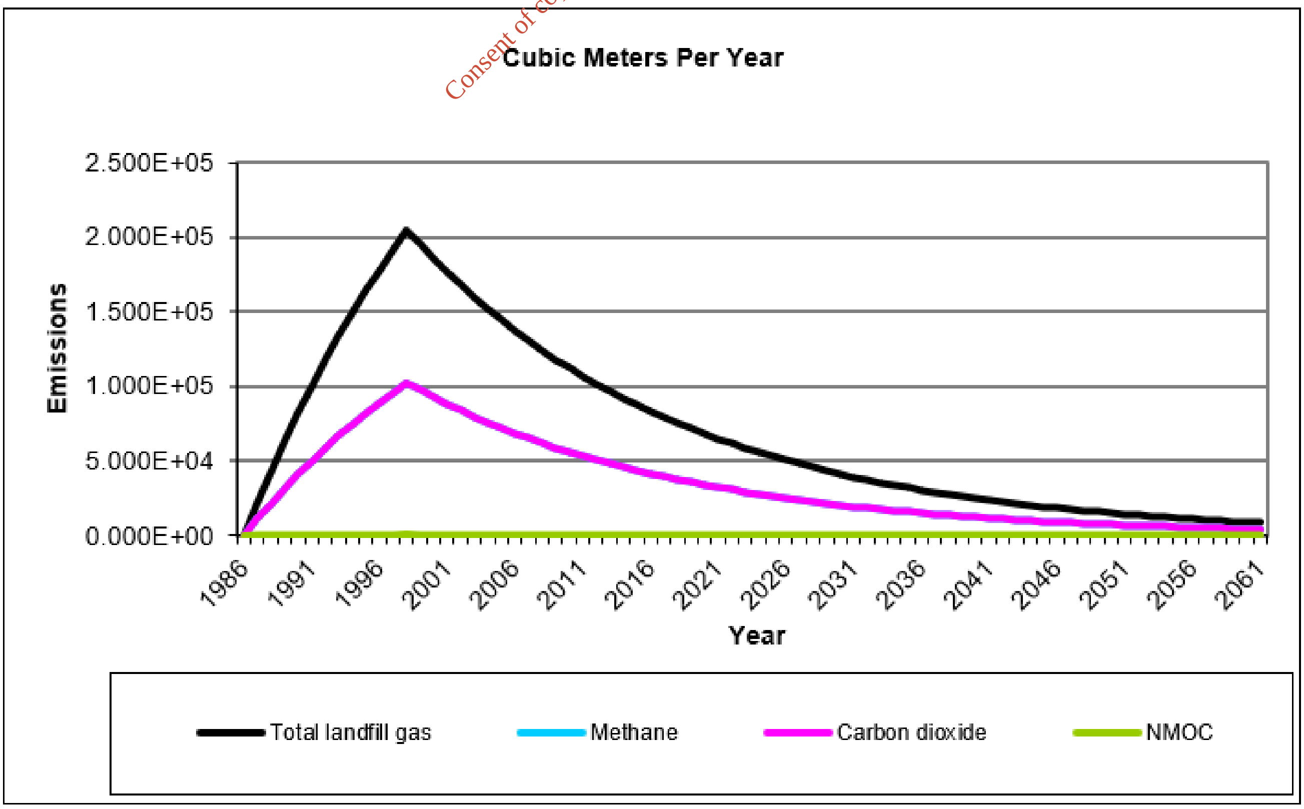


Figure 3-2: LandGEM Landfill Gas Volume Generation Rate

The complete summary report on model inputs and outputs/results generated by LandGEM is included in Appendix 3 of this report.

4. Summary Findings And Recommendations

4.1 Summary Findings

4.1.1 Overview

The Tier 3 assessment:

- Reviewed the findings of the Tier 1 risk assessment (determined the site to be of Moderate risk (Class B in 2007) and a low risk (Class C in 2013).
- Reviewed the findings of the Tier 2 site investigation and risk assessment (determined the site to be Moderate risk (Class B)).
- Assessed and determined the overall risk the site may pose to the receiving environment.
- Determined appropriate measures, if required, to mitigate or eliminate that risk.

Intrusive site investigations showed that the site only comprises:

- A shallow soil cap (min: 0.4 m, max: 0.6 m)
- Made ground (sandy gravelly clay) to 2.5 m with evidence of MSW

This Tier 3 assessment determined:

- The site to be a Moderate (Class B) risk.
- The main risk is the direct surface water connection between the waste body and the Gurteenacloona stream

4.1.2 Surface Water

The assimilative capacity assessment and mass balance calculations indicated that:

- The environmental impact direct leachate discharges and contaminated groundwater locally entering the Gurteenacloona stream was estimated to be low.

A mass balance calculation was carried out to predict the potential concentration of ammonia within the river downstream of the site, assuming discharge rates of 1 l/s to 5 l/s of leachate to the river. The calculation predicted:

- For assumed leachate breakout flow rates (1 to 5 l/s) the downstream surface water assimilative capacity will be able to accommodate leachate breakouts containing up to 0.262 mg/l NH_4. Under these flow rates the risk of ammonia contaminating receiving surface waters is low for 95%-ile flows.

Under these flow rates the risk of ammonia contaminating receiving surface waters is low for both 95%-ile flows and mean flows.

Because site observations found no evidence of leachate breakouts and the risk of leachate contaminating receiving waters is considered to be low remedial works are not considered in the short term to be necessary. However, it is recommended that surface water monitoring infrastructure and an additional borehole are installed to support future monitoring. The interim measures are discussed in detail in Section 5 below.

4.1.3 Groundwater

Quantitative risk assessments of potential leachate generation from the site, determined:

- That leachate generated at the landfill site is unlikely to have a long-term negative impact on either groundwater or surface water quality downstream of the site at the compliance point located 1 km downstream of the site.

However, the presence of waste and the migration of leachate to the underlying groundwater and the proximity of the site to a river means that:

- There is an inherent risk to surface water quality.
- The presence of waste may pose a risk to groundwater quality at a local level.
- The presence of waste may pose a landfill gas migration risk

4.1.4 Landfill Gas

The output from LandGEM model (Appendix 3) showed that landfill gas will continue to be generated for several years although in minimal quantities. Although the risk from landfill gas is relatively low, the concentrations of gas detected during fielding monitoring and the indication that gas will continue to be produced, it is recommended that appropriate landfill gas management measures be implemented at the site to monitor potential risk.

Appropriate control landfill gas monitoring selected in accordance with the EPA Guidance document: *Management of Low Levels of Landfill Gas* appropriate measures are discussed in Section 5.1 below.

4.2 Recommendations

In summary because the site has a cap, albeit contaminated with C&D waste, compliant in thickness with the Landfill Directive and the EPA Landfill Site Design Manual Guidance for Non-hazardous, Tier 3 environmental risk assessment:

- Confirmed the risk rating of the site, as per the EPA CoP to be Moderate risk (Class B).
- Defined the primary environmental risk as being leachate contamination of downstream surface and ground waters.
- Determined the need for additional annual surface and ground water monitoring infrastructure.
- Determined the need for gas monitoring.

The primary objective in providing monitoring infrastructure is to facilitate development of environmental records to facilitate a future risk assessment, once harvesting of the trees has been carried out, and the need or other for future remedial works.

5. REMEDIAL ACTION PLAN

5.1 Overview of the Risks

5.1.1 Summary Findings

The existing site has a basic soil cap with an established tree cover. Tier 1, 2 and 3 investigations showed:

- Evidence of in-situ mixed C&D and municipal solid wastes.
- Evidence of waste in adjacent surface drain side slopes.
- Evidence of low-level landfill gas emissions.
- Assessment that leachate has potential to contaminate local receiving surface and groundwaters.
- An in-situ landfill cap that is compliant in thickness only with the Landfill Directive and the Environmental Protection Agency (EPA) publication landfill manual - Landfill Site Design.

