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CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

TIER 3 RISK ASSESSMENT
HISTORIC LANDFILL AT CLAREMORRIS, CO. MAYO

Prepared for: Mayo County Council

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Abstract: This report represents the findings of a Tier 3 risk assessment carried out at Claremorris Historic Landfill, Co. Mayo, conducted in accordance with the EPA Code of Practice for unregulated landfill sites.

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EXECUTIVE SUMMARY

Fehily Timoney and Company (FT) was appointed by Mayo County Council (MCC) to complete a Tier 3 environmental risk assessment (ERA) of Claremorris Historic Landfill in accordance with the Environmental Protection Agency (EPA) Code of Practice (CoP) (2007): Environmental Risk Assessment for Unregulated Waste Disposal Sites.

The historic landfill occupies approximately 3.8 ha of open land located to the east of the Claremorris town centre. The site is currently vacant albeit with evidence of rough grazing by horses. Neighbouring adjacent land uses include grassland and, residential land located approximately 280 m west of the site. An electric substation is located approximately 150 m north of the site. The site is bounded by a railway to the North and by the Knock-Claremorris Bypass (N17) to the West, the other sides are bounded by agricultural land (boggy ground). There are no dwellings located within or immediately adjacent the site boundary, however a housing estate (approximately 280 m west) and Claremorris town centre (approximately 80m north-west) are located in the surroundings.

It is proposed that the site be developed to form part of a larger solar farm which incorporates both the field underlain by the historical landfill and an adjacent privately-owned field.

An initial risk assessment of the site was completed by MCC in 2010 which determined that the site had a moderate risk (Class B) to the environment, with the highest score assigned being 61% to leachate migration to the groundwater body via groundwater pathways.

A site investigation (S.I.) program was completed in 2011. The findings of the site investigation work suggest the waste material is deposited in a single infill area over an estimated plan area of 26,000 m^2.

MCC initially estimated that approximately 168,000 tonnes were deposited at the site. A review of S.I. data suggests that this quantity may be 279,623 tonnes.

Analysis of waste samples from the trial pits excavated, when assessed against the inert waste acceptance criteria, indicated that much of the waste material within the site is typically inert. The waste classification is considered to reflect the level of degradation over time since landfilling ceased. Trial pits confirmed the waste material is near the surface with a minimal topsoil and clay cover present across the site.

Landfill gas monitoring from perimeter well BH02 at the site indicates gas concentrations detected are below threshold levels set by the EPA CoP. However, gas concentrations measured in 2010 at BH01 located within the waste body yielded a methane concentration of 78%. Groundwater monitoring was conducted on BH01 and BH02. Surface water sampling was also undertaken.

Based on the results of this updated assessment, the site is still classified as a **Moderate Risk Classification (Class B)**. The principal risk identified on the site is the risk posed to the aquifer from migration of leachate from the waste material encountered at the site through groundwater.

The purpose of this Tier 3 assessment was to further examine and quantify those risks/impacts through generation of computer models allowing a prediction of both the current and future impacts on:

- Groundwater quality, and
- The current and future extent landfill gas being generated by the waste present on site.

This information was used to inform appropriate remedial and mitigation measures to be implemented on site to either eliminate or reduce these risks.

Estimation of leachate generation at the site indicates that the site may contribute a very small amount of groundwater recharge volume to the wider Clare/Corrib groundwater body, therefore it is not likely to have an impact regionally.

LandGEM was utilised to estimate the quantity of landfill gas produced by the waste underlying the site. The model suggests that the site is continuing to produce landfill gas and methane in moderate quantities, thereby requiring remedial actions to be implemented.

The Tier 3 assessment concluded an engineered landfill cap layer will be required across the site to mitigate the impacts of leachate generated on site on the underlying aquifer and receptors downgradient. The proposed landfill cap will be constructed in accordance with the EPA recommendations/requirements for landfill site design. An engineered cap will have a barrier layer which will isolate rainfall inputs and so reduce future leachate generation. This cap should also be designed to take into consideration the proposed future use of the site as a solar farm and will be required to support any proposed on-site solar farm infrastructure.

To monitor the efficacy of the proposed remediation measures, additional groundwater monitoring locations are proposed downstream of the site. Additional surface water monitoring locations are also proposed upstream and downstream of the waste body.

The landfill capping shall also include active or passive landfill gas controls. A final decision on landfill gas control measures will be made upon completion of a landfill gas pumping trial. The pumping trial shall be used to determine the quantity and quality of landfill gas actively produced at the site. The most appropriate landfill gas control measures should be determined with reference to EPA Guidance: Management of Low Levels of Landfill Gas and EPA Landfill Manuals, Landfill Site Design.

1. INTRODUCTION

1.1 Background

The Claremorris waste footprint (3.8 ha.) is located within open land located approximately 1 km south-east from the centre of Claremorris town. Claremorris is approximately 24 km south-east of Castlebar. The landfill site is located in the townland of Clare and situated in agricultural land. The site is, bounded by a railway to the north and by the Knock-Claremorris Bypass (N17) to the West. The south and east boundaries comprise (boggy) agricultural lands. Access to the site was difficult due to overgrown brambles, gorse, trees and alien species.

The exact waste footprint area was unconfirmed. The site operated as a regional landfill accepting municipal waste from 1982 to March 1996. The site was capped with boulder clay, but no remediation works have been completed. It has been reported that on occasion fires broke out on the site.

MCC is required to complete a tiered risk assessment of unregulated waste disposal sites in accordance with the Environmental Protection Agency (EPA) code of practice for unregulated waste disposal sites.

A Tier 2 Environmental Risk Assessment was conducted in 2010 and the report can be found in Appendix 1. A site investigation was carried out and the report containing the findings can be found in Appendix 2. MCC's 2010 assessment determined that the site had a moderate risk to the environment, which the highest normalised score assigned being 61.25%.

1.2 Scope of Works

FT's scope of work was to undertake a Tier 3 risk assessment of the site in accordance with the EPA Code of Practice (CoP) 2007: *Environmental Risk Assessment for Unregulated Waste Disposal Sites*. FT undertook the following:

- Desk study.
- Site walkover.
- Environmental risk assessment (ERA).
- Development of a conceptual site model (CSM).

The Tier 3 risk assessment was undertaken in tandem with a proposed Part 8 planning application to develop the site and surrounding area into a solar farm. The proposed application accelerated the need to regularise the site by MCC.

As part of the initial desk study, a review of available information including the previous site investigation and assessment was undertaken. This was followed-up with a site walkover by FT personnel. The desk study and site walkover were used to provide an updated view of the condition of the site and as a preliminary step in determining appropriate remediation measures.

The site walkover checklist, accompanying photo log and site walkover notes are included in Appendix 3 to this report.

The information gathered from the desk study and previous intrusive site investigation were used to inform the development of the conceptual site model (CSM) and the Environmental Risk Assessment (ERA). This report presents the findings of the assessment.

2. DESK STUDY

2.1 Introduction

The desk study included the review of the following literature sources and websites:

- Geological Survey of Ireland, Groundwater Web Mapping: www.gsi.ie.
- Environmental Protection Agency Maps: http://gis.epa.ie/Envision.
- National Parks and Wildlife Service Map Viewer: www.npws.ie.
- DoHPLG/EPA/Local Authority maps: www.catchments.ie.
- Mayo County Council Site Plans and Drawings.
- BS 5930: 1999, Code of Practice for Site Investigations.
- BS 10175: 2000, Investigation of Potentially Contaminated Sites – Code of Practice.
- EPA's Historic Mine Sites - Inventory and Risk Classification (2009).
- EPA - Assessing and Developing Natural Background Levels for Chemical Parameters in Irish Groundwater (2017).

A desktop review of available documentation for the site was conducted followed by a site walkover on 16th January 2020.

2.2 Desk Study

This section of the report presents the findings of the desk study.

2.2.1 Site Description and On-Site Conditions

The Historic landfill is approximately 3.8 ha in size, of open land located to the east of Claremorris town and centre. The site is currently vacant with evidence of rough grazing by horses. Neighbouring land uses include grassland and a housing estate (c. 280 m west). An electric substation is located c. 150m north of the site. The site is bounded by a railway to the North and by the Knock-Claremorris Bypass (N17) to the West, the other sides are bounded by (boggy) agricultural land. There are no dwellings located within or immediately adjacent the site boundary. Claremorris city centre (c. 800m north-west) is located in the surroundings.

The Corine 2018 land use classification for the site is mostly inland wetlands (peat bogs).

The location of the site is shown in Figure 2-1.

2.2.2 Previous Studies

A Tier 2 Environmental Risk Assessment was conducted in 2010 and can be found in Appendix 1. A site investigation was carried out and the report containing the findings is found in Appendix 2.

The Tier 2 assessment comprised the following:

- Desk study.
- Development of a conceptual site model (CSM).
- Site investigation works.
- Sample collection.
- Identification of contaminant sources, pathways of contaminant migration and potential receptors which may be vulnerable if exposed to those contaminants; i.e. the identification of Source- Pathway-Receptor (SPR) linkages.
- The prioritisation of sites and SPR linkages based on their perceived risk.

Based on the available information, the Tier 2 Assessment determined that the overall risk score for Claremorris Landfill was 61.25%, resulting in a risk classification of **Moderate (Class B)**.

Figure 2-1: Location of Site

https://uss.ftco.ie/DMS/view_document.aspx?ID=524257&Latest=true

2.2.3 Topography

The surrounding site is relatively flat. The waste deposition area is raised with respect to the surrounding topography. The site is readily accessed via an artificial steep incline/embankment from N17 road to the west of the site. The site generally falls from south to north towards the railway and west to east towards the bogland and stream.

Regionally, Claremorris town is located within an extensive flat area along the south-east of County Mayo, with land slightly sloping upwards to the north-east of the town.

2.2.4 Geology

Drift/Quaternary Geology

The quaternary Map provided by GSI Online identifies most quaternary sediments at the site as 'Gravels derived from Limestones' and a south-west portion as 'Cut over raised peat'; 'Till derived from limestones' and 'Cut over raised peat' is found in the surroundings. Quaternary sediments are shown in Figure 2-2.

During the installation of boreholes during the site investigation, the presence of natural-black brown peat till is described in the driller's logs to depths of approximately 5.90 m and 4.0 m BGL at boreholes BH01 and BH02, respectively (See Appendix 2).

Solid or Bedrock Geology

The GSI online 1:100,000 scale bedrock geology map, shows the bedrock beneath to be found on a single formation. The entirety of the site and surrounding area are underlain by the Ballymore Limestone Formation (CDBLYM) which is generally made up of dark fine-grained limestone and shale. No areas of bedrock outcrop are shown within or in the immediate vicinity of the site.

The bedrock geology is presented in Figure 2-3.

No bedrock encountered during the installation of boreholes BH01 and BH02, as referenced in the JS Drilling borehole logs (Appendix 2).

