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Derrinumera Landfill – Integrated Constructed Wetland

Preliminary Design Report

Mayo Co. Co.

Report No. B1853-BLP-R-ENV-03
March 2023
Revision 01

VESI ENVIRONMENTAL
Integrating our water back into nature

Comhairle Contae Mhaigh Eo
Mayo County Council

Document Control

Project: Derrinumera Landfill – Integrated Constructed Wetland

Document: Preliminary Design Report

Client: Mayo Co. Co.

Report Number: B1853-BLP-R-ENV-03

Document Checking:

Revision	Revision/ Review Date	Details of Issue	Authorised		
			Prepared By	Checked By	Approved By
01	13th March 2023	Issued for Review	Aila Carty VESI	Maurice Ryan ByrneLooby	Maurice Ryan ByrneLooby
00	20th December 2022	Issued for Review	Aila Carty VESI	Maurice Ryan ByrneLooby	Maurice Ryan ByrneLooby
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Contents

1 INTRODUCTION

1.1 Report Objectives

A Feasibility and Preliminary Design Report has been prepared for the proposed development of an Integrated Constructed Wetland (ICW) for the treatment of landfill leachate for the landfill at Derrinumera, County Mayo. The purpose of this report is to describe the assessments undertaken to date; outline the requirements to satisfy licence conditions; propose a preliminary design and outline the next stages of the development.

1.2 Background

It is proposed to develop an Integrated Constructed Wetland (ICW) for the treatment of landfill leachate for the landfill at Derrinumera, County Mayo. This landfill, which has been closed since 2012, produces approximately 35,000 – 40,000m^3 of leachate per annum. At present, leachate and leachate contaminated water produced on site are being collected in 3 No. pre-cast concrete tanks and transported via road tanker to Rathroeen Landfill, Ballina, Co. Mayo. It is then discharged into a holding tank before being pumped into the Ballina Wastewater Treatment Plant (WWTP) for processing. This practice is not feasible long term and alternative solutions have been assessed. An ICW was deemed the most suitable treatment system for the facility as part of a previous assessment (Frank Harvey Report - *Derrinumera Landfill, Proposals for Treatment of Leachate*) due to its effectiveness, economical running costs, minimal sludge production and low environmental impact. An ICW would enable leachate to be managed on site and eliminate the need for external treatment and associated risks. It would also eliminate the carbon footprint associated with transport of leachate off-site.

Figure 1 – Aerial view of site (ref. Mayo Co. Co.)

2 REVIEW OF EXISTING INFORMATION

2.1 Records review

Information and data were received and reviewed from Mayo County Council. Included in this information and data was

- Frank Harvey Report - *Derrinumera Landfill, Proposals for Treatment of Leachate*. Issue 2, dated February 2017
- Topographical Information – *Derrinumera Landfill, Site Layout Plan, Topographical Survey* by Tobin Consulting Engineers (ref. 6467-6001 Rev C, dated 26th April 2012);
- EPA Waste Licence No. W0021-02, dated 15th January 2013;
- Groundwater Monitoring Results, Mayo Co. Co. for all GW monitoring wells between the years 2005-2020;
- Leachate Loading Volume Records. Mayo Co. Co. between the years 2017-2022;
- *Landfill Gas Infrastructure Drawing*, by Tobin Consulting Engineers (ref. 6286-1001 Rev A, dated 17th December 2010);
- Apex Geophysics Report – *Geophysical Investigation at Derrinumera Landfill, Co. Mayo* (ref. AGP21141-01, dated 31st January 2022).
- Report on *Archaeological Testing at Derrinumera Landfill Site*, conducted by Mr. Bernard Guinan (License Number 22E0488, August 2022)

2.2 Review of Published Geological Information

Information published by the Geological Survey of Ireland (GSI) indicates that the site is underlain by blanket peat and/or till derived from Devonian sandstones, with rock outcrop/subcrop exposed in the western area of the site. Bedrock comprises quartzite-clast conglomerate of the Croaghmoyle Formation and is Middle Devonian in age.

2.3 Review of Aerial Photographs

Aerial photographs published by the Ordnance Survey Ireland (OSI) were reviewed for dates between 1995 and 2005, together with aerial (drone) images provided by Mayo County Council. In addition to demonstrating historical development of the Derrinumera Landfill site during this time, the photographs appear to show that the proposed ICW area, together with potential borrow pit areas (outside the licence boundary site), have been disturbed by either landfill associated works and/or historical peat stripping activities. The aerial imagery is included in the accompanying appendices.

2.4 Review of Historical Ordnance Survey Maps

Historical Ordnance Survey Maps, published by Ordnance Survey Ireland, date between 1829-41 for the Six-Inch Series and 1897-1913 for the 25-inch series. Examination of both show no development at the site during these periods in time. The 25-inch series shows 'rough pasture' and 'cropping rock' at the site.

2.5 Hydrogeological Assessment

2.5.1 Aquifer Category

According to information taken from EPA Maps, the entirety of the proposed development sits on a Locally important bedrock aquifer. This is defined as 'Bedrock which is Moderately Productive only in Local Zones' and is given the code 'Ll'.

2.5.2 Groundwater Vulnerability

According to information taken from EPA Maps, groundwater vulnerability ranges from 'High' (H) to 'Extreme' (E) across the proposed development boundary. Moreover, some sections are classified as 'Rock at or near surface' (X).