Whilst the in-situ cap thickness exceeds 1.0 m, settlement and root development may compromise the cap permeability such that rainfall deep percolation inputs may increase the risk of leachate production albeit that evapotranspiration from trees may also reduce deep percolation inputs.

Leachate production, owing to the steep terrain, cap thickness and established vegetation cover, are unlikely to produce significant volumes.

The in-situ cap and detritus from leaves may facilitate passive venting and oxidation of landfill gas and there are no sensitive local receptors that may be impacted by landfill gas migration even if it does occur.

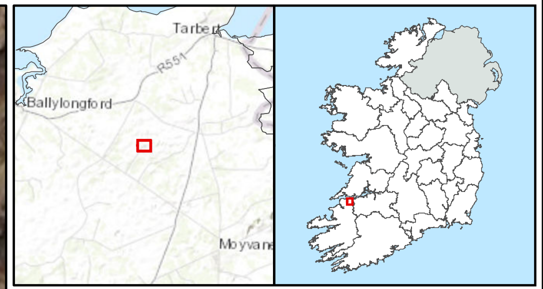
Owing to its remote location, established tree canopy and findings of the modelling exercises and quantitative risk assessments, remedial measures are not recommended for the immediate future.

Because the is no significant evidence of environmental pollution it is recommended that forestry plantation be allowed to mature without any remedial works on the cap being required prior to harvesting of trees. Harvesting is unlikely to happen for a further 15 or 20 years.

In the interim period it is recommended that annual groundwater, surface water and gas monitoring be carried out until such time as the trees are harvested. Thereafter, following a review of gas, surface and groundwater monitoring data a new risk assessment should be carried out using available data to review the risk rating of the site and to determine whether the plantation can be re-planted and/ or if there is a requirement for future Remedial works.

Figure 5-1 below shows: The proposed surface water outfall structure, existing groundwater borehole 1 and proposed groundwater boreholes 2 and 3.

Path: R:\Map Production\2019\P1766\Workspace\Leanamore\P1766_Fig4-1_SWMonitoringLocations_A3.mxd



Proposed Borehole Location

Surface Water Monitoring Access

Rivers

Site Boundary

TITLE: Proposed Surface Water Monitoring Locations	
PROJECT: Lenamore Landfill, Co. Kerry	
FIGURE NO: 4.1	
CLIENT: Kerry County Council	
SCALE: 1:1500	**REVISION:** 0
DATE: 04/03/2020	**PAGE SIZE:** A3

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5.1.2 Surface Water Monitoring Infrastructure

To facilitate safe access to surface monitoring it is proposed that a structure be constructed at the surface water location SW outfall proposed in Figure 5-1.

Engineering solutions will need to consider most appropriate methodology following a design risk assessment that will need to consider safe access and agrees to the drain invert.

It is recommended that a concrete step, handrail and self-cleansing recessed concrete invert and concrete protected side slopes, or similar approved, be constructed to allow water to be retained to a depth not less than 150 mm.

5.1.3 Groundwater Monitoring Infrastructure

It is recommended that two additional boreholes be located downstream of the landfill footprint in the location shown on Figure 5-1.

Prior to work taking place there will be a requirement to seek approval to fell trees locally.

Engineering solutions will need to consider the most appropriate drilling methodology following a design risk assessment that will need to consider:

- Tree felling (BH1 and BH2)
- Proximity to deep drain (BH2).
- Peat overburden and risk of rotational failure during drilling (BH1 and BH2).
- Safe access and egress during future monitoring (BH1, BH2, BH3).

5.1.4 Proposed Groundwater and Surface Water Monitoring Regime

The EPA Landfill Monitoring landfill manual outlines recommended, minimum monitoring requirements for ground and surface waters. These parameters are shown in Table 5-1 below and are as presented in Table C.2 of the EPA's *Landfill Manuals - Landfill Monitoring, 2nd Edition (2003).*

Groundwater monitoring shall be carried out at existing perimeter wells BH01 and proposed BH02 and surface water monitoring shall be carried out at the proposed surface water discharge outfall in the north west corner of the site annually in accordance parameters listed in Table 5-1.

Table 5-1: Parameters for Monitoring of Groundwater, Surface Water and Leachate

Monitoring Parameter[3] See Footnote	Frequency*	Surface Water	Groundwater
Level	Quarterly+	-	✓
Flow Rate		-	-
Temperature		✓	✓
Dissolved Oxygen		✓	-
pH		✓	✓
Electrical Conductivity[4]		✓	✓
Total suspended solids		✓	-
Total dissolved solids		-	✓
Ammonia (as N)		✓	✓
Total oxidized nitrogen (as N)		✓	✓
Total organic carbon		-	✓
Biochemical Oxygen Demand		✓	-
Chemical Oxygen Demand		✓	-
Metals[5]		✓	✓
Total Alkalinity (as $CaCO_3$)		✓	✓
Sulphate		✓	✓
Chloride		✓	✓
Molybdate Reactive Phosphorous[6]		✓	✓
Cyanide (Total)		✓	✓
Fluoride		✓	✓
Trace organic substances[7]	Annually	✓	✓
Faecal and Total Coliforms[8]		-	✓
Biological assessment	-	-	-

[3] Tables D.1 and D.2 of the EPA Landfill Monitoring manual recommend guideline minimum reporting values for parameters

[4] Where saline influences are suspected, a salinity measurement should also be taken.

[5] Metals for analysis should include: calcium, magnesium, sodium, potassium, iron, manganese, cadmium, chromium (total), copper, nickel, lead, zinc, arsenic, boron and mercury.

[6] Total Phosphorus should be measured in leachate samples where colorimetric interference is likely.

[7] Table D.2 of the EPA Landfill Monitoring manual recommends trace organic substances that should be included in the determination. Surface water should be analysed for the pesticide sand solvents listed in the Water Quality (dangerous Substances) Regulations (S.I No. 12 of 2001).

[8] Required for drinking water supplies within 500m of the landfill.

5.1.5 Proposed Gas Monitoring Regime

Gas monitoring shall be carried out at existing and proposed boreholes (2 No.).

It is recommended that:

- Gas monitoring be carried out annually.
- Groundwater wells used for gas monitoring wells be allowed to vent passively throughout the year.
- Prior to annual monitoring, well vents should be closed for a period of 24 hours to allow representative sampling.

Gas sampling to determine if gas migration is occurring should be carried out using a calibrated gas analyser for the following parameters:

- Methane.
- Carbon dioxide.
- Oxygen.
- Carbon monoxide.
- Temperature.

5.2 Remediation Cost Estimates

The following section outlines the potential costs associated with the remediation of the site. The costs estimate is limited to “once-off” civil and mechanical and electrical works.

Long term costs associated with maintenance, license compliance and environmental liabilities are not considered.

Table 5-2 outlines the costs associated with site preparation and development of monitoring infrastructure.

Table 5-2: Engineers Estimate for Additional Monitoring Infrastructure

Item	Quantity	Unit	Rate, €	Cost
Design				
Allowance for Additional Bore hole site Investigation works	1	Rate	€5,000	€5,000
Detailed Design and Supervision	1	Rate	€2,500	€2,500
Land rental costs and tree value	1	Rate	€10,000	€10,000
General Site Clearance and Demolition Works		***ha***		
General Site Clearance	0.1	ha	€20,000	€2,000
Tree removal	1	Sum	€5,000	€5,000
Excavation Works	0	m^2		
Excavation of Existing Cover/Capping for Reuse/Filling	0	m^3	€15	€0
Monitoring infrastructure	0			
Preparation of Excavated Surfaces	100	m^2	€1	€75
Supply and Installation of 50mm Protection Layer	100	m^2	€2	€175
Fencing	1	m2	€1,000	€1,000
Allowance Landfill Gas Migration Network Infrastructure	1	Sum	€2,000	€2,000
Allowance local paved works	100	m^3	€15	€1,500
Allowance geogrid	100	m^2	€5	€500
Allowance separation membrane	100	m^2	€2	€200
Surface water monitoring infrastructure	1	Sum	€5,000	€5,000
Borehole	1	Sum	€20,000	€20,000
Sub-Total 1				**€54,950**
Add 10% Contractor Prelims	10.0%			€5,495
Sub-Total 2				**€50,445**
Add 7.5% Contingency	7.5%			€4,533
Grand Total (excl VAT)				**€64,978**

FT in making this Engineers Estimate advises the following:

- FT used rates over the period 2018 to 2019 for similar tendered works items where possible and has used engineering judgement to estimate rates & sums where similar rates were not available.
- Management of hazardous materials was not allowed for.
- Pricing was based on a concept design, no detailed designs were prepared.
- The cost estimate assumes that materials to be imported are readily available from local sources.
- The cost estimate excludes VAT.
- The cost estimate excludes in/deflation.
- The estimate includes for a level of contingency as indicated.