Figure 2-2: Quaternary Geology

https://uss.ftco.ie/DMS/view_document.aspx?ID=524259&Latest=true

Figure 2-3: Bedrock Geology

https://uss.ftco.ie/DMS/view_document.aspx?ID=524260&Latest=true

2.2.5 Hydrogeology

An examination of the national bedrock aquifer map on the GSI online mapping classifies the underlying bedrock aquifer as 'Regionally Important Aquifer - Karstified (conduit)'. The bedrock aquifer mapping is presented in Figure 2-4.

GSI mapping indicates the presence of karst aquifer located within the site.

Historical mapping for the area shows few springs in the surrounding area. There are several standalone dwellings and clusters of residential units in relative proximity to the site and wider environment where unregistered private wells may be present.

Table 2-1 presents the details of the GSI registered boreholes and springs within 1km of the site. It is noted that all wells listed below have location accuracies of 1 – 2km and may be located outside of the 1km radius.

Table 2-1 Borehole and Spring Descriptions near the Project Site

BH/Spring	Yield class	Yield (m^3/day)	Use	Depth (m)	Depth to Rock confidence (m)	Distance from site (km)	Date
1127SEW004	-	-	Group Scheme	-	-	0.53	1899

The GSI mapping showing approximately locations of known wells and springs is included in Figure 2-5.

There are no Groundwater Drinking Water Protection Areas within the site boundaries according to GSI. The closest, Loughanemon Barnacarroll GWS, is located approximately 3.2km North from the site. Approximately 4.7 km from the site, also North, Kilcolman Facefield GWS is located. Irishtown GWS can be found c. 5.8km South-East.

The GSI shows that the groundwater body (GWB) underlying the site is the Cong-Robe GWB and it is a Karstic aquifer. The most recent (2013-2018) Water Framework Directive quality status for the GWB is 'Good'. The WFD risk to groundwater quality was most recently classified as 'Review'.

The closest groundwater dependant ecosystem in the area, according to Catchments Maps, is the Clare-Corrib Groundwater in SAC Habitats (Code: IE_WE_G_0020), located c.4.9km South-East of the site at its closest point.

The GSI mapping shows three different groundwater recharge area rates for the site, the primary two areas are:

a. *High: A pre-cap recharge rate of 707mm/yr for the site was calculated applying a recharge co-efficient of 85.0% to an effective rainfall rate of 832 mm/yr. GSI define the hydrogeological setting as High Permeable Subsoil, Sand and Gravels overlain by Well-drained Soil. Found in most of the site.*
b. *Low: A pre-cap recharge rate of 33mm/yr for the site was calculated applying a recharge co-efficient of 4.0% to an effective rainfall rate of 832 mm/yr. GSI define the hydrogeological setting as Peat. Found in the south-western portion of the site.*

Figure 2-4: Aquifer Classification

https://uss.ftco.ie/DMS/view_document.aspx?ID=524261&Latest=true

Figure 2-5: Wells and Springs

https://uss.ftco.ie/DMS/view_document.aspx?ID=524262&Latest=true

2.2.6 Groundwater Vulnerability

Groundwater vulnerability, as defined by the GSI, is the term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The factors used in assessing groundwater vulnerability include subsoil type and thickness and recharge type as indicated in Table 2-2. The GSI procedure whereby groundwater protection is assessed is outlined in the EPA-GSI publication Groundwater Protection Schemes (DELG/EPA/GSI, 1999).

The GSI Online mapping data set identifies the vulnerability of groundwater to contamination is classified as H (High) in the majority of the site and M (Moderate) in the most south-western and north-western points of the site. The Groundwater Vulnerability mapping is presented in Figure 2-6.

Table 2-2 GSI Guidelines – Aquifer Vulnerability Mapping

Vulnerability Rating	Hydrogeological Conditions		
	Subsoil Permeability (Type) and Thickness		
	High Permeability (Shallow Bedrock)	Moderate Permeability (e.g. Sandy soil)	Low Permeability (e.g. Clayey subsoil, clay, peat)
Extreme (E)	0 - 3.0 m	0 - 3.0 m	0 - 3.0 m
High (H)	>3.0 m	3.0 -10.0 m	3.0 - 5.0 m
Moderate (M)	N/A	>10.0 m	5.0 - 10.0 m
Low (L)	N/A	N/A	>10 m

Notes:
N/A = Not Applicable
Precise permeability values cannot be given at present

Figure 2-6: Groundwater Vulnerability

https://uss.ftco.ie/DMS/view_document.aspx?ID=524263&Latest=true

2.2.7 Hydrology

According to catchment maps, the site is located within the Corrib catchment (Hydrometric Area 30), at Sub catchment Robe_SC_010 (Code: 30_9) and Robe_020 Sub-basin. The nearest surface water feature to the site is the Robe_020 (also known as Kilbeg-Malone) river (Status: Good) which flows in a south-westerly direction approximately 300 m east from the site eventually meeting the Robe_030 river (Status: Moderate) c. 3.6km downstream of the site.

The Robe_030 river flows in a south-westerly direction eventually meeting the Robe_060 river (Status: Good). Robe_060 discharges to Cong Canal_010 (Status: Good), which flows to three different lakes and to Corrib_010 River (Status: Unassigned). Corrib_010 River discharges to Corrib Estuary (Status: Good) and, lastly, to Inner Galway Bay North (Status: Good) in the South, c. 52km from the site.

2.2.8 Ecology

The site is not within or directly adjacent to any Natural Heritage Area (NHA), proposed NHA (pNHA), Special Area of Conservation (SAC) or Special Protection Area (SPA). The nearest protected site is the Carrowkeel Turlough SAC and pNHA (Site Code: 000475) and it is located c.6.8km south-west of the site at its closest point.

There does not appear to be any direct pathway or linkage between the site and this protected area.

There is a Special Area of Conservation, River Moy SAC (Site Code: 002298), located 7.57km north at its closest point from the site.

Another protected site in relative proximity to the site is Lough Corrib SAC (Site Code: 000297), located around c.10km on the south-east of the site.

There are no other protected sites in the vicinity of the site or any sites that could be considered at risk.

The ecology protected areas mapping is presented in Figure 2-7.

2.2.9 Site History

The earliest historical map available on the OSI website dates from 1837-1842 and 1888-1913. The OSI identifies the land within the site boundary was historically used for agricultural purposes (rough pastures).

The OSI Historical Mapping is presented in Figure 2-8.

Historical aerial imagery from 1995 show evidence of filling activity. The next imagery available in 2000 indicates the activity has ceased.

2.2.10 Existing Geological History

The GSI holds no records of areas of Geological Heritage within the site boundary.

The nearest recorded of geological heritage held by the GSI is approximately 12.6km north-east of the site boundary at Knock-Ballyhaunis area.

Knock-Ballyhaunis area is described as a *"Field of megalineations, largest in Ireland, largest individual lineations in Ireland. Many megalineations in till, interspersed with crag-and-tail features."* and the geological feature of note is "*Mega-Flutings".*

Another Geological Heritage is Garranlahan Esker, located 18.5km East from the site. Garranlahan Esker is described as *"a long, beaded, often high, sinuous esker ridge system"* and the geological feature of note is *"long, wide tunnel-deposited esker"*.

The geological heritage mapping is presented in Figure 2-9.

2.2.11 Existing Geotechnical Stability

The GSI landslides database indicates that there are no recorded geo-hazards within the site boundary.

The closest one is located 17km to the north-west of the site, at Bohola, in the village of Carranteaun below Kiltimagh Mountain in December 2001.

2.2.12 Archaeological Heritage

There are six National Monuments to the North, West and East of the site boundaries, between c.0.3km and c.0.9km. They belong to Clare and Kilbeg-Malone Townlands. The Archaeological Survey of Ireland (ASI) is in the process of providing information on monuments, and these records have not been uploaded.

Figure 2-7: Ecologically Protected Sites

https://uss.ftco.ie/DMS/view_document.aspx?ID=524264&Latest=true

Figure 2-8: OSI Historical Mapping

https://uss.ftco.ie/DMS/view_document.aspx?ID=524265&Latest=true

Figure 2-9: Geological Heritage

https://uss.ftco.ie/DMS/view_document.aspx?ID=524266&Latest=true

2.3 Previous Site Investigation - N17

FT reviewed the GSI Online borehole Mapping and Site investigation reporting log as part of this desk study. FT reviewed a relevant Site Investigations report which was prepared by IGCL Ltd for the N17 road works.

The IGCL report is included in Appendix 4 to this report.

The review highlighted two boreholes located close to the site for the then proposed (now existing) railway overbridge. The boreholes are referred to as 1250R and 1250L indicating their chainage location. The approximate location of these boreholes according the GSI is shown in Figure 2-10 below.

Figure 2-10: GSI Geotechnical Boreholes (Blue Triangle)

A descriptive extract from the report regarding the boreholes is quoted below:

(b) Chainage 1250 - Bridge over Railway

Two holes were bored at this location. In borehole 1250R, 1.00 metres of filling overlies a 2.00 metres peat stratum. Coarse compact gravel was noted from 3.00 to 3.80 metres with Limestone rock found at 3.80 metres.

In Borehole 1250L, fill and peat again occurred to a depth of 1.40 metre, overlying a firm stiff gravelly clay. Gravel was noted from 2.70 to 3.70 metres with refusal (probably rock) at 3.70 metres.

Diamond drilling methods were used to recover NQ (50mm) core at both locations. At 1250R good quality core was recovered from 3.70 metres below ground level to 7.00 metres, while at Borehole 1250L solid rock core was recovered from 4.90 to 6.70 metres. Some weathered rock was noted in Borehole 12501. above the solid horizon.

3. TIER 2 SITE INVESTIGATION

3.1 Previous Site Investigation Works

A site investigation on the site was carried out by JS Drilling on behalf of MCC in 2010 and 2011. The full report is presented in Appendix 2.

The scope of site investigation works at the time included:

- Drilling of 2 No. boreholes.
- Excavation of 7 No. trial pits to the full depth of the waste body where possible.
- *In-situ* monitoring of landfill gas.
- Collection of soil/waste samples during drilling/trial pitting.
- Conversion of the 2 No. boreholes to groundwater/leachate monitoring wells.
- Collection of groundwater/leachate from each of the monitoring wells.

The locations of the intrusive works are presented in Figure 3-1.

Figure 3-1: Site Investigation Location Plan

https://uss.ftco.ie/DMS/view_document.aspx?ID=525827&Latest=true

3.1.1 Trial Pits

A JS Drilling Engineering Geologist supervised the advancement of 7 No. trial pits, shown in Figure 3-1 on the 25th November 2010.

Seven trial pits (TP01–TP07) were excavated using a tracked excavator fitted with a 1m wide and 3m length bucket, to a maximum depth of 6.50m below existing ground level (BGL). The profiles identified during trial pitting provided a picture of the underlying geology of the site and a general profile of the buried waste.

A summary of the ground conditions is presented in Table 3-1 below with photographs and exploratory hole logs provided in the JS Drilling site investigation report, Appendix 2.