Prices may change subject to prevailing market conditions.

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APPENDIX 1

Environmental Agency (UK) Remedial Targets Worksheet

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		Ammoniacal Nitrogen		from Level 1
Target Concentration	C_T	1.75E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived valu

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	2.62E-01	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	1.00E+99	days	*Assumed high value (no degradation)*
Calculated decay rate	λ	6.93E-100	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	5.00E+01	m	*Approximate width of site/ waste extent based on SI*
Plume thickness at source	Sy	2.50E+00	m	*Assumed thickness from Geophysics*
Saturated aquifer thickness	da	1.00E+01	m	
Bulk density of aquifer materials	ρ	2.60E+00	g/cm^3	*Assumed limestone density*
Effective porosity of aquifer	n	2.75E-01	fraction	
Hydraulic gradient	i	1.00E-02	fraction	
Hydraulic conductivity of aquifer	K	5.18E-01	m/d	
Distance to compliance point	x	1.00E+03	m	
Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	
Distance (depth) to compliance point perpendicular to flow direction	y	[redacted]	m	
Time since pollutant entered groundwater	t	9.13E+03	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	0.00E+00	l/kg	*see options*
Longitudinal dispersivity	ax	1.00E+02	m	*see options*
Transverse dispersivity	az	1.00E+01	m	*see options*
Vertical dispersivity	ay	1.00E+00	m	*see options*

Calculated Parameters

	Variable	Value	Unit
Groundwater flow velocity	v	1.89E-02	m/d
Retardation factor	Rf	1.00E+00	fraction
Decay rate used	λ	6.93E-100	d^{-1}
Rate of contaminant flow due to retardation	u	1.89E-02	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	1.64E-03	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.60E+02**	

Remedial Targets

Remedial Target	**2.80E+01**	**mg/l**	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	**1000**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**1.64E-03**	**mg/l**	Domenico - Steady state

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	0.00E+00	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	0.00E+00	l/kg

Define dispersivity (click brown cell and use pull down list)

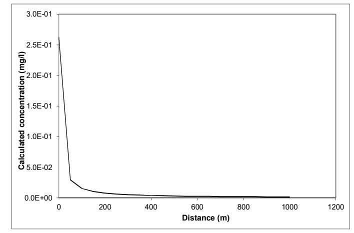
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	5.00E+00	1.00E+02	1.18E+01	m
Transverse dispersivity	**az**	4.00E+01	1.00E+01	1.18E+00	m
Vertical dispersivity	**ay**	9.50E+01	1.00E+00	1.18E-01	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source. Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Lenamore
Completed by:	EA
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Domenico - Steady state
From calculation sheet

Distance	Concentration
	mg/l
0	2.6E-01
50.0	2.95E-02
100.0	1.56E-02
150.0	1.06E-02
200.0	8.01E-03
250.0	6.44E-03
300.0	5.39E-03
350.0	4.63E-03
400.0	4.06E-03
450.0	3.62E-03
500.0	3.26E-03
550.0	2.97E-03
600.0	2.72E-03
650.0	2.51E-03
700.0	2.34E-03
750.0	2.18E-03
800.0	2.05E-03
850.0	1.93E-03
900.0	1.82E-03
950.0	1.72E-03
1000.0	1.64E-03

FEHILY TIMONEY

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APPENDIX 2

Surface Water Assimilative Capacity Assessment

Assimilative capacity = (Cmax – Cback) x F95 x 86.4 kg/day **Ammonia**

Where:

C_{max} = maximum permissible concentration (EQS – 95%ile value) (mg/l) 0.14

C_{back} = background upstream concentration (mg/l mean value) 0.035

F95 = the 95%ile flow in the river (m^3/s) 0.04

Note: (60x60x24)/1000 = 86.4

AC kg/d	=	**(Cmax**		**-**	**Cbak)**	**x**	**F95**	**x**	**86.4**
	=	0.14		-	0.035	x	0.04	x	86.4
	=		0.105			x	0.04	x	86.4
AC kg/d	=	**0.36**	**kg/day**						

Emission Concentration (mg/l) 0.262

Flow (m3/day)	Daily Mass Emission (kg/day)	%-age of AC
86.4	0.023	6%
172.8	0.045	12%
259.2	0.068	19%
345.6	0.091	25%
432	0.113	31%

Mass balance Equation:

$$T = \frac{FC + fc}{F + f}$$

$$f(m^3/sec) = \frac{f\left(\frac{m^3}{day}\right) \div 24hours}{3600\ seconds}$$

F =	0.04	m^3/sec
C =	0.035	mg/l
f =	86.4	m^3/day
	0.005	m^3/sec
c =	0.262	mg/l

where:

- F is the river flow upstream of the discharge (95%ile flow m^3/sec);
- C is the concentration of pollutant in the river upstream of the discharge (mean concentration in m
- f is the flow of the discharge (m^3/sec);
- c is the maximum concentration of pollutant in the discharge (mg/l
- T is the concentration of pollutant downstream of the discharge.

T = $\frac{F \times C + f \times c}{F + f}$

1 $\frac{0.035 \times 0.035 + 0.005 \times 0.262}{0.035 + 0.005}$

2 $\frac{0.001225 + 0.001}{0.0400}$

3 $\frac{0.003}{0.040}$

4 **T = 0.063 mg/l**

EQS

0.14 *95%-ile EQS*

FEHILY TIMONEY

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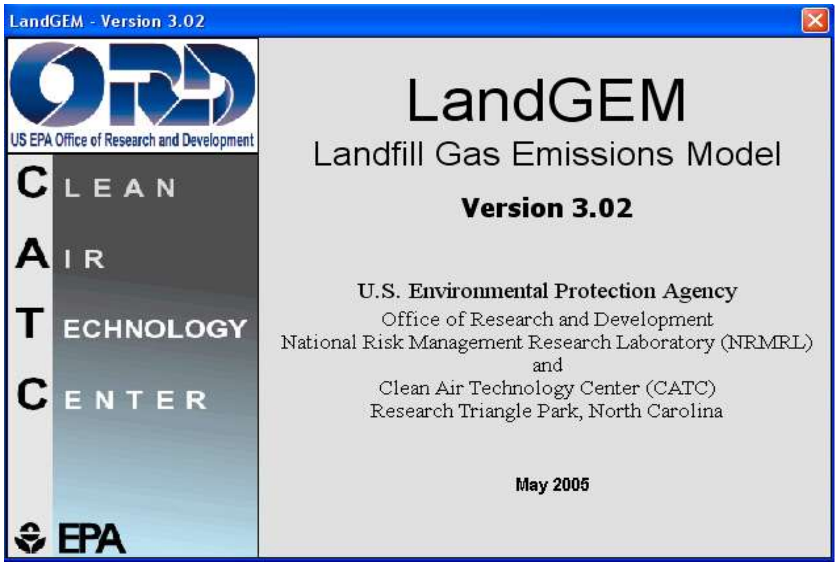
APPENDIX 3

LandGEM Model Summary Report



Summary Report

Landfill Name or Identifier:

Date: Monday 13 July 2020

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1986**	
Landfill Closure Year (with 80-year limit)	**1998**	
Actual Closure Year (without limit)	***1998***	
Have Model Calculate Closure Year?	**Yes**	
Waste Design Capacity	**16,000**	*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**170**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1986	1,333	1,466	0	0
1987	1,333	1,466	1,333	1,466
1988	1,333	1,466	2,666	2,933
1989	1,333	1,466	3,999	4,399
1990	1,333	1,466	5,332	5,865
1991	1,333	1,466	6,665	7,332
1992	1,333	1,466	7,998	8,798
1993	1,333	1,466	9,331	10,264
1994	1,333	1,466	10,664	11,730
1995	1,333	1,466	11,997	13,197
1996	1,333	1,466	13,330	14,663
1997	1,333	1,466	14,663	16,129
1998	4	4	15,996	17,596
1999	0	0	16,000	17,600
2000	0	0	16,000	17,600
2001	0	0	16,000	17,600
2002	0	0	16,000	17,600
2003	0	0	16,000	17,600
2004	0	0	16,000	17,600
2005	0	0	16,000	17,600
2006	0	0	16,000	17,600
2007	0	0	16,000	17,600
2008	0	0	16,000	17,600
2009	0	0	16,000	17,600
2010	0	0	16,000	17,600
2011	0	0	16,000	17,600
2012	0	0	16,000	17,600
2013	0	0	16,000	17,600
2014	0	0	16,000	17,600
2015	0	0	16,000	17,600
2016	0	0	16,000	17,600
2017	0	0	16,000	17,600
2018	0	0	16,000	17,600
2019	0	0	16,000	17,600
2020	0	0	16,000	17,600
2021	0	0	16,000	17,600
2022	0	0	16,000	17,600
2023	0	0	16,000	17,600
2024	0	0	16,000	17,600
2025	0	0	16,000	17,600

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	(short tons/year)	(Mg)	(short tons)
2026	0	0	16,000	17,600
2027	0	0	16,000	17,600
2028	0	0	16,000	17,600
2029	0	0	16,000	17,600
2030	0	0	16,000	17,600
2031	0	0	16,000	17,600
2032	0	0	16,000	17,600
2033	0	0	16,000	17,600
2034	0	0	16,000	17,600
2035	0	0	16,000	17,600
2036	0	0	16,000	17,600
2037	0	0	16,000	17,600
2038	0	0	16,000	17,600
2039	0	0	16,000	17,600
2040	0	0	16,000	17,600
2041	0	0	16,000	17,600
2042	0	0	16,000	17,600
2043	0	0	16,000	17,600
2044	0	0	16,000	17,600
2045	0	0	16,000	17,600
2046	0	0	16,000	17,600
2047	0	0	16,000	17,600
2048	0	0	16,000	17,600
2049	0	0	16,000	17,600
2050	0	0	16,000	17,600
2051	0	0	16,000	17,600
2052	0	0	16,000	17,600
2053	0	0	16,000	17,600
2054	0	0	16,000	17,600
2055	0	0	16,000	17,600
2056	0	0	16,000	17,600
2057	0	0	16,000	17,600
2058	0	0	16,000	17,600
2059	0	0	16,000	17,600
2060	0	0	16,000	17,600
2061	0	0	16,000	17,600
2062	0	0	16,000	17,600
2063	0	0	16,000	17,600
2064	0	0	16,000	17,600
2065	0	0	16,000	17,600

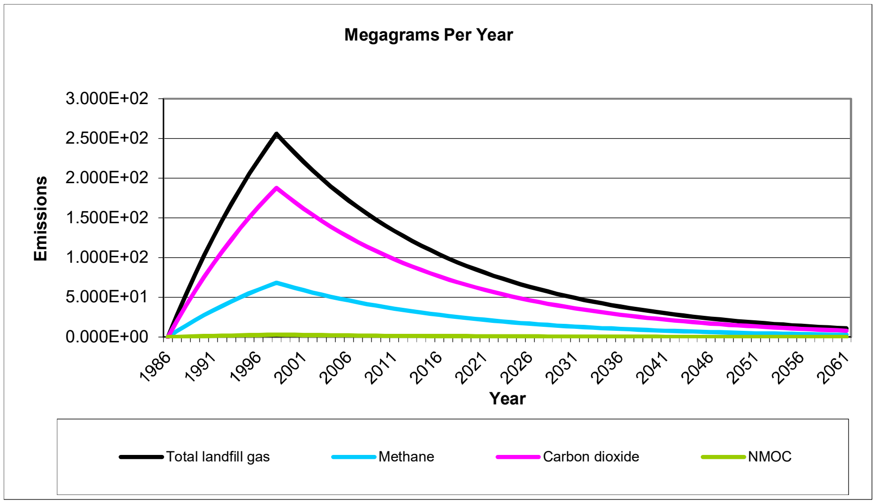
Pollutant Parameters

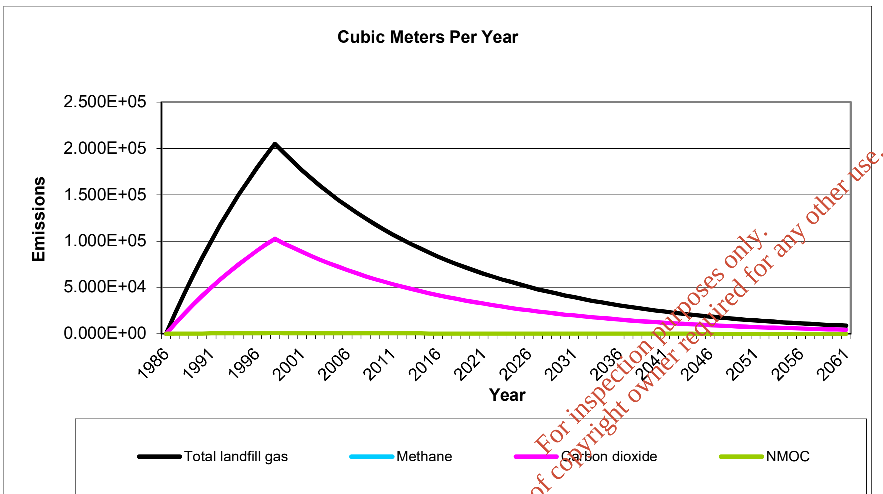
	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

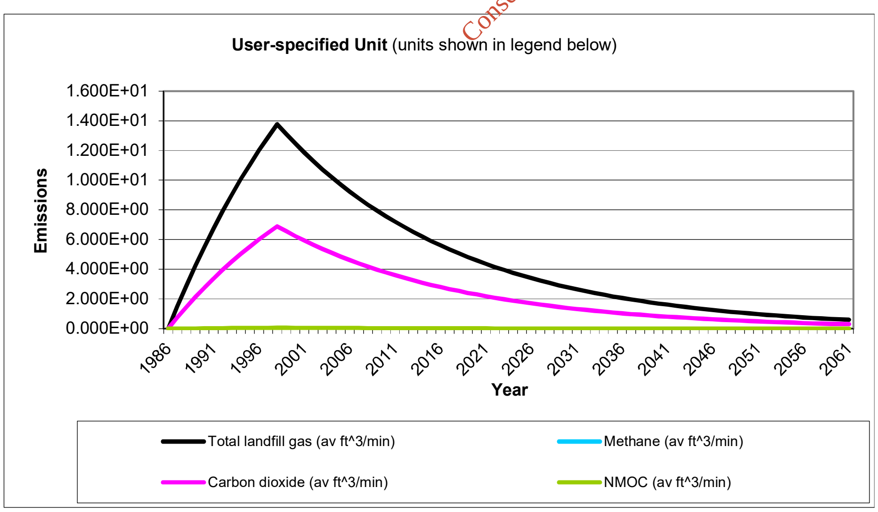
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
3.000E+02
2.500E+02
2.000E+02
1.500E+02
1.000E+02
5.000E+01
0.000E+00
Emissions
1986 1991 1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
2.500E+05
2.000E+05
1.500E+05
1.000E+05
5.000E+04
0.000E+00
Emissions
1986 1991 1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
1.600E+01
1.400E+01
1.200E+01
1.000E+01
8.000E+00
6.000E+00
4.000E+00
2.000E+00
0.000E+00
Emissions
1986 1991 1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1986	0	0	0	0	0	0
1987	2.767E+01	2.216E+04	1.489E+00	7.392E+00	1.108E+04	7.444E-01
1988	5.400E+01	4.324E+04	2.905E+00	1.442E+01	2.162E+04	1.453E+00
1989	7.904E+01	6.329E+04	4.252E+00	2.111E+01	3.164E+04	2.126E+00
1990	1.029E+02	8.236E+04	5.534E+00	2.747E+01	4.118E+04	2.767E+00
1991	1.255E+02	1.005E+05	6.753E+00	3.353E+01	5.025E+04	3.376E+00
1992	1.471E+02	1.178E+05	7.912E+00	3.928E+01	5.888E+04	3.956E+00
1993	1.676E+02	1.342E+05	9.015E+00	4.476E+01	6.709E+04	4.508E+00
1994	1.871E+02	1.498E+05	1.006E+01	4.997E+01	7.490E+04	5.032E+00
1995	2.056E+02	1.646E+05	1.106E+01	5.492E+01	8.232E+04	5.531E+00
1996	2.233E+02	1.788E+05	1.201E+01	5.963E+01	8.939E+04	6.006E+00
1997	2.400E+02	1.922E+05	1.291E+01	6.412E+01	9.611E+04	6.457E+00
1998	2.560E+02	2.050E+05	1.377E+01	6.838E+01	1.025E+05	6.887E+00
1999	2.436E+02	1.951E+05	1.311E+01	6.507E+01	9.753E+04	6.553E+00
2000	2.317E+02	1.856E+05	1.247E+01	6.190E+01	9.278E+04	6.234E+00
2001	2.204E+02	1.765E+05	1.186E+01	5.888E+01	8.825E+04	5.930E+00
2002	2.097E+02	1.679E+05	1.128E+01	5.601E+01	8.395E+04	5.640E+00
2003	1.994E+02	1.597E+05	1.073E+01	5.327E+01	7.985E+04	5.365E+00
2004	1.897E+02	1.519E+05	1.021E+01	5.068E+01	7.596E+04	5.104E+00
2005	1.805E+02	1.445E+05	9.710E+00	4.820E+01	7.225E+04	4.855E+00
2006	1.717E+02	1.375E+05	9.236E+00	4.585E+01	6.873E+04	4.618E+00
2007	1.633E+02	1.308E+05	8.786E+00	4.362E+01	6.538E+04	4.393E+00
2008	1.553E+02	1.244E+05	8.357E+00	4.149E+01	6.219E+04	4.179E+00
2009	1.478E+02	1.183E+05	7.950E+00	3.947E+01	5.916E+04	3.975E+00
2010	1.405E+02	1.125E+05	7.562E+00	3.754E+01	5.627E+04	3.781E+00
2011	1.337E+02	1.071E+05	7.193E+00	3.571E+01	5.353E+04	3.597E+00
2012	1.272E+02	1.018E+05	6.842E+00	3.397E+01	5.092E+04	3.421E+00
2013	1.210E+02	9.687E+04	6.509E+00	3.231E+01	4.843E+04	3.254E+00
2014	1.151E+02	9.214E+04	6.191E+00	3.074E+01	4.607E+04	3.096E+00
2015	1.095E+02	8.765E+04	5.889E+00	2.924E+01	4.382E+04	2.945E+00
2016	1.041E+02	8.337E+04	5.602E+00	2.781E+01	4.169E+04	2.801E+00
2017	9.904E+01	7.931E+04	5.329E+00	2.646E+01	3.965E+04	2.664E+00
2018	9.421E+01	7.544E+04	5.069E+00	2.517E+01	3.772E+04	2.534E+00
2019	8.962E+01	7.176E+04	4.822E+00	2.394E+01	3.588E+04	2.411E+00
2020	8.525E+01	6.826E+04	4.586E+00	2.277E+01	3.413E+04	2.293E+00
2021	8.109E+01	6.493E+04	4.363E+00	2.166E+01	3.247E+04	2.181E+00
2022	7.713E+01	6.177E+04	4.150E+00	2.060E+01	3.088E+04	2.075E+00
2023	7.337E+01	5.875E+04	3.948E+00	1.960E+01	2.938E+04	1.974E+00
2024	6.979E+01	5.589E+04	3.755E+00	1.864E+01	2.794E+04	1.878E+00
2025	6.639E+01	5.316E+04	3.572E+00	1.773E+01	2.658E+04	1.786E+00
2026	6.315E+01	5.057E+04	3.398E+00	1.687E+01	2.528E+04	1.699E+00
2027	6.007E+01	4.810E+04	3.232E+00	1.605E+01	2.405E+04	1.616E+00
2028	5.714E+01	4.576E+04	3.074E+00	1.526E+01	2.288E+04	1.537E+00
2029	5.436E+01	4.353E+04	2.924E+00	1.452E+01	2.176E+04	1.462E+00
2030	5.170E+01	4.140E+04	2.782E+00	1.381E+01	2.070E+04	1.391E+00
2031	4.918E+01	3.938E+04	2.646E+00	1.314E+01	1.969E+04	1.323E+00
2032	4.678E+01	3.746E+04	2.517E+00	1.250E+01	1.873E+04	1.259E+00
2033	4.450E+01	3.564E+04	2.394E+00	1.189E+01	1.782E+04	1.197E+00
2034	4.233E+01	3.390E+04	2.278E+00	1.131E+01	1.695E+04	1.139E+00
2035	4.027E+01	3.224E+04	2.167E+00	1.076E+01	1.612E+04	1.083E+00