Table 3-1 Summary of Ground Conditions

Trial Pit ID	Depth of cover material (m BGL)	Depth to base of made ground/waste (m BGL)	Profile Description
TP01	0.0 - 0.40 (Made Ground) 0.40 – 6.40 (Made Ground)	6.40 (base of excavation)	Soft black-brown PEAT with some plastic and waste content. Waste moderately well-rotted, mainly domestic with some C&D (concrete insulation). Strong pungent odour.
TP02	0.0 - 0.40 (Made Ground) 0.40 – 6.50 (Made Ground)	6.50 (base of excavation)	Soft black-brown peat FILL with some plastic and waste content. Waste moderately well-rotted, mainly domestic with some C&D (concrete insulation). Strong pungent odour.
TP03	0.0 – 0.70 (Made Ground) 0.70 – 6.20 (Made Ground) 6.20 – 6.40 (Peat)	6.40 (base of excavation – base of waste body)	Soft black-brown peat FILL with some plastic and waste content. Waste moderately well-rotted, mainly domestic plastic bags of waste. Strong pungent odour. Natural soft-firm dry PEAT.
TP04	0.0 - 0.50 (Made Ground) 0.50 – 5.50 (Made Ground)	5.50 (base of excavation - terminated due to ground conditions)	Soft black-brown peat FILL with some roots and vegetation in top 0.20m. Wet waste poorly well-rotted, mainly domestic plastic bags of waste. Strong pungent odour.
TP05	0.0 - 0.30 (Made Ground) 0.30 – 0.90 (Made Ground) 0.90 – 4.0 (Made Ground)	4.50 (base of excavation – base of waste body)	Soft black-brown peat FILL with some roots and vegetation in top 0.20m. Brown black peat FILL with plastic and waste mixed in.

Trial Pit ID	Depth of cover material (m BGL)	Depth to base of made ground/waste (m BGL)	Profile Description
	4.0 – 4.50 (Peat)		Waste moderately well-rotted, mainly domestic plastic bags of waste. Strong pungent odour. Natural dark brown-black PEAT.
TP06	0.0 - 0.40 (Made Ground) 0.40 – 0.70 (Made Ground) 0.70 – 6.50 (Made Ground)	6.50 (base of excavation)	Soft black-brown peat FILL. Brown black peat FILL with plastic and waste mixed in. Waste moderately well-rotted, mainly domestic plastic bags of waste and paper dated 1994. Strong pungent-sweet odour.
TP07	0.0 - 0.30 (Made Ground) 0.30 – 5.40 (Made Ground) 5.40 – 5.50 (Peat)	5.50 (base of excavation – base of waste body)	Soft black-brown peat FILL. Waste moderately well-rotted, mainly domestic plastic bags of waste. Strong pungent-sweet odour. Natural black brown PEAT.

Made ground comprising waste was encountered in all 7 No. trial pits (TP01-TP07). No bedrock was encountered.

Waste material was encountered between 0.0m – 6.50m in all trial pits from TP01 to TP07. No groundwater was encountered. Leachate found in all 7 No. trial pits from 3.70m to 6.0m BGL.

Natural ground comprising of Peat was confirmed in 3 No. trial pits (TP03, TP05 and TP07).

3.1.2 Waste Sampling

A total of 6 No. samples of the made ground / waste at the site was collected from trial pits TP01-TP06.

All samples were submitted for Waste Acceptance Criteria (WAC) testing to Severn Trent Laboratories Ltd., a UKAS/MCERTS approved laboratory. Samples were collected from site under Chain of Custody procedures.

The results are provided in Appendix 1 of the JS Drilling Report, Appendix 2 of this report.

The results are discussed in Section 4.1.

3.1.3 Slit Trenches

The lateral extent of the waste body was determined by 7 No. slit trenches (ST01-ST07) excavated along the edge of the landfill, as shown in Figure 3-1. Slit trench logs are included in Appendix 2 of JS Drilling report, (see Appendix 2 of this report) the findings are summarised on Table 3-2 below.

Table 3-2 Summary of Slit Trench Findings

Slit Trench ID	Length (m)	Description
ST01	4	Edge of waste running into natural PEAT ground.
ST02	6	Edge of waste running into natural PEAT ground.
ST03	5	Waste up to 3.0m BGL, no edge found.
ST05	6	Edge of waste into natural PEAT, very soft saturated ground.
ST06	5	Edge of waste into natural PEAT.
ST07	5	No lateral edge of waste but vertical depth shallow (0.30 – 0.40m) suggesting edge is close.

All slit trenches except ST03 (which waste was up to 3m BGL) were able to identify the edge of waste around the periphery of the site. BH02 was drilled approximately 30m south of this slit trench and waste appears to be tapering to 0.80m at this location indicating the edge of waste.

3.1.4 Evidence of Historic Landfilling

The trial pit excavation works identified waste material tending to the western site boundary with thicknesses ranging from 0.0 (topsoil) – 6.50m BGL (base of excavation). Evidence of waste material was identified in all 7 No. trial pits locations (TP01-TP07). The waste encountered was described mainly as plastic bags, a paper and concrete insulation. The waste material description as described by JS Drilling Engineering Geologist is typical of MSW material.

The base of the waste material was not reached in 4 No. trial pits at the termination depth of 6.50m BGL in 3 No. trial pits (TP01, TP02 and TP06) and at 5.5m BGL in 1 No. trial pit (TP04).

As noted, most of the Made Ground waste material encountered comprised brown black Peat mixed with MSW.

3.1.5 Waste Delineation

The combined findings of the trial pits and slit trenches excavations were used to interpret the aerial extent of the waste mass since a geophysical surveying was not undertaken at the site.

The findings of the intrusive site investigation show the area where landfill material is present however the exact lateral extent of waste is not clear.

Considering the depths found in the trial pitting and the lateral extent found in the slit trenches excavations the interpreted landfill extent covers an area of 38,044 m^2 and initial volume calculation estimates an interred waste volume of approximately 168,000 m^3 at the site.

The maximum anticipated waste footprint is presented in Drawing number P2348-0400-002 included in Appendix 7.

3.1.6 Borehole Installation and Groundwater and Leachate Sampling

Two boreholes, BH01 and BH02, were drilled using window sampling drilling methods to a total depth of 5.90m BGL and 4.0m BGL respectively, at the site. The boreholes were drilled for installing leachate (BH01) and groundwater (BH02) monitoring installations.

BH01 was drilled through the waste body into the underlying natural subsoil and BH02 was drilled on the periphery of the site into natural ground, down gradient of the landfill (see Figure 3-1).

Leachate and groundwater monitoring were undertaken in boreholes BH01 and BH02, respectively, on the 2nd December 2010. The sample containers were labelled with a unique number and placed in a cooler box for transportation to STL laboratories in the UK, time sensitive analysis (BOD, COD and faecal coliforms in the groundwater) was carried out in local lab Complete Laboratory Solutions (CLS) in Galway. Laboratory results can be seen as Appendix 1 in the JS Drilling report, Appendix 2 of this report and are further discussed in Section 4.2 and 4.3.

3.1.7 Knock/Claremorris By-pass Site Investigation

As stated in Section 3.1 above a site investigation was previously prepared on behalf of Mayo County Council (see Appendix 4). This report was prepared in January 1994 and detailed the findings of a programme of site investigation along a proposed route for the Knock/Claremorris N17 by-pass. FT reviewed this report to obtain any relevant information regarding the geological characteristics of the area surrounding the historical landfill site.

The site investigation included the installation of a series of boreholes at locations along the proposed bypass route. It was found that boreholes had been excavated at by-pass chainage section 1250, at a proposed (now existing) railway bridge, approximately 150m north-west of the historical landfill. Two boreholes were bored at this location 1250L and 1250R. 1250L comprised of an initial bore using a cable percussion tool followed by a rotary core while 1250R comprised rotary core only.

A summary of the borehole logs for each borehole are shown in below in Table 3-3.

Table 3-3 Knock/Claremorris By-pass S.I Investigation Borehole 1250 Logs

Borehole Log ID	Depth of material (m BGL)
1250L (cable tool)	0.0 - 0.60 - Made Ground (gravel) 0.6 - 1.4 (soft brown fibrous peat) 1.4 - 2.7 (firm to stiff grey silty sandy gravelly CLAY with cobbles) 2.7 - 3.7 (compact fine to coarse angular sandy GRAVEL with cobbles) Refusal at 3.7m

Borehole Log ID	Depth of material (m BGL)
1250L (rotary core)	0 - 2 - Overburden (fragments of limestone with slight clay smearing present) 2.0 - 3.5m (dark grey fine-grained slightly weathered siliceous LIMESTONE moderately strong or strong 3.5 - 5.05 - Locally moderately weathered and becoming increasingly carbonaceous from 4.1 to 4.4m 5.05/5.25 - 5.7 - highly fractured/non-intact with much of core represented as fine-grained size angular fragments 5.7 - 6.7 generally slightly weathered, strong to very strong (end of borehole)
1250R (rotary core)	0.0 - 3.7 - Stiff dark brown peaty clay/clayey peat 3.7 - 7.0 - Dark grey/grey black fine grained, moderately and slightly weathered limestone, moderately strong to strong. 4.6-4.85 prominent highly weathered shaley limestone, weak to mid-weak

4. ENVIRONMENTAL ASSESSMENT

The results of the environmental assessment previously undertaken as part of the Tier 2 investigation at the Claremorris Historic Landfill site are presented in the following sections.

4.1 Waste / Made Ground Assessment

The waste / made ground sample was compared against Waste Acceptance Criteria (WAC) to determine the appropriate waste classification rating associated with the interred waste. WAC screening is chosen for this assessment to suitably categorise the interred waste as inert, non-hazardous or hazardous material.

4.1.1 Chemical Results for Waste Samples

The waste/ made ground samples analysed from the site investigations were assessed against the Waste Classification Assessment Criteria. A summary of the results for Claremorris Historic Landfill is outlined in Table 4-1 below, while the laboratory reports are presented in Appendix 1 of the JS Drilling report, See Appendix 2 of this report.