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2036	3.830E+01	3.067E+04	2.061E+00	1.023E+01	1.534E+04	1.030E+00
2037	3.644E+01	2.918E+04	1.960E+00	9.732E+00	1.459E+04	9.802E-01
2038	3.466E+01	2.775E+04	1.865E+00	9.258E+00	1.388E+04	9.324E-01
2039	3.297E+01	2.640E+04	1.774E+00	8.806E+00	1.320E+04	8.869E-01
2040	3.136E+01	2.511E+04	1.687E+00	8.377E+00	1.256E+04	8.436E-01
2041	2.983E+01	2.389E+04	1.605E+00	7.968E+00	1.194E+04	8.025E-01
2042	2.838E+01	2.272E+04	1.527E+00	7.580E+00	1.136E+04	7.634E-01
2043	2.699E+01	2.161E+04	1.452E+00	7.210E+00	1.081E+04	7.261E-01
2044	2.568E+01	2.056E+04	1.381E+00	6.858E+00	1.028E+04	6.907E-01
2045	2.442E+01	1.956E+04	1.314E+00	6.524E+00	9.779E+03	6.570E-01
2046	2.323E+01	1.860E+04	1.250E+00	6.206E+00	9.302E+03	6.250E-01
2047	2.210E+01	1.770E+04	1.189E+00	5.903E+00	8.848E+03	5.945E-01
2048	2.102E+01	1.683E+04	1.131E+00	5.615E+00	8.417E+03	5.655E-01
2049	2.000E+01	1.601E+04	1.076E+00	5.341E+00	8.006E+03	5.379E-01
2050	1.902E+01	1.523E+04	1.023E+00	5.081E+00	7.616E+03	5.117E-01
2051	1.809E+01	1.449E+04	9.735E-01	4.833E+00	7.244E+03	4.867E-01
2052	1.721E+01	1.378E+04	9.260E-01	4.597E+00	6.891E+03	4.630E-01
2053	1.637E+01	1.311E+04	8.808E-01	4.373E+00	6.555E+03	4.404E-01
2054	1.557E+01	1.247E+04	8.379E-01	4.160E+00	6.235E+03	4.189E-01
2055	1.481E+01	1.186E+04	7.970E-01	3.957E+00	5.931E+03	3.985E-01
2056	1.409E+01	1.128E+04	7.581E-01	3.764E+00	5.642E+03	3.791E-01
2057	1.340E+01	1.073E+04	7.212E-01	3.580E+00	5.367E+03	3.606E-01
2058	1.275E+01	1.021E+04	6.860E-01	3.406E+00	5.105E+03	3.430E-01
2059	1.213E+01	9.712E+03	6.525E-01	3.240E+00	4.856E+03	3.263E-01
2060	1.154E+01	9.238E+03	6.207E-01	3.082E+00	4.619E+03	3.104E-01
2061	1.097E+01	8.788E+03	5.904E-01	2.931E+00	4.394E+03	2.952E-01
2062	1.044E+01	8.359E+03	5.616E-01	2.788E+00	4.180E+03	2.808E-01
2063	9.930E+00	7.951E+03	5.343E-01	2.652E+00	3.976E+03	2.671E-01
2064	9.446E+00	7.564E+03	5.082E-01	2.523E+00	3.782E+03	2.541E-01
2065	8.985E+00	7.195E+03	4.834E-01	2.400E+00	3.597E+03	2.417E-01
2066	8.547E+00	6.844E+03	4.598E-01	2.283E+00	3.422E+03	2.299E-01
2067	8.130E+00	6.510E+03	4.374E-01	2.172E+00	3.255E+03	2.187E-01
2068	7.733E+00	6.193E+03	4.161E-01	2.066E+00	3.096E+03	2.080E-01
2069	7.356E+00	5.891E+03	3.958E-01	1.965E+00	2.945E+03	1.979E-01
2070	6.997E+00	5.603E+03	3.765E-01	1.869E+00	2.802E+03	1.882E-01
2071	6.656E+00	5.330E+03	3.581E-01	1.778E+00	2.665E+03	1.791E-01
2072	6.332E+00	5.070E+03	3.407E-01	1.691E+00	2.535E+03	1.703E-01
2073	6.023E+00	4.823E+03	3.240E-01	1.609E+00	2.411E+03	1.620E-01
2074	5.729E+00	4.588E+03	3.082E-01	1.530E+00	2.294E+03	1.541E-01
2075	5.450E+00	4.364E+03	2.932E-01	1.456E+00	2.182E+03	1.466E-01
2076	5.184E+00	4.151E+03	2.789E-01	1.385E+00	2.075E+03	1.395E-01
2077	4.931E+00	3.949E+03	2.653E-01	1.317E+00	1.974E+03	1.327E-01
2078	4.691E+00	3.756E+03	2.524E-01	1.253E+00	1.878E+03	1.262E-01
2079	4.462E+00	3.573E+03	2.401E-01	1.192E+00	1.786E+03	1.200E-01
2080	4.244E+00	3.399E+03	2.283E-01	1.134E+00	1.699E+03	1.142E-01
2081	4.037E+00	3.233E+03	2.172E-01	1.078E+00	1.616E+03	1.086E-01
2082	3.840E+00	3.075E+03	2.066E-01	1.026E+00	1.538E+03	1.033E-01
2083	3.653E+00	2.925E+03	1.965E-01	9.758E-01	1.463E+03	9.827E-02
2084	3.475E+00	2.782E+03	1.870E-01	9.282E-01	1.391E+03	9.348E-02
2085	3.305E+00	2.647E+03	1.778E-01	8.829E-01	1.323E+03	8.892E-02
2086	3.144E+00	2.518E+03	1.692E-01	8.398E-01	1.259E+03	8.458E-02

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2087	2.991E+00	2.395E+03	1.609E-01	7.989E-01	1.197E+03	8.046E-02
2088	2.845E+00	2.278E+03	1.531E-01	7.599E-01	1.139E+03	7.653E-02
2089	2.706E+00	2.167E+03	1.456E-01	7.229E-01	1.084E+03	7.280E-02
2090	2.574E+00	2.061E+03	1.385E-01	6.876E-01	1.031E+03	6.925E-02
2091	2.449E+00	1.961E+03	1.317E-01	6.541E-01	9.804E+02	6.587E-02
2092	2.329E+00	1.865E+03	1.253E-01	6.222E-01	9.326E+02	6.266E-02
2093	2.216E+00	1.774E+03	1.192E-01	5.918E-01	8.871E+02	5.960E-02
2094	2.108E+00	1.688E+03	1.134E-01	5.630E-01	8.438E+02	5.670E-02
2095	2.005E+00	1.605E+03	1.079E-01	5.355E-01	8.027E+02	5.393E-02
2096	1.907E+00	1.527E+03	1.026E-01	5.094E-01	7.635E+02	5.130E-02
2097	1.814E+00	1.453E+03	9.760E-02	4.845E-01	7.263E+02	4.880E-02
2098	1.726E+00	1.382E+03	9.284E-02	4.609E-01	6.909E+02	4.642E-02
2099	1.641E+00	1.314E+03	8.831E-02	4.384E-01	6.572E+02	4.416E-02
2100	1.561E+00	1.250E+03	8.400E-02	4.171E-01	6.251E+02	4.200E-02
2101	1.485E+00	1.189E+03	7.991E-02	3.967E-01	5.946E+02	3.995E-02
2102	1.413E+00	1.131E+03	7.601E-02	3.774E-01	5.656E+02	3.801E-02
2103	1.344E+00	1.076E+03	7.230E-02	3.590E-01	5.381E+02	3.615E-02
2104	1.278E+00	1.024E+03	6.878E-02	3.415E-01	5.118E+02	3.439E-02
2105	1.216E+00	9.737E+02	6.542E-02	3.248E-01	4.868E+02	3.271E-02
2106	1.157E+00	9.262E+02	6.223E-02	3.090E-01	4.631E+02	3.112E-02
2107	1.100E+00	8.810E+02	5.920E-02	2.939E-01	4.405E+02	2.960E-02
2108	1.047E+00	8.381E+02	5.631E-02	2.796E-01	4.190E+02	2.815E-02
2109	9.956E-01	7.972E+02	5.356E-02	2.659E-01	3.986E+02	2.678E-02
2110	9.470E-01	7.583E+02	5.095E-02	2.530E-01	3.792E+02	2.548E-02
2111	9.008E-01	7.213E+02	4.847E-02	2.406E-01	3.607E+02	2.423E-02
2112	8.569E-01	6.862E+02	4.610E-02	2.289E-01	3.431E+02	2.305E-02
2113	8.151E-01	6.527E+02	4.385E-02	2.177E-01	3.263E+02	2.193E-02
2114	7.753E-01	6.209E+02	4.172E-02	2.071E-01	3.104E+02	2.086E-02
2115	7.375E-01	5.906E+02	3.968E-02	1.970E-01	2.953E+02	1.984E-02
2116	7.016E-01	5.618E+02	3.775E-02	1.874E-01	2.809E+02	1.887E-02
2117	6.673E-01	5.344E+02	3.590E-02	1.783E-01	2.672E+02	1.795E-02
2118	6.348E-01	5.083E+02	3.415E-02	1.696E-01	2.542E+02	1.708E-02
2119	6.038E-01	4.835E+02	3.249E-02	1.613E-01	2.418E+02	1.624E-02
2120	5.744E-01	4.599E+02	3.090E-02	1.534E-01	2.300E+02	1.545E-02
2121	5.464E-01	4.375E+02	2.940E-02	1.459E-01	2.188E+02	1.470E-02
2122	5.197E-01	4.162E+02	2.796E-02	1.388E-01	2.081E+02	1.398E-02
2123	4.944E-01	3.959E+02	2.660E-02	1.321E-01	1.979E+02	1.330E-02
2124	4.703E-01	3.766E+02	2.530E-02	1.256E-01	1.883E+02	1.265E-02
2125	4.473E-01	3.582E+02	2.407E-02	1.195E-01	1.791E+02	1.203E-02
2126	4.255E-01	3.407E+02	2.289E-02	1.137E-01	1.704E+02	1.145E-02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1986	0	0	0	0	0	0
1987	2.028E+01	1.108E+04	7.444E-01	3.177E-01	8.864E+01	5.955E-03
1988	3.957E+01	2.162E+04	1.453E+00	6.199E-01	1.729E+02	1.162E-02
1989	5.792E+01	3.164E+04	2.126E+00	9.074E-01	2.532E+02	1.701E-02
1990	7.538E+01	4.118E+04	2.767E+00	1.181E+00	3.294E+02	2.214E-02
1991	9.199E+01	5.025E+04	3.376E+00	1.441E+00	4.020E+02	2.701E-02
1992	1.078E+02	5.888E+04	3.956E+00	1.688E+00	4.710E+02	3.165E-02
1993	1.228E+02	6.709E+04	4.508E+00	1.924E+00	5.367E+02	3.606E-02
1994	1.371E+02	7.490E+04	5.032E+00	2.148E+00	5.992E+02	4.026E-02
1995	1.507E+02	8.232E+04	5.531E+00	2.361E+00	6.586E+02	4.425E-02
1996	1.636E+02	8.939E+04	6.006E+00	2.563E+00	7.151E+02	4.805E-02
1997	1.759E+02	9.611E+04	6.457E+00	2.756E+00	7.689E+02	5.166E-02
1998	1.876E+02	1.025E+05	6.887E+00	2.939E+00	8.200E+02	5.510E-02
1999	1.785E+02	9.753E+04	6.553E+00	2.797E+00	7.803E+02	5.243E-02
2000	1.698E+02	9.278E+04	6.234E+00	2.660E+00	7.422E+02	4.987E-02
2001	1.615E+02	8.825E+04	5.930E+00	2.531E+00	7.060E+02	4.744E-02
2002	1.537E+02	8.395E+04	5.640E+00	2.407E+00	6.716E+02	4.512E-02
2003	1.462E+02	7.985E+04	5.365E+00	2.290E+00	6.388E+02	4.292E-02
2004	1.390E+02	7.596E+04	5.104E+00	2.178E+00	6.077E+02	4.083E-02
2005	1.323E+02	7.225E+04	4.855E+00	2.072E+00	5.780E+02	3.884E-02
2006	1.258E+02	6.873E+04	4.618E+00	1.971E+00	5.498E+02	3.694E-02
2007	1.197E+02	6.538E+04	4.393E+00	1.875E+00	5.230E+02	3.514E-02
2008	1.138E+02	6.219E+04	4.179E+00	1.783E+00	4.975E+02	3.343E-02
2009	1.083E+02	5.916E+04	3.975E+00	1.696E+00	4.733E+02	3.180E-02
2010	1.030E+02	5.627E+04	3.781E+00	1.614E+00	4.502E+02	3.025E-02
2011	9.798E+01	5.353E+04	3.597E+00	1.535E+00	4.282E+02	2.877E-02
2012	9.320E+01	5.092E+04	3.421E+00	1.460E+00	4.073E+02	2.737E-02
2013	8.866E+01	4.843E+04	3.254E+00	1.389E+00	3.875E+02	2.603E-02
2014	8.433E+01	4.607E+04	3.096E+00	1.321E+00	3.686E+02	2.476E-02
2015	8.022E+01	4.382E+04	2.945E+00	1.257E+00	3.506E+02	2.356E-02
2016	7.631E+01	4.169E+04	2.801E+00	1.195E+00	3.335E+02	2.241E-02
2017	7.259E+01	3.965E+04	2.664E+00	1.137E+00	3.172E+02	2.131E-02
2018	6.905E+01	3.772E+04	2.534E+00	1.082E+00	3.018E+02	2.028E-02
2019	6.568E+01	3.588E+04	2.411E+00	1.029E+00	2.870E+02	1.929E-02
2020	6.248E+01	3.413E+04	2.293E+00	9.787E-01	2.730E+02	1.835E-02
2021	5.943E+01	3.247E+04	2.181E+00	9.310E-01	2.597E+02	1.745E-02
2022	5.653E+01	3.088E+04	2.075E+00	8.856E-01	2.471E+02	1.660E-02
2023	5.377E+01	2.938E+04	1.974E+00	8.424E-01	2.350E+02	1.579E-02
2024	5.115E+01	2.794E+04	1.878E+00	8.013E-01	2.236E+02	1.502E-02
2025	4.866E+01	2.658E+04	1.786E+00	7.622E-01	2.126E+02	1.429E-02
2026	4.628E+01	2.528E+04	1.699E+00	7.251E-01	2.023E+02	1.359E-02
2027	4.403E+01	2.405E+04	1.616E+00	6.897E-01	1.924E+02	1.293E-02
2028	4.188E+01	2.288E+04	1.537E+00	6.561E-01	1.830E+02	1.230E-02
2029	3.984E+01	2.176E+04	1.462E+00	6.241E-01	1.741E+02	1.170E-02
2030	3.789E+01	2.070E+04	1.391E+00	5.936E-01	1.656E+02	1.113E-02
2031	3.605E+01	1.969E+04	1.323E+00	5.647E-01	1.575E+02	1.058E-02
2032	3.429E+01	1.873E+04	1.259E+00	5.371E-01	1.499E+02	1.007E-02
2033	3.262E+01	1.782E+04	1.197E+00	5.109E-01	1.425E+02	9.577E-03
2034	3.102E+01	1.695E+04	1.139E+00	4.860E-01	1.356E+02	9.110E-03
2035	2.951E+01	1.612E+04	1.083E+00	4.623E-01	1.290E+02	8.666E-03