Table 4-1 Waste Sampling Results – Solid Waste Analysis

Parameter	Units	Inert Waste Acceptance Criteria	Non-Hazardous Waste Acceptance Criteria	Hazardous Waste Acceptance Criteria	Sampling Results - Sample ID					
					TP01 (4.0m)	TP02 (4.0m)	TP03 (3.0m)	TP04 (4.0m)	TP05 (3.50m)	TP06 (4.0m)
Asbestos in soil	--	**Detected**	**Detected**	**Detected**						
Arsenic	l.kg^{-1}	**0.5**	**2**	**25**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Barium	l.kg^{-1}	**20**	**100**	**300**	0.52	0.4	0.29	0.62	0.33	0.2
Cadmium	l.kg^{-1}	**0.04**	**1**	**5**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Chromium	l.kg^{-1}	**0.5**	**10**	**70**	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Copper	l.kg^{-1}	**2**	**50**	**100**	<0.10	<0.10	<0.10	<0.10	0.14	0.35
Mercury	l.kg^{-1}	**0.01**	**0.2**	**2**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum	l.kg^{-1}	**0.5**	**10**	**30**	<0.020	<0.020	0.05	<0.020	0.08	**0.65**
Nickel	l.kg^{-1}	**0.4**	**10**	**40**	<0.20	<0.20	<0.20	<0.20	<0.20	0.22
Lead	l.kg^{-1}	**0.5**	**10**	**50**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Antimony	l.kg^{-1}	**0.06**	**0.7**	**5**	<0.060	<0.060	<0.060	<0.060	<0.060	**0.08**
Selenium	l.kg^{-1}	**0.1**	**0.5**	**7**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Zinc	l.kg^{-1}	**4**	**50**	**200**	<0.25	<0.25	<0.25	<0.25	<0.25	0.76
Chloride	l.kg^{-1}	**800**	**15000**	**25000**	510	800	170	470	550	**3600**
Fluoride	l.kg^{-1}	**10**	**150**	**500**	2	<2.0	<2.0	<2.0	<2.0	<2.0
Sulphate	l.kg^{-1}	**1000**	**20000**	**50000**	**1700**	**4200**	**2100**	**4400**	**5100**	**4800**
Total Dissolved Solids (TDS)	l.kg^{-1}	**4000**	**60000**	**100000**	**4200**	**9700**	**4600**	**8400**	**9600**	**16000**
Phenol Index	l.kg^{-1}	**1**	**--**	**--**	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Dissolved Organic Carbon (DOC)	l.kg^{-1}	**500**	**800**	**1000**	170	**580**	240	270	320	**1100**

Parameter	Units	Inert Waste Acceptance Criteria	Non-Hazardous Waste Acceptance Criteria	Hazardous Waste Acceptance Criteria	Sampling Results - Sample ID					
					TP01 (4.0m)	TP02 (4.0m)	TP03 (3.0m)	TP04 (4.0m)	TP05 (3.50m)	TP06 (4.0m)
Total Organic Carbon	%	**3**	**5**	**6**	**10**	**9.9**	**7.1**	**12**	**10**	**19**
Loss on Ignition	%	--	--	**10**	**13**	**19**	**16**	**20**	**26**	**37**
Total BTEX	$mg.kg^{-1}$	**6**	--	--						
Total PCBs (7 Congeners)	$mg.kg^{-1}$	**1**	--	--	0.045	<0.010	<0.010	<0.010	<0.010	<0.010
Mineral Oil (C10-C40)	$mg.kg^{-1}$	**500**	--	--	**540**	**1000**	220	170	**780**	310
Total (Of 17) PAH's	$mg.kg^{-1}$	**100**	--	--	5	3.2	1.5	7.3	7.4	4.3
pH	pH units	--	**>6**	--	7.8	7.9	8	7.8	7.9	8
Acid Neutralisation Capacity (pH4)	$mol.kg^{-1}$	--	**To evaluate**	**To evaluate**	0.029	0.03	0.03	0.043	0.039	0.069
Acid Neutralisation Capacity (pH7)	$mol.kg^{-1}$	--	**To evaluate**	**To evaluate**	0.0058	0.0046	0.0081	0.0052	0.0045	0.013
Additional Waste Analysis										
Conductivity @20 C	uS/cm				1100	3200	1100	400	3000	<100
Benzene	$mg.kg^{-1}$				<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Toluene	$mg.kg^{-1}$				<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Ethylbenzene	$mg.kg^{-1}$				<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
m&p-Xylene	$mg.kg^{-1}$				<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
o-Xylene	$mg.kg^{-1}$				<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

* Hazardous Waste Landfill Criteria: >6% TOC
* Items in **bold** are in exceedance of the Inert WAC limit value
* Items shaded in **green** are in exceedance of the Non-Hazardous WAC limit value
* Items shaded in **orange** are in exceedance of the Hazardous WAC limit value

4.1.2 Waste Classification

As can be seen in Table 4-1, based on the 6 No. samples submitted for laboratory analysis, waste material encountered within the site are typically inert in terms of leachate production, except for Dissolved Organic Carbon, Total Organic Carbon and Loss on Ignition.

4.2 Groundwater Analysis

One round of groundwater quality monitoring was undertaken at the site on the 2nd December 2010. The findings from the monitoring and an interpretation of the results are presented in the following sections.

4.2.1 Groundwater Depth Analysis

Groundwater depth analysis was undertaken on the 2nd December 2010. The average static groundwater level is presented in Table 4-2.

Table 4-2 Groundwater Depth Analysis

Borehole ID	Location Gradient	Top of Casing (mAOD)	Dip (m) Dec/10	Groundwater Level (mAOD)
BH02	Down gradient	64	0.785	63.215

*Note: Location gradient is in reference to the identified waste deposition area

Based on the above field survey measurements, groundwater levels were present below the surface at 0.785m below ground level (m bgl). Therefore, based on this standalone measurement, it can be assumed that the potentiometric groundwater surface intersects the waste body further upgradient. However, this could not be absolutely confirmed as no groundwater was recorded by JS Drilling within 7 No. trial pits and borehole BH01 within the waste body.

4.2.2 Groundwater Borehole Position

The groundwater sample analysed from BH02 was tested for limited criteria i.e. Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Faecal Coliforms and Total Coliforms. The results for these parameters are shown in Table 4-3 below. The complete laboratory report is presented in Appendix 1 of JS Drilling Report, Appendix 2 to this report.

Table 4-3 Groundwater Sampling Results

Analysis	Units	Sample ID
		BH02
BOD	mg/l	28
COD	mg/l	482
Faecal Coliforms	cfu/100ml	<1
Total Coliforms	cfu/100ml	6,800

4.2.3 Groundwater Quality Discussion

A slight odour was noted from the groundwater sample BH02, which could possibly be attributed to the presence of peat as the underlying strata. The water was brown and murky and cleared slightly after purging 3 well volumes.

4.3 Leachate Analysis

One round of leachate monitoring was undertaken at the site on the 2nd December 2010. The findings from the monitoring and an interpretation of the results are presented below.

4.3.1 Leachate Depth Analysis

Leachate depth analysis was undertaken on the 2nd December 2010 and the result is presented in Table 4-4:

Table 4-4 Leachate Depth Analysis

Borehole ID	Location Gradient	Top of Casing (mAOD)	Dip (m) Dec/10	Leachate Level (mAOD)
BH01	Cross-gradient	68	2.63	65.37

*Note: Location gradient is in reference to the identified waste deposition area

4.3.2 Leachate Borehole Position

The leachate sample analysed from BH01 was tested for limited parameters i.e. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The results for these parameters are shown in Table 4-5 below. The complete laboratory report is presented in Appendix 1 of JS Drilling Report, Appendix 2 to this report.

Table 4-5 Leachate Sampling Results

Analysis	Units	Sample ID
		BH01
BOD	mg/l	2972
COD	mg/l	6160

4.3.3 Leachate Analysis Discussion

A strong pungent odour was noted from the black leachate sample collected from BH01. Leachate did not change in odour or colour after purging. The leachate analysis results are compared to the concentrations provided for COD, BOD_{20} and BOD_5 for typical acetogenic and methanogenic leachates as per the EPA Manual Landfill (2003), as summarised in Table 4-6 below.

Table 4-6 Summary of Acetogenic and Methanogenic Composition for COD, BOD20 and BOD5

	Parameter	COD	BOD_{20}	BOD_5
Acetogenic Leachates (mg/l)	Min	2,740	2,000	2,000
	Max	152,000	125,000	68,000
	Median	23,600	14,900	14,600
	Mean	36,817	25,108	18,632
Methanogenic Leachates (mg/l)	Min	622	110	97
	Max	8,000	1,900	1,770
	Median	1,770	391	253
	Mean	2,307	544	374

Source: EPA Landfill Manual (2003)

When assessed against typical landfill leachate parameters reported in the EPA Landfill Manual (2003), the leachate composition at the Claremorris landfill appears to be more representative of the mean to maximum concentrations of the methanogenic phase. Although the concentrations of BOD do exceed the maximum concentrations for BOD_{20} and BOD_5 of the methanogenic phase it is considered that the leachate would be closer to methanogenic phase waste than acetogenic at the time of sampling.

The results of this assessment are in line with the age of the site and the nature of the waste encountered

4.4 Landfill Gas Monitoring

JS Drilling carried out monitoring of landfill gas (LFG) parameters at each monitoring borehole location (BH01 and BH02), trial pit excavated (TP01-TP07) and slit trench (SL01-SL03 and SL05-SL07). In accordance with the EPA CoP, methane, carbon dioxide, oxygen and atmospheric pressure were analysed at the 15 No. monitoring locations using a portable Landfill Gas Meter GA94.

4.4.1 Monitoring Results

In accordance with the CoP, the trigger level for methane outside the waste body is 1% v/v and for carbon dioxide is 1.5% v/v.

The monitoring results for methane, carbon dioxide and oxygen levels for the monitoring boreholes are summarised in Table 4-7.

Table 4-7 Landfill Gas Monitoring Results November 2010

Date: 25/11/2010					
Sample Station	CH_4 (% v/v)	CO_2 (% v/v)	O_2 (% v/v)	Atmospheric Pressure (mbar)	Staff Member
TP01	0.1	0.2	21.0	0956	AMR
TP02	0.1	0.1	20.9	0955	
TP03	0.1	0.2	20.9	0954	
TP04	0.1	0.2	20.9	0954	
TP05	0.1	0.2	20.9	0956	
TP06	0.1	0.2	20.9	0956	
TP07	0.1	0.1	21.0	0954	
Date: 26/11/10					
BH01	**78.1**	**32.2**	0	0959	AMR
BH02	0.4	**1.6**	20.1	0961	
ST01	0.1	0.1	21.0	0954	
ST02	0.1	0.2	21.0	0954	
ST03	0.1	0.1	21.0	0956	
ST05	0.1	0.1	21.0	0956	
ST06	0.1	0.2	21.0	0958	
ST07	0.1	0.1	21.0	0958	

As can be seen in Table 4-7, concentrations of both CO_2 and CH_4 at all trial pits and slit trenches are below the threshold values set by the CoP during the monitoring round.

However, at monitoring borehole BH01, located within the waste body both gases exceed the limits set, and at BH02 carbon dioxide concentration slightly exceeds the limit.

4.5 Surface Water Monitoring

Surface water sampling was completed in 2009 on adjacent water courses. Two samples were collected from two different locations, one north and the other south of the site, as shown in Figure 4-1.

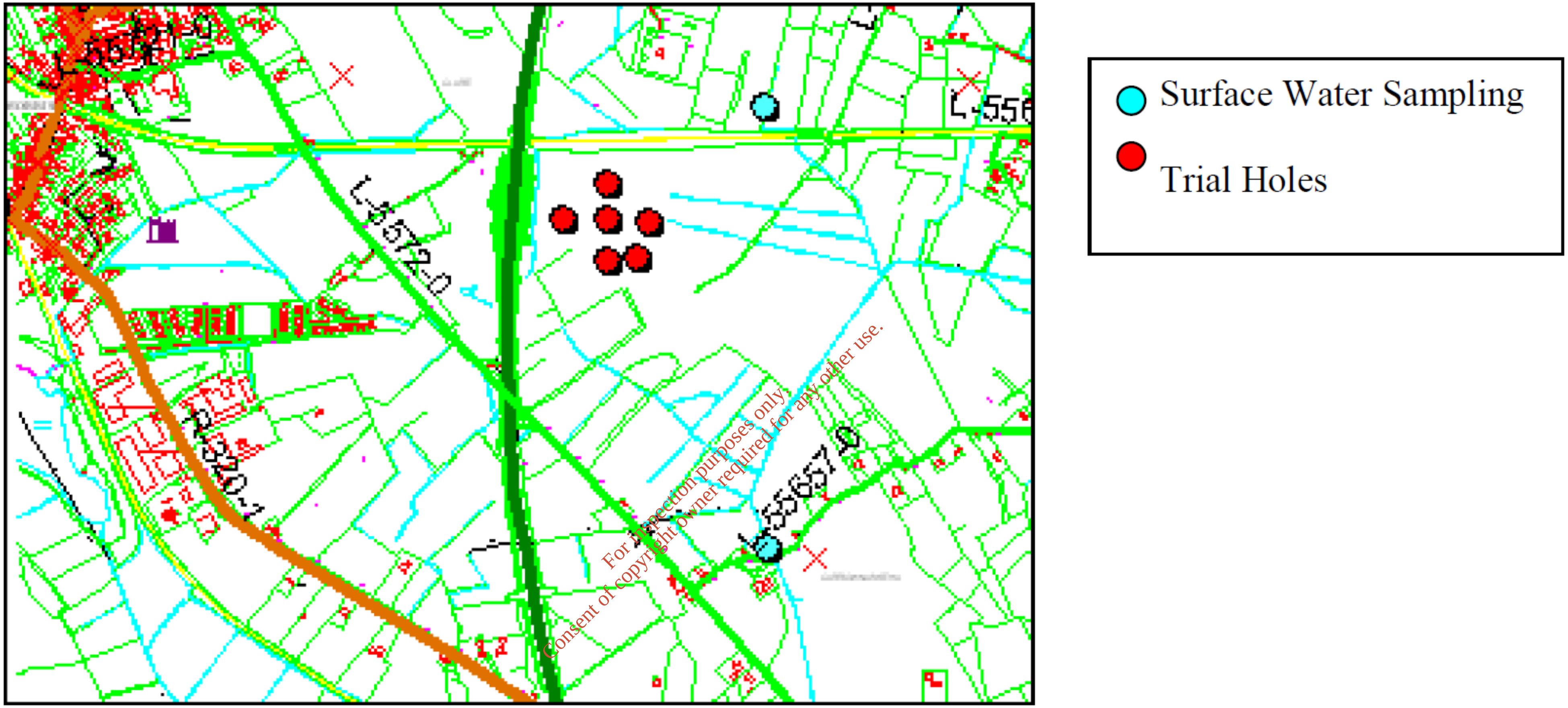

Figure 4-1: Surface Water Sampling Locations

4.6 Conceptual Site Model (CSM)

Taking into account the information obtained from the desk study, assessment, intrusive site investigation and site walkover revised conceptual site models were prepared as part of this Tier 3 assessment and is presented overleaf.

Figure 4-2: Conceptual Site Model (West - East)

https://uss.ftco.ie/DMS/view_document.aspx?ID=540239&Latest=true

Figure 4-3: Conceptual Site Model (North - South)

https://uss.ftco.ie/DMS/view_document.aspx?ID=540240&Latest=true

5. TIER 3 RISK ASSESSMENT

5.1 Tier 2 Risk Classification and Tier 3 SPRs Considered

Previous assessment carried out by Mayo County Council (MCC) confirmed that the historical landfill typically contains mixed municipal/household waste deposited within a single infill area covering an area approximately 26,000m^2 (refer to Appendix 1). It is estimated that approximately 168,000 - 279,623 tonnes of waste is present at the site. MCC initially estimated 168,000 tonnes of waste would have been deposited at the site (refer to Appendix 1). Following a review of the site investigation (Appendix 2) an estimate of 297,623 tonnes is based on the application of an average waste thickens of 5.25 m over an area of 38,044 m^2 and assumed a waste density of 1.4 tonne/m^3.

The initial risk assessment for the site carried out by Mayo County Council utilised the EPA online section 22 register Tier 1 risk assessment tool. In carrying out this Tier 3 assessment a review of the SPR risk scoring was conducted and updated accordingly. This revised risk scoring takes account of the proposed development of the site as a solar farm and therefore considers future receptors of the landfill should the solar farm be constructed.

Table 5-1 Risk Classification Calculation - Claremorris Landfill

EPA Ref	Risk	Points		Rationale
1a	Leachate; source/hazard scoring matrix, based on waste footprint.	Municipal >1≤5ha	7.00	Site is <5ha and entirety of the site is likely underlain by waste. Site investigation indicates waste is likely MSW
1b	Landfill gas; source/hazard scoring matrix, based on waste footprint.	Municipal >1≤5ha	7.00	Site is <5ha and entirety of the site is likely underlain by waste. Site investigation indicates waste is likely MSW
2a	Leachate migration: Pathway (Vertical)	2.00		Groundwater vulnerability varies but is predominantly high beneath the site.
2b	Leachate migration: Pathway (Horizontal)	5.00		Aquifer underlying the site is classified by the GSI as being a regionally important karstified aquifer
2c	Leachate migration: Pathway (Surface water drainage)	2.00		There is a direct connection between the waste body and the adjacent surface water body receptor via drainage ditch immediately west of the site along N17 embankment and ditch immediately north of the site which follows the rail in an easterly direction.
2d	Landfill gas: Pathway (Lateral migration potential)	1.00		GSI characterise surrounding soil in the immediate vicinity as being peat
2e	Landfill gas: Pathway (Upwards migration potential)	1.00		GSI characterise surrounding soil in the immediate vicinity as being peat

EPA Ref	Risk	Points	Rationale
3a	Leachate migration: Receptor (Human presence)	1.00	No houses identified within 250m, but many located within 1km of the site.
3b	Leachate migration: Receptor (Protected areas – SWDTE or GWDTE) (Surface water/ groundwater dependent terrestrial ecosystems)	0.00	No SWDTE or GWDTE identified within 1km of the site
3c	Leachate migration: Receptor (Aquifer category – Resource potential)	5.00	Site is underlain by a regionally important aquifer
3d	Leachate migration: Receptor (Public water supplies – other than private wells)	3.00	There were no public water supplies identified likely to be impacted by the site identified.
3e	Leachate migration: Receptor (Surface water bodies)	1.00	The Kilbeg-Malone River located approximately 300m east of the waste body. This surface water feature is a tributary of the Robe River which is located c. 3.6km south of the site
3f	Landfill Gas: Receptor (Human presence)	5.0	Proposed development of the site as a solar farm would give rise to a human presence on site and the presence of infrastructure on site i.e. panels framework, pipework, cabling etc. provides potential conduits for landfill gas.

The highest single risk rating for the site was calculated to be 50% for source-pathway-receptor (SPR) Linkage 5 which referred to leachate migration through groundwater pathway to underlying aquifer. The SPR linkages examined in this Tier 3 are highlighted in Table 5-2 and discussed in further detail below.

SPR No.	Linkage	Normalised Score	Justification
Leachate migration through combined groundwater and surface water pathways			
SPR1	Leachate => surface water	21	Site is located within a regionally important karstified aquifer and there are also land drains immediately adjacent to the site, however the nearest mapped waterbody is located approximately 300m from the waste body.
SPR2	Leachate => SWDTE	0	There are no SWDTEs or GWDTEs located within 1km of the site.
Leachate migration through groundwater pathway			

SPR No.	Linkage	Normalised Score	Justification
SPR3	Leachate => human presence	20	There are no houses identified within 250m of the site
SPR4	Leachate => GWDTE or SWDTE	0	There are no SWDTEs or GWDTEs located within 1km of the site.
SPR5	Leachate => Aquifer	61	Site is located within a regionally important aquifer and groundwater vulnerability is high beneath the site.
SPR6	Leachate => Public Supply	26	There were no public water supplies identified within 1km of the site.
SPR7	Leachate => Surface water	20	Kilbeg-Malone River located approximately 300m east of the site.
Leachate migration through surface water pathway			
SPR8	Leachate => Surface Water	23	There are land drains located immediately west and north of the waste body.
SPR9	Leachate => SWDTE	0	There are no SWDTEs located
Landfill gas migration pathway (lateral & vertical)			
SPR10	Landfill Gas => Human Presence	23	Closest human receptors identified as being an electrical sub-station <250m north of the site.
SPR11	Landfill Gas => Human Presence	14	Proposed development of the site as a solar farm would give rise to a human presence on site and the presence of infrastructure on site i.e. panels framework, pipework, cabling etc. provides potential conduits for landfill gas.

5.1.1 Leachate Migration Through Groundwater Pathway to Underlying Aquifer (SPR5)

A risk rating of 61% was calculated for the SPR5 linkage. This rating refers to the risk of leachate migrating to the underlying groundwater aquifer. The aquifer underlying the site was identified as being a regionally important and karstified limestone aquifer. The karst characteristic of the aquifer was a significant factor when calculating the risk that the historical landfill site poses to groundwater contamination.

5.1.2 Lateral and Vertical Migration of Landfill Gas (SPR10 And SPR11)

Based on the characteristics of the site, the surrounding environment and receptors the Tier 3 risk evaluation and rating yielded low risk scores of 23% for lateral migration (SPR10) and 14% for vertical (SPR11) landfill gas migration. Landfill gas monitoring at the site showed only trace quantities of methane (0.1% v/v) below the trigger value of 1%v/v at all trial pits and slit trenches. BH02 yielded slightly higher concentration of methane at 0.4% v/v.

BH01 however yielded significantly higher methane concentrations of 78.1% v/v, it is noted however that BH01 is located within the waste body, and therefore higher concentrations of methane are not unexpected. With respect to carbon dioxide both BH01 and BH02 yielded concentrations of 32.2% v/v and 1.6% v/v respectively. BH02 is located within the waste body and therefore marginally exceeds the EPA trigger value of 1.5% v/v for carbon dioxide concentrations outside the waste body. Although, no sensitive receptors were identified to be present either directly above the waste or in the immediate vicinity of the waste, these monitoring results dictate that the potential risks from landfill gas migration be examined further, particularly if the site is to be developed.

6. DETAILED QUANTITATIVE RISK ASSESSMENT (DQRA)

The EPA Code of Practice on Environmental Risk Assessment for Unregulated Waste Disposal Sites requires a Tier 3 assessment to include some form of quantitative risk assessment either as a Generic Quantitative Risk Assessment (GQRA) or as a Detailed Quantitative Risk Assessment (DQRA).

This Tier 3 assessment report uses a DQRA to further assess the risks to groundwater and from landfill gas migration and addresses the following primary risks:

- Leachate migration through groundwater pathway to underlying aquifer (SPR5)
- Lateral and vertical migration of landfill gas (SPR10 and SPR11)

The detailed quantitative risk assessments rely on information gathered as part of the Tier 2 investigations (see Sections 2-4). 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 8.7 of this report.

6.1 Landfill Groundwater Recharge/Contribution

The GSI online mapping indicates that the site location is underlain by a 'Regionally Important Aquifer - Karstified (diffuse)'. The aquifer vulnerability is classified as being high at the site, indicating that the aquifer at the is location is highly vulnerable to and can directly influenced by rainwater infiltration at the site, and as subsequently by any pollutants migrating vertically to the bedrock aquifer.