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2036	2.807E+01	1.534E+04	1.030E+00	4.398E-01	1.227E+02	8.243E-03
2037	2.670E+01	1.459E+04	9.802E-01	4.183E-01	1.167E+02	7.841E-03
2038	2.540E+01	1.388E+04	9.324E-01	3.979E-01	1.110E+02	7.459E-03
2039	2.416E+01	1.320E+04	8.869E-01	3.785E-01	1.056E+02	7.095E-03
2040	2.298E+01	1.256E+04	8.436E-01	3.601E-01	1.004E+02	6.749E-03
2041	2.186E+01	1.194E+04	8.025E-01	3.425E-01	9.555E+01	6.420E-03
2042	2.080E+01	1.136E+04	7.634E-01	3.258E-01	9.089E+01	6.107E-03
2043	1.978E+01	1.081E+04	7.261E-01	3.099E-01	8.646E+01	5.809E-03
2044	1.882E+01	1.028E+04	6.907E-01	2.948E-01	8.224E+01	5.526E-03
2045	1.790E+01	9.779E+03	6.570E-01	2.804E-01	7.823E+01	5.256E-03
2046	1.703E+01	9.302E+03	6.250E-01	2.667E-01	7.441E+01	5.000E-03
2047	1.620E+01	8.848E+03	5.945E-01	2.537E-01	7.078E+01	4.756E-03
2048	1.541E+01	8.417E+03	5.655E-01	2.414E-01	6.733E+01	4.524E-03
2049	1.466E+01	8.006E+03	5.379E-01	2.296E-01	6.405E+01	4.303E-03
2050	1.394E+01	7.616E+03	5.117E-01	2.184E-01	6.092E+01	4.094E-03
2051	1.326E+01	7.244E+03	4.867E-01	2.077E-01	5.795E+01	3.894E-03
2052	1.261E+01	6.891E+03	4.630E-01	1.976E-01	5.513E+01	3.704E-03
2053	1.200E+01	6.555E+03	4.404E-01	1.880E-01	5.244E+01	3.523E-03
2054	1.141E+01	6.235E+03	4.189E-01	1.788E-01	4.988E+01	3.352E-03
2055	1.086E+01	5.931E+03	3.985E-01	1.701E-01	4.745E+01	3.188E-03
2056	1.033E+01	5.642E+03	3.791E-01	1.618E-01	4.513E+01	3.033E-03
2057	9.824E+00	5.367E+03	3.606E-01	1.539E-01	4.293E+01	2.885E-03
2058	9.345E+00	5.105E+03	3.430E-01	1.464E-01	4.084E+01	2.744E-03
2059	8.889E+00	4.856E+03	3.263E-01	1.392E-01	3.885E+01	2.610E-03
2060	8.455E+00	4.619E+03	3.104E-01	1.325E-01	3.695E+01	2.483E-03
2061	8.043E+00	4.394E+03	2.952E-01	1.260E-01	3.515E+01	2.362E-03
2062	7.651E+00	4.180E+03	2.808E-01	1.199E-01	3.344E+01	2.247E-03
2063	7.278E+00	3.976E+03	2.671E-01	1.140E-01	3.181E+01	2.137E-03
2064	6.923E+00	3.782E+03	2.541E-01	1.084E-01	3.025E+01	2.033E-03
2065	6.585E+00	3.597E+03	2.417E-01	1.032E-01	2.878E+01	1.934E-03
2066	6.264E+00	3.422E+03	2.299E-01	9.813E-02	2.738E+01	1.839E-03
2067	5.958E+00	3.255E+03	2.187E-01	9.334E-02	2.604E+01	1.750E-03
2068	5.668E+00	3.096E+03	2.080E-01	8.879E-02	2.477E+01	1.664E-03
2069	5.391E+00	2.945E+03	1.979E-01	8.446E-02	2.356E+01	1.583E-03
2070	5.128E+00	2.802E+03	1.882E-01	8.034E-02	2.241E+01	1.506E-03
2071	4.878E+00	2.665E+03	1.791E-01	7.642E-02	2.132E+01	1.432E-03
2072	4.640E+00	2.535E+03	1.703E-01	7.269E-02	2.028E+01	1.363E-03
2073	4.414E+00	2.411E+03	1.620E-01	6.915E-02	1.929E+01	1.296E-03
2074	4.199E+00	2.294E+03	1.541E-01	6.578E-02	1.835E+01	1.233E-03
2075	3.994E+00	2.182E+03	1.466E-01	6.257E-02	1.746E+01	1.173E-03
2076	3.799E+00	2.075E+03	1.395E-01	5.952E-02	1.660E+01	1.116E-03
2077	3.614E+00	1.974E+03	1.327E-01	5.661E-02	1.579E+01	1.061E-03
2078	3.438E+00	1.878E+03	1.262E-01	5.385E-02	1.502E+01	1.009E-03
2079	3.270E+00	1.786E+03	1.200E-01	5.123E-02	1.429E+01	9.602E-04
2080	3.111E+00	1.699E+03	1.142E-01	4.873E-02	1.359E+01	9.134E-04
2081	2.959E+00	1.616E+03	1.086E-01	4.635E-02	1.293E+01	8.688E-04
2082	2.815E+00	1.538E+03	1.033E-01	4.409E-02	1.230E+01	8.265E-04
2083	2.677E+00	1.463E+03	9.827E-02	4.194E-02	1.170E+01	7.862E-04
2084	2.547E+00	1.391E+03	9.348E-02	3.990E-02	1.113E+01	7.478E-04
2085	2.422E+00	1.323E+03	8.892E-02	3.795E-02	1.059E+01	7.113E-04
2086	2.304E+00	1.259E+03	8.458E-02	3.610E-02	1.007E+01	6.767E-04

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2087	2.192E+00	1.197E+03	8.046E-02	3.434E-02	9.580E+00	6.437E-04
2088	2.085E+00	1.139E+03	7.653E-02	3.266E-02	9.112E+00	6.123E-04
2089	1.983E+00	1.084E+03	7.280E-02	3.107E-02	8.668E+00	5.824E-04
2090	1.887E+00	1.031E+03	6.925E-02	2.955E-02	8.245E+00	5.540E-04
2091	1.795E+00	9.804E+02	6.587E-02	2.811E-02	7.843E+00	5.270E-04
2092	1.707E+00	9.326E+02	6.266E-02	2.674E-02	7.461E+00	5.013E-04
2093	1.624E+00	8.871E+02	5.960E-02	2.544E-02	7.097E+00	4.768E-04
2094	1.545E+00	8.438E+02	5.670E-02	2.420E-02	6.751E+00	4.536E-04
2095	1.469E+00	8.027E+02	5.393E-02	2.302E-02	6.421E+00	4.315E-04
2096	1.398E+00	7.635E+02	5.130E-02	2.189E-02	6.108E+00	4.104E-04
2097	1.329E+00	7.263E+02	4.880E-02	2.083E-02	5.810E+00	3.904E-04
2098	1.265E+00	6.909E+02	4.642E-02	1.981E-02	5.527E+00	3.714E-04
2099	1.203E+00	6.572E+02	4.416E-02	1.885E-02	5.257E+00	3.532E-04
2100	1.144E+00	6.251E+02	4.200E-02	1.793E-02	5.001E+00	3.360E-04
2101	1.088E+00	5.946E+02	3.995E-02	1.705E-02	4.757E+00	3.196E-04
2102	1.035E+00	5.656E+02	3.801E-02	1.622E-02	4.525E+00	3.040E-04
2103	9.849E-01	5.381E+02	3.615E-02	1.543E-02	4.304E+00	2.892E-04
2104	9.369E-01	5.118E+02	3.439E-02	1.468E-02	4.094E+00	2.751E-04
2105	8.912E-01	4.868E+02	3.271E-02	1.396E-02	3.895E+00	2.617E-04
2106	8.477E-01	4.631E+02	3.112E-02	1.328E-02	3.705E+00	2.489E-04
2107	8.064E-01	4.405E+02	2.960E-02	1.263E-02	3.524E+00	2.368E-04
2108	7.670E-01	4.190E+02	2.815E-02	1.202E-02	3.352E+00	2.252E-04
2109	7.296E-01	3.986E+02	2.678E-02	1.143E-02	3.189E+00	2.143E-04
2110	6.940E-01	3.792E+02	2.548E-02	1.087E-02	3.033E+00	2.038E-04
2111	6.602E-01	3.607E+02	2.423E-02	1.034E-02	2.885E+00	1.939E-04
2112	6.280E-01	3.431E+02	2.305E-02	9.838E-03	2.745E+00	1.844E-04
2113	5.974E-01	3.263E+02	2.193E-02	9.358E-03	2.611E+00	1.754E-04
2114	5.682E-01	3.104E+02	2.086E-02	8.902E-03	2.483E+00	1.669E-04
2115	5.405E-01	2.953E+02	1.984E-02	8.468E-03	2.362E+00	1.587E-04
2116	5.142E-01	2.809E+02	1.887E-02	8.055E-03	2.247E+00	1.510E-04
2117	4.891E-01	2.672E+02	1.795E-02	7.662E-03	2.138E+00	1.436E-04
2118	4.652E-01	2.542E+02	1.708E-02	7.288E-03	2.033E+00	1.366E-04
2119	4.425E-01	2.418E+02	1.624E-02	6.933E-03	1.934E+00	1.300E-04
2120	4.210E-01	2.300E+02	1.545E-02	6.595E-03	1.840E+00	1.236E-04
2121	4.004E-01	2.188E+02	1.470E-02	6.273E-03	1.750E+00	1.176E-04
2122	3.809E-01	2.081E+02	1.398E-02	5.967E-03	1.665E+00	1.119E-04
2123	3.623E-01	1.979E+02	1.330E-02	5.676E-03	1.584E+00	1.064E-04
2124	3.447E-01	1.883E+02	1.265E-02	5.399E-03	1.506E+00	1.012E-04
2125	3.278E-01	1.791E+02	1.203E-02	5.136E-03	1.433E+00	9.627E-05
2126	3.119E-01	1.704E+02	1.145E-02	4.885E-03	1.363E+00	9.158E-05

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