The karstified nature of the underlying aquifer limits the applicability of tradition screening tools or dispersion modelling assessments at the site as karst aquifer can be dominated by conduit flow rather than diffuse flow.

An attempt at quantifying the risk posed by the site at an aquifer scale is therefore made below in assessing the overall size of the site and its potential for leachate generation vs. the overall size of the aquifer.

6.1.1 Potential Leachate Generation

In quantifying the potential impact that the leachate generated at the historical landfill may have on the underlying groundwater aquifer it is important to estimate the quantity of leachate or contaminated groundwater produced at the site.

The vertical infiltration of rainfall above the site to the underlying groundwater aquifer is determined by the groundwater recharge rate at this site. The recharge coefficient as defined by GSI varies across the site, at 4%, 42.5% and 85%. In determining the recharge rate at the site, GSI applied an effective rainfall rate of 832 mm/year. At each of the recharge coefficient applied the recharge rates are as follows:

- 33 mm/year (at 4%) [0.033 m/year]
- 354 mm/year (at 42.5%) [0.354 m/year]
- 707 mm/year (at 85%) [0.707 m/year]

Multiplying the recharge rates by the estimated waste footprint area (38,044 m^2) calculates the potential leachate generation summarised in Table 6-1.

Table 6-1 Potential Leachate Generation

Recharge Rate (m/year)	Leachate Generation (m^3/year)	Leachate Generation (m^3/day)
0.033	1255	**3.44**
0.354	13,468	**36.9**
0.707	26,897	**73.7**

GSI have characterised the underlying aquifer, the Clare-Corrib groundwater body as being 1,422 km^2 in area. The Claremorris historical landfill waste footprint was determined to be 38,044 m^2. This is accounts for 0.003% of the Clare-Corrib GWB area.

6.2 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 6-2 below.

The results of this model would 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 gases emitted from offsite well BH02 was conducted in November 2010 as part of the Tier 2 site investigation. This well yielded methane concentrations of 0.4% v/v and carbon dioxide concentrations of 1.6% v/v. In accordance with the EPA CoP the trigger level for methane outside the waste body is 1.0% v/v for and 1.5% v/v for carbon dioxide. Well BH01 which was installed within the waste body yielded methane concentrations of 78.1% v/v and carbon dioxide concentrations of 32.2% v/v (see Table 4-7). In developing the model two waste design capacities were applied. In MCC's initial assessment of the site it was estimated that approximately 168,000 tonnes of waste were deposited at the site. The 2010 site investigation conducted at the site determined that the waste thickness at the sized varied from approximately 4.0 m to 6.5 m. Assuming a waste footprint area of 38,044 m^2 and an average waste thickness of 5.25 m this estimated 199,731 m^3 deposited at the site. At an assumed density of 1.4 tonne/m^3 its estimated that 279,623 tonnes of waste have been deposited at the site. Both of these tonnages have been applied in the model to show the range of potential of gas generation.

Table 6-2 LandGEM Model Inputs

Landfill Characteristics	Input	Source
Landfill Open Year	1982	Exact timeframe of landfill operation is unknown. Assumed site to be operational through the 1970s. Start of filling operations assumed.
Landfill Closure Year	1996	Anecdotal evidence suggests landfilling activities ceased c.1980
Have Model Closure Calculate Closure Year	Yes	
Waste Design Capacity (megagrams/tonnes)	168,000 (MCC) 279,623 (Site Investigation)	Estimated quantity by Mayo County Council (MCC). Estimate based on 4.0m to 6.5m (average 5.25) waste thickness determined from site investigation and estimated 38,044 m^2 waste footprint.
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 – 170	
NMOC Concentration (ppmv as hexane)	CAA – 4,000	
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)		
1982 - 1996	11,200 (MCC) 18,642 (S.I)	Exact waste acceptance quantities per year are unknown. Worst case assumed waste design capacity was filled equally over 1982 - 1996 period

6.2.1 Results - LandGEM

As an output, LandGEM produces a report on the model inputs and outputs. This report is included in Appendix 5 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 (2021) and after 10 years of further degradation (2031) are presented in Table 6-3. The model predicted that the site is currently generating 35 - 58 m^3/hr of methane across the entire site area. This will reduce to 21 - 35m^3/hr by 2031.

Table 6-3 Estimated landfill Gases Generated (2021 and 2031)

Gas/Pollutant	Tonnes/year		m^3/year		tonnes/hour		m^3/hour	
@ 168,000 tonnes	**2021**	**2031**	**2021**	**2031**	**2021**	**2031**	**2021**	**2031**
Total Landfill Gas	758	460	606,700	368,000	0.09	0.05	**69**	**42**
Methane	202	123	303,300	184,000	0.02	0.01	35	21
Carbon dioxide	555	337	303,300	184,000	0.06	0.04	35	21
NMOC	9	5	2,427	1,427	0.00	0.00	0.28	0.17
@ 279,623 tonnes	**2021**	**2031**	**2021**	**2031**	**2021**	**2031**	**2021**	**2031**
Total Landfill Gas	1,261	765	1,010,000	612,500	0.14	0.09	**115**	**70**
Methane	337	204	504,900	306,200	0.04	0.02	58	35
Carbon dioxide	924	561	504,900	306,200	0.11	0.06	58	35
NMOC	14	9	4,039	2,450	0.00	0.00	0.46	0.28

The approximate maximum waste deposition footprint was estimated to be approximately 38,044 m^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 6-4.

Table 6-4 Estimated gases generated/released per m2 (2021)

Gas/Pollutant At 168,000 tonnes	Tonnes/year/m²	m³/year/m²	tonnes/hour/m²	m³/hour/m²
Total Landfill Gas	0.020	16	0.000	0.002
Methane	0.005	8	0.000	0.001
Carbon dioxide	0.015	8	0.000	0.001
NMOC	0.000	0.064	0.000	0.000
At 279,623 tonnes				
Total Landfill Gas	0.033	27	0.000	0.003
Methane	0.009	13	0.000	0.002
Carbon dioxide	0.024	13	0.000	0.002
NMOC	0.000	0.106	0.000	0.000

6.2.2 Discussion of Results

It is noted that a traditional detailed quantitative risk assessment of the risk posed by the landfill body to the groundwater aquifer is difficult given it karstified nature and the potential of the aquifer to display conduit flow characteristics (which are difficult to model/risk assess) vs a diffuse flow regime.

Assessment of the landfill area and potential leachate contribution versus the total area of the aquifer at 0.003% indicates that the likely risk is potentially very low to negligible. Review of previous site investigations (Section 2.2.2) do indicated that the waste is likely underlain by peat and possible layers of gravelly clay/stiff gravel directly atop bedrock. It can be assumed that although some protection may be afforded by the underlying subsoils the groundwater vulnerability could be classified as High or even Extreme.

It is therefore difficult to fully discount the risk that the site poses to the underlying aquifer and remediation measures to further limit the potential for leachate generation and isolated the source of the contamination (i.e. capping) are considered necessary.

The outcome of the LandGEM model predicts a rate of landfill gas generation in the current year of approximately 69 – 115 m³/hr dependant on the estimated tonnages.

The EPA guidance document, 'Management of Low Levels of Landfill Gas' outlines readily available flaring technologies that meet EPA requirements on temperature and retention specifications. These technologies generally require gas flow rates ranging from 40 to 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 6-3 LandGEM estimated that in the current year (2021) an estimated quantity of 69-115 m³/hour of landfill gas across the whole site is generated and assuming approximately 50% percent of that volume being methane (35-58m³). Landfill gas monitoring of groundwater well BH02 (in waste) conducted in 2010 yielded high concentrations of methane and carbon dioxide at 78.1% v/v and 32.2% v/v respectively. The LandGEM model suggests that at the estimated quantity of waste deposited at the site that methane production is still occurring and will continue for a number of years.

Figure 6-1 and Figure 6-2 below show the estimated landfill gas generation rates per year during the assumed operational phase (c.1982 to 1996) and predicted generation rates from 1996 onwards following closure of the site. It is noted that the model assumes equal production rates for both methane and carbon dioxide and are represented by the pink trendline.

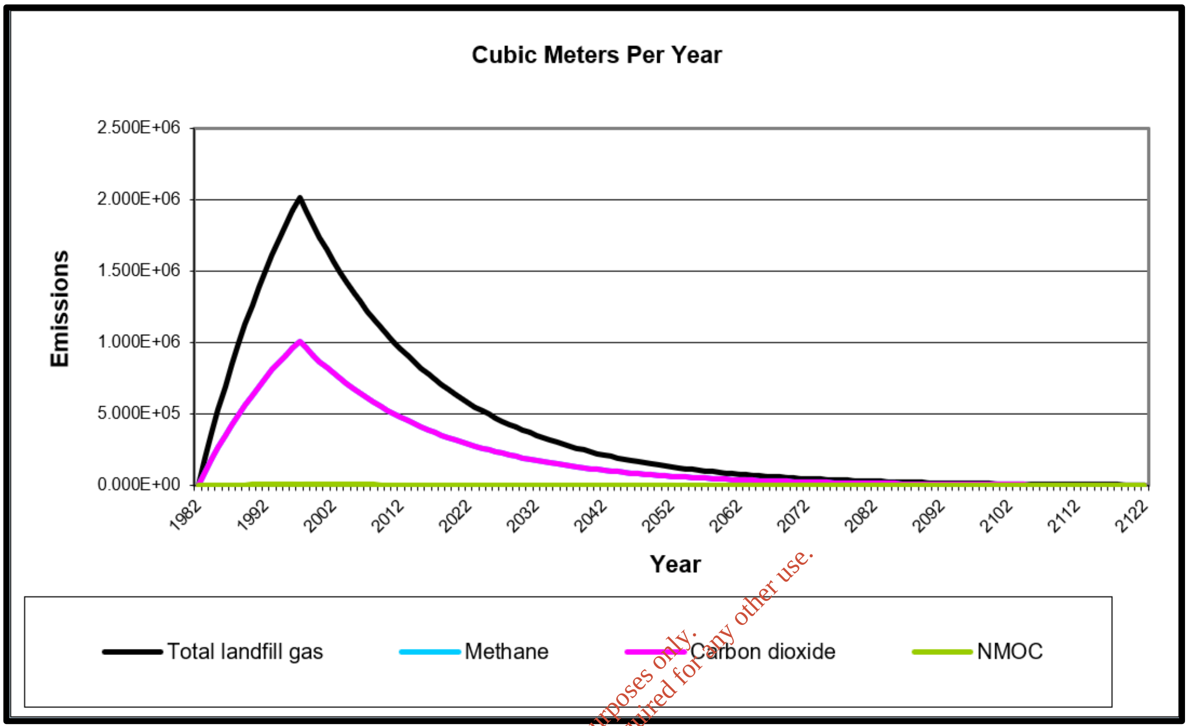

Figure 6-1: LandGEM Landfill Gas Volume Generation Rate (at 168,000 tonnes)

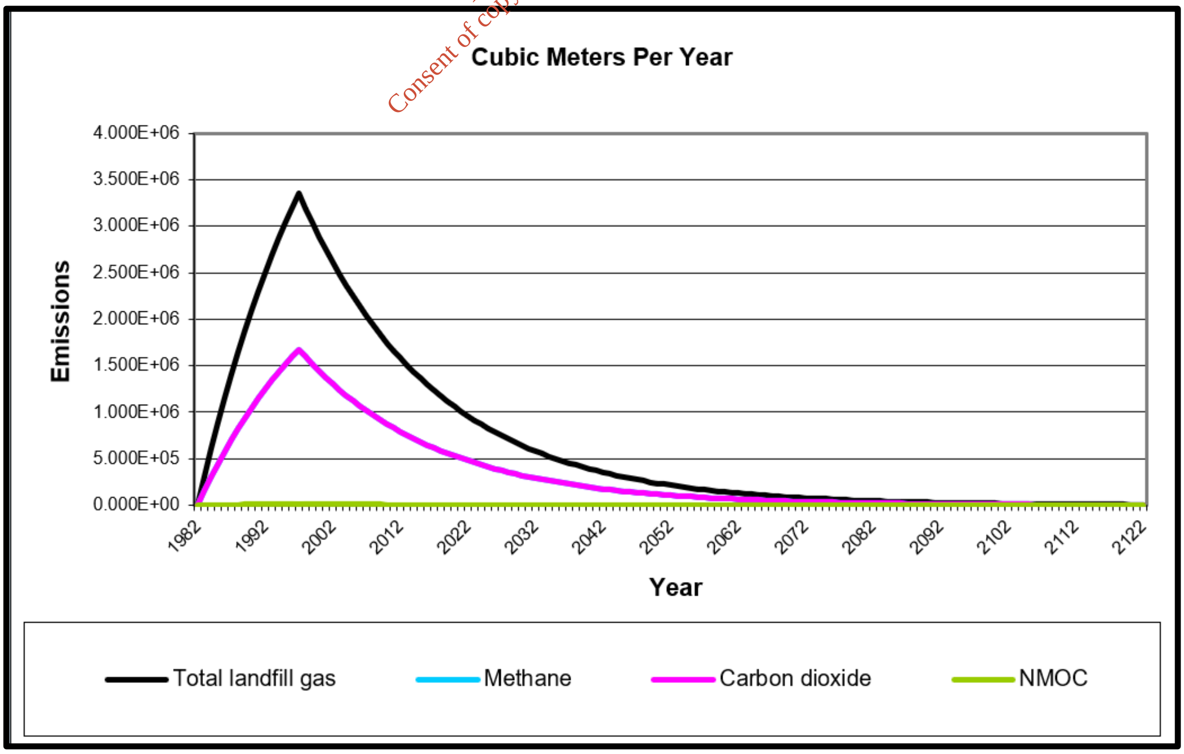

Figure 6-2: LandGEM Landfill Gas Volume Generation Rate (at 279,623 tonnes)

7. CONCLUSIONS AND RECOMMENDATIONS

The aim of this Tier 3 assessment was to examine (quantitatively) the potential impact of the historical landfill site on the receiving environment i.e. leachate generation/migration upon the underlying groundwater and potential vertical and lateral gas migration upon nearby receptors.

The examination of the potential generation from the site determined that on a regional scale the site does not pose a risk to the groundwater quality of the underlying groundwater body with the site only occupying 0.003% of the groundwater body area.

A review of the trial pit and borehole logs showed that the site only comprises a relatively shallow soil cap with an average thickness of 0.56m (min:0.3m, max:0.9m), therefore it is recommended that a more suitable cap be installed. The purpose of the cap will to twofold; to reduce the infiltration of rainfall to the underlying waste subsequently reduce or eliminate any leachate generation and to provide adequate physical separation between the waste mass and future receptors at the site e.g. livestock, construction personnel etc.

Further details regarding the proposed landfill cap are discussed in Section 8.2 below.

The output from LandGEM showed that landfill gas will continue to be generated for several years although in moderate quantities. Gas monitoring indicated the presence of gas in high quantities within the waste body with carbon dioxide concentrations also being detected slightly above the trigger value for wells outside of the waste body. It recognised that, owing to the nature of solar farms the level and frequency of human activity at the site will likely be quite low, however it is recommended that landfill gas control measures should be installed at the site to further minimise the risk of landfill gas migration and exposure to any human receptors at or close to the site.

Appropriate control measures shall be selected in accordance with the EPA Guidance document: *Management of Low Levels of Landfill Gas. Appropriate measures are* are discussed in Section 8.2.7

8. REMEDIAL ACTION PLAN

8.1 Overview

Based on the findings of the modelling exercises and quantitative risk assessment measures are proposed to mitigate the identified risks associated with leachate and landfill gas migration. The previous Tier 2 assessment and DQRA in Section 2 above concluded that the primary risk associated with the site at present is that of leachate migration into the underlying groundwater aquifer.

Regarding the risk of landfill gas migration, although the calculated SPR risk scores were determined to be low, the proximity of the site to residential areas and proposed after use require pro-active measures to mitigate the risk of landfill gas migration.

Following comprehensive desktop review, a site investigation and a Tier 2 assessment identified the primary source-pathway-receptors (S-P-R) linkages for the site to be leachate migration through groundwater pathways to the underlying groundwater aquifer.

8.2 Proposed Remediation Works

The following remediation measures are proposed to mitigate the effect of the landfill on:

- The underlying aquifer and on groundwater quality.
- Landfill gas migration.

8.2.1 Landfill Capping

A fully engineered landfill cap is proposed for the site. The landfill cap shall be design in accordance with the EPA Landfill design manual for non-inert, non-hazardous landfills. The capping shall typically consist of the following or equivalent

- 200mm Topsoil Layer.
- 800mm Sub Soil.
- Sub-Surface Drainage Geocomposite.
- 1mm LLDPE Barrier Layer.
- Sub-Surface Landfill Gas Collection Geocomposite.

The capping design shall be consistent with the proposed development of the site as a solar farm providing a suitable base for the solar panel arrays. The sub soil layer shall be therefore be adequately specified to ensure it is free draining and can support any proposed infrastructure and the solar panel network. Construction details for respective elements of the proposed cap will be subject to detailed design and prior Agency approval.

Key design criteria recommendations for respective elements are listed below under respective section headings.

8.2.2 Topsoil

Topsoil 200 mm shall be placed on top of the subsoil. Topsoil shall be seeded with a robust pasture or similar durable grassland mix.

Topsoil shall be compliant to BS3882:2015 or equal approved and graded to ensure no localized surface depressions are present.

8.2.3 Subsoil

Infill subsoil materials will be required to re-profile the landfill to fill in localised depressions.

Subsoil 800 mm thick shall be provided using a uniformly graded material with stone sizes not greater that 50 mm or equal approved.

8.2.4 Subsurface drainage on cap

A subsurface drainage layer on the cap barrier (hydraulic conductivity should be equal to or greater than $1x10^{-4}$ m/s for a thickness of 500 mm) or equal approved geocomposite shall be placed between the subsoil and barrier layer.

The drainage layer shall discharge to a subsurface pipe work collection system and thence to the surface drainage system.

Sub surface drainage layout shall be subject to detailed design.

8.2.5 Surface drainage

Surface drainage layouts using grassed waterways shall collect and direct surface water runoff including subsurface drainage outfall flows to one or more dedicated surface drainage outfalls into existing surface water perimeter drain(s).

Surface drainage shall be designed to mitigate the risk of rill or gully erosion giving rise to suspended solids loading exceeding of 25 mg/l on the cap and within receiving waters.

Surface drainage layout shall be subject to detailed design.

8.2.6 Barrier System

The barrier system shall use 1.0 mm LLDPE or similar approved.

This barrier will require vertical cut-offs on all boundaries to mitigate the risk of landfill gas migration and leachate egress following secondary consolidation.

8.2.7 Landfill Gas

8.2.7.1 Landfill Gas Pumping Trial

It is proposed that a landfill gas pumping trial be designed and conducted on site to accurately quantify the flow rate and quality of landfill gas being produce at the site to further quantify risks associated with possible landfill gas migration (SPR10 and SPR11).

Landfill gas pumping trials shall be designed and undertaken by an appropriately qualified person, the results of which shall be supported by a suitably calibrated landfill gas generation model.

It is recommended, subject to findings, that an appropriate remediation design shall be adopted. Appropriate control measures shall be selected in accordance with the EPA Guidance document: *Management of Low Levels of Landfill Gas.*

8.2.7.2 Landfill Gas Infrastructure

Subject to landfill gas flow rates the following installations may need to be considered to collect landfill gas:

- Below liner gas collection infrastructure comprising:
  - Under liner gas collection infrastructure
  - Vertical wells
- Above liner gas collection infrastructure comprising:
  - Above liner pipework connecting wells to oxidation technology
  - Condensate management infrastructure

Subject to gas flow rates and calorific value the following oxidation technologies maybe considered:

- High Calorific gas will typically require active extraction and subsequent oxidation using a high temperature high calorific (HTHC) flare.
- Low calorific gas will typically require active extraction and subsequent oxidation using a high temperature low calorific (HTLC) flare.
- Very low calorific gas may require active extraction or passive ventilation to support oxidation in a biological filter.
- Extremely low calorific gas may require passive venting via a carbon filter to mitigate the risk of odour nuisance.

Whichever technology is used the site will require power and telemetry connections to operate and or monitor oxidation technology. Where active extraction is required power will also be required to manage condensate management infrastructure.

8.2.7.3 Landfill Gas Management

A gas management risk assessment shall be carried out prior to detailed design.

Gas management proposals shall:

- Mitigate environmental pollution in accordance with best practice.
- Mitigate risks of asphyxiation and explosion.

Gas management design proposals shall make reference to gas prediction model estimates in this report and shall to facilitate detailed design and or selection of the most appropriate landfill gas oxidation solution or venting as may be required. All gas management proposals shall be subject to detailed designs.

The underliner gas collection layer shall comprise:

- An under-liner gas collection geocomposite or similar approved stone drainage later. e and collection pipework. The Landfill Directive does not define a thickness or permeability. The EPA Landfill Site Design manual advises equivalence should not be less than a 150 mm stone layer with a hydraulic permeability of $1x10^{-4}$m/s. the
- Provision for passive venting of landfill above the liner with methane oxidation if required.
- Management of below liner leachate breakouts.

The above liner gas collection pipework, if required, shall make provision for:

- Vertical wells and above liner collection pipework.
- Condensate management and associated infrastructure

In relation to whichever oxidation or passive venting technologies are required:

- Flare compounds shall be fenced.
- Gas vent stacks shall terminate at least 3.0 m above adjacent ground surfaces and be capped to prevent rainfall ingress and insertion of ignition sources (cigarettes or other).
- Biological filters shall be fenced and isolated from pedestrian, vehicular or animal activities.
- Equipment shall be specified to accommodate appropriate ATEX classifications.

8.3 Environmental Monitoring

8.3.1 Groundwater

It is recommended that groundwater monitoring be conducted quarterly at existing groundwater wells BH01 and BH02, and two new monitoring points LW01 and LW02 to monitor changes in the leachate composition.

It is further recommended that 3 No. additional combined groundwater and landfill gas monitoring wells be installed outside and downstream of the waste body to monitor effects if any of leachate migrating and potentially contaminating downstream groundwater and/or surface water receiving bodies.

8.3.2 Surface Water

It is recommended that surface water monitoring be conducted on a quarterly basis at 6 no. monitoring locations as follows:

- Upstream of waste body on N17 embankment toe drain.
- Upstream of waste body on drain to the railway line.
- Downstream of waste body on drain to the railway line.
- Upstream location on the Robe_020 (Kilbeg-Malone) prior to railway line drain.
- River downstream of railway line drain.
- Downstream location on the Robe_020 (Kilbeg-Malone) prior to confluence with Lisduff 30 (RWC: IE_WE_30R010200).

The proposed locations should be selected for accessibility prior to establishing dedicated sampling points with appropriate access and signage.

8.3.3 Monitoring Parameters

The EPA Landfill Monitoring landfill manual outlines recommended, minimum monitoring requirements for surface water, groundwater and leachate. These parameters are shown in Table 8-1 below and are as presented in Table C.2 of the EPA's *Landfill Manuals - Landfill Monitoring, 2nd Edition (2003).*

Table 8-1 Parameters for Monitoring of Groundwater, Surface Water and Leachate

Monitoring Parameter[1] See Footnote	Frequency*	Surface Water	Groundwater	Leachate
Level	Quarterly+	-	-	-
Flow Rate		-	-	-
Temperature		✓	✓	✓
Dissolved Oxygen		✓	-	-
pH		✓	✓	✓
Electrical Conductivity[2]		✓	✓	✓
Total suspended solids		✓	-	-
Total dissolved solids		-	✓	
Ammonia (as N)		✓	✓	✓
Total oxidized nitrogen (as N)		✓	✓	✓
Total organic carbon		-	✓	-
Biochemical Oxygen Demand		✓	-	✓
Chemical Oxygen Demand		✓	-	-

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

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

Monitoring Parameter[1] See Footnote	Frequency*	Surface Water	Groundwater	Leachate
Metals[3]		✓	✓	✓
Total Alkalinity (as $CaCO_3$)		✓	✓	-
Sulphate		✓	✓	✓
Chloride		✓	✓	✓
Molybdate Reactive Phosphorous[4]		✓	✓	✓
Cyanide (Total)		✓	✓	✓
Fluoride		✓	✓	✓
Trace organic substances[5]	Annually	✓	✓	✓
Faecal and Total Coliforms[6]		-	✓	-
Biological assessment	-	-	-	-

***Note: Parameters proposed to be monitored on a quarterly basis should initially be monitored monthly for a duration of 12-months following the issuing of a Certificate of Authorisation (CoA) for the purpose of establishing baseline characteristics at each monitoring location**

+Annual parameters may be reduced to annual with the agreement on the agency dependant on the results and variation observed with time and versus the baseline assessment

8.3.4 Landfill Gas

Landfill gas migration monitoring shall be conducted in tandem with groundwater monitoring at each proposed and existing borehole location. Monitoring parameters should at a minimum include;

- Methane
- Carbon Dioxide
- Oxygen
- Balance

8.4 Japanese Knotweed Management

The invasive plant species, Japanese Knotweed (Fallopia japonica) is present on site and above the historic landfill. Herbicide was applied in September 2014 and 2015, with no further treatments being carried out since.

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

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

[5] 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)

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

The Japanese Knotweed Company (JKC) on behalf of Mayo County Council - Claremorris & Western District Energy Co-op carried out additional inspections in August 2018 and 2019 and produced an update report on the assessment and management of the Japanese knotweed in September 2019.

A further updated report; *Japanese Knotweed Management and Treatment Plan Including Biosecurity Measures,* was prepared in January 2020 and this is presented in Appendix 6 of this report.

The 2020 *Japanese Knotweed Management and Treatment Plan Including Biosecurity Measures* report specifies a plan for managing and treating the Japanese knotweed during the construction and operational stages of the proposed solar farm. The proposed remediation plan and remediation design must consider the risks associated with Japanese Knotweed and all measures outlined in the management report produced by JKC. The management report also notes the development of a site remediation plan for the site and states that the Japanese Knotweed management plan may also need to be updated to reflect any proposed remediation works.

8.5 Future Potential Use: Solar Farm

All remediation work proposals should be reviewed at detailed design stage with respect to the decision or otherwise to progress with the construction of the proposed solar farm development. All remediation works and solar farm works shall be cognizant of the nature of the site.

Particular attention will be required to the selection and construction of a suitable capping layer upon which the solar farm may be located. It is recommended that the solar farm developer and the remediation designer agree on the mechanism required to fix panels to the engineered cap in order to mitigate the risk of damage to the barrier liner which is normally placed 1.0m below the surface.

The solar development shall also be required to consider the risks associated with landfill gas. Suitable protection and design measures shall be employed particularly with respect to structures and or conduits installed above or within the capping. The detailed solar panel design shall consider all relevant ATEX regulations when preparing detailed designs.

8.6 Remediation Design

The preliminary remediation design is presented in the following drawings:

- P2348-0400-0001
- P2348-0400-0002

Drawings are included in Appendix 7 of this document.

8.7 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.

8.7.1 Landfill Capping

Table 8-2 outlines the costs associated with capping the site. The proposed capping is as per the EPA Landfill Design manual recommendations as presented previously.

Table 8-2 Landfill Capping: Cost Estimates

Item	Quantity	Unit	Rate, €	Cost	Note
Design					
Allowance for Additional Site Investigation works	1	Rate	€25,000.00	€25,000.00	Allowance
Detailed Design and Supervision	1	Rate	€100,000.00	€100,000.00	Allowance
General Site Clearance and Demolition Works	***3.8***	***ha***			
General Site Clearance	3.8	ha	€7,500.00	€28,500.00	Allowance for Clearance of Existing Site
Allowance for JPK Works	1	Sum	€25,000.00	€25,000.00	Allowance
Excavation Works	38,000	m^2			Estimated area of Capping Area 38,000 m2
Excavation of Existing Cover/Capping for Reuse/Filling	19,000	m^3	€2.50	€47,500.00	Excavation of area to 500mm
Entrance Works	38,000	m^2			Estimated area of Capping Area 38,000 m2
Upgrade of Site Entrance for Works	1	Sum	€25,000.00	€25,000.00	Estimate/PC Sum
Landfill Capping Works	38,000				

Item	Quantity	Unit	Rate, €	Cost	Note
Preparation of Excavated Surfaces	38,000	m^2	€0.75	€28,500.00	Approximate Area, Local Rates 2018
Supply and Installation of 50mm Protection Layer	38,000	m^2	€1.75	€66,500.00	Approximate Area, Local Rates 2018
Supply and Installation of Landfill Gas Collection Layer	38,000	m^2	€5.50	€209,000.00	Approximate Area, Local Rates 2018 puse pipes
Installation of 1mm LLDPE Cap	38,000	m^2	€6.50	€247,000.00	Approximate Area, Local Rates 2018
Installation of Sub Surface drainage collection Layer	38,000	m^2	€5.50	€209,000.00	Approximate Area, Local Rates 2018 plus pipes
Sub Surface Drainage Layer	38,000	m^2	€1.00	€38,000.00	
Geogrid	38,000	m^2	€4.50	€171,000.00	Allowance for differential settlement
Importation of 800mm Subsoil Capping Layer	38,000	m^2	€8.50	€323,000.00	Approximate Area, Local Rates 2018
Importation of 200mm Topsoil Capping Layer	38,000	m^2	€3.00	€114,000.00	Approximate Area, Local Rates 2018
Seeding	38,000	m^2	€2.00	€76,000.00	
Fencing	716	m	€100.00	€71,554.18	Approximation
Allowance Landfill Gas Migration Network Infrastructure	5000	m^2	€3.00	€15,000.00	Allowance
Allowance Surface Water Drainage Infrastructure	38,000	m^2	€4.00	€152,000.00	Allowance
Independent CQA	1	Sum	€15,000.00	€15,000.00	Estimate Local Rates
Landfill Gas Pumping Test					
-					
Mobilisation	1	Sum	€3,500.00	€3,500.00	Local Rates 2018
Landfill Gas Well ex. M&E, inc. piping and backfill	4	No.	€4,000.00	€16,000.00	Assumed design depth 6 8m and spacing, Local Rates 2018
Landfill Gas Well Heads	4	No.	€500.00	€2,000.00	Local Rates 20198
Supporting Infrastructure	1	Sum	€5,000.00	€5,000.00	Allowance
Design, Supervision and Interpretation	1	Sum	€10,000.00	€10,000.00	Allowance

Item	Quantity	Unit	Rate, €	Cost	Note
Sub Total 1				**€2,023,054.18**	
Add 10% Contractor Prelims	10.0%			€202,305.42	
Sub-Total 2				**€2,225,359.6**	
Add 7.5% Contingency	7.5%			€166,901.97	
Grand Total (excl VAT)				**€2,392,261.57**	

- This preliminary cost estimate does not purport to guess potential tender submissions in current and future market conditions.
- FTC has used approximations of rates for similar works items where possible and has used engineering judgement to estimate rates & sums where similar rates are not available.
- Management of Hazardous Materials has not been allowed for.
- Pricing is based primarily on concept design provided for the site; no detailed designs have been completed.
- This cost estimate assumes that materials to be imported are available from local sources
- This cost estimate excludes VAT.
- This cost estimate excludes in/deflation.
- This estimate includes for a level of contingency as indicated.
- Costs are largely based on previously tendered rates for similar work or cited reference sources, Prices may have changed in the intervening period.
- It is assumed that the new site is serviced by public road access, water supply and sewerage services.

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30 YEARS

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APPENDIX 1

Tier 2 Risk Assessment
Mayo County Council

https://uss.ftco.ie/DMS/view_document.aspx?ID=527370&Latest=true

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APPENDIX 2

JSDrilling Site Investigation Report

https://uss.ftco.ie/DMS/view_document.aspx?ID=519845&Latest=true

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APPENDIX 3

Site Walkover Photos

https://uss.ftco.ie/DMS/view_document.aspx?ID=540190&Latest=true

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APPENDIX 4

Report on Site Investigation for Proposed Knock/Claremorris By-pass

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https://uss.ftco.ie/DMS/view_document.aspx?ID=539506&Latest=true

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APPENDIX 5

LandGEM Summary Reports

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https://uss.ftco.ie/DMS/view_document.aspx?ID=540196&Latest=true

https://uss.ftco.ie/DMS/view_document.aspx?ID=540197&Latest=true

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APPENDIX 6

Japanese Knotweed Management and Treatment Plan Including Biosecurity Measures

https://uss.ftco.ie/DMS/view_document.aspx?ID=536767&Latest=true

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APPENDIX 7

Remediation Design Drawings

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\\FTC-FS01\PublicShare\1-Drawings For Review\P2348\P2348-0400-0001.pdf

\\FTC-FS01\PublicShare\1-Drawings For Review\P2348\P2348-0400-0002.pdf

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