2.5.3 Hydrology

The first order 'Glaishwy' system (River waterbody code: IE_WE_32N010020) flows in a south to north direction, immediately east of the proposed development area. This system flows into Beltra Lough, part of the Newport River SAC site code 002144, approximately 3.2 km north of the proposed development.

The Derrinumera stream (River waterbody code: IE_WE_32O050500) flows south at the south east of the facility and joins the Owennabrockagh Stream (River waterbody code:_WE_32O040500) c. 700m south of the site. Both the Owennabrockagh and the Glaishwy flow into Clew Bay, which is an SAC Site Code: 001482).

2.5.4 Flooding

Using information taken from www.floodinfo.ie, it was determined that there is no risk of flooding to the proposed development area or the Glaishwy system. NIFM mapping was reviewed which included the modelling available for the Owenbrockagh River and on the Newport River/Beltra Lake, however no modelling of the Glaishwy stream is available.

2.6 Review of Site Assessment

A site assessment was undertaken by ByrneLooby and VESI Environmental to understand the site conditions and determine the suitability of the site for development of an Integrated Constructed Wetland (ICW) to treat landfill leachate on site.

The groundwater response for the proposed site is classified by the Irish Department of Environment, Heritage and Local Government (Integrated Constructed Wetlands: Guidance Document for Farmyard Soiled Water & Domestic Wastewater Applications) as being R1 to R3 over the extent of the site. This response level indicates the site is suitable for the construction of an ICW when the requirements are met. These requirements include suitable depths of ground conditions, including a minimum of 0.5m-0.75 of soils with a permeability of $1x10^{-8}$m/s, with a further 1m of cohesive subsoil.

review of background information and data on the leachate requiring treatment has determined the treatment area required for effective treatment. The geophysical report and GW monitoring results give insight to the level of exfiltration from the site and the geophysical layout of the site and the importance in containment of leachate. The topographical information assisted in assessing potential location for the ICW and indicated areas for further site investigation.

A potential hydrological pathway exists between Derrinumera Landfill and the Newport River Special Area of Conservation (SAC) (site code: 002144). Due to the sensitive nature of this SAC, its potential link with the landfill site is considered as part of this study.

2.7 Review of Report on Geophysical Investigation

A geophysical survey was undertaken at Derrinumera Landfill for Mayo County Council in 2002 by Apex Geophysics under the instruction of Tobin Consulting Engineers. The survey was partially repeated in 2009 and those locations were again resurveyed in 2021. A report on the Geophysical Investigations was submitted to the EPA on 31st January 2022. A combination of Electromagnetic Conductivity (EM) and Electrical Resistivity Tomography (ERT) techniques were employed to assess the movement of contaminated groundwater.

Some variation in the values between the surveys was attributed to the stripping of subsoils for use in capping of the landfill cells. Regarding the occurrence of leachate plumes, the results of the survey indicated that shallow leachate plumes (in the upper 6m), generally appear to have decreased over time, with the exception of possible increase in leachate content/concentration east of MW25. Low bedrock resistivities indicated possible migration of leachate through the bedrock at depth (>10m bgl), with leachate levels increasing deeper in the groundwater. The suggested migration of leachate through the bedrock was noted in the south east of the landfill site.

Repetition of the survey was recommended, with a suggestion of seismic refraction profiling outside the cut-off wall, to enable the depth to bedrock to be clearly defined.

The proposed ICW project aims to include for management/treatment of the leachate plumes. The extent of treatment and volumes to be managed will be dependent on various factors to be agreed with the EPA.

2.8 Review of Archaeology Report

Mayo Co. Co. completed an archaeological appraisal and investigation of the proposed ICW location (License Number 22E0488). The investigating archaeologist, Mr. Bernard Guinan, noted that there were no elements of archaeological value within the proposed development area. The findings of the investigation are included in Appendix B.

3 SITE INSPECTION AND INVESTIGATIONS

3.1 Introduction

Following detailed examination of available information, potentially suitable areas for development of ICW cells were identified. Locations were selected based on proximity to existing landfill; position within site boundary and licenced area and anticipated optimum suitability for ICW construction. These areas were further investigated on the ground by means of a walkover survey and intrusive site investigations.

3.2 Walkover

An initial walkover was undertaken in January 2022, with a further walkover conducted on the 8th and 9th of August 2022 in parallel with site investigation works. Weather conditions in August were warm and dry and followed a protracted period of dry weather during the summer months. An extensive intrusive archaeological investigation had taken place in advance of the site visit.

3.2.1 Existing Infrastructure

Both landfill capped cells have a network of pipes for internal gas transport. Cell 1 has a subsurface gas transport system while Cell 2 has a gas transport system on the surface of the capped cell. A pumping station is located on each Cell, one immediately northeast of Cell 1, and another on the west flank of Cell 2. There are three balancing leachate tanks located to the west of Cell 1, north of the Civic Amenity Site. A leachate holding lagoon is located north of Cell 2. There are two surface water settlement ponds, one located to the west of Cell 2 and one located north of the leachate lagoon.

3.2.2 Site Conditions

The site is characterised by the existing roadways and infrastructure serving Derrinumera Landfill and Civic Amenity Site. The site boundaries in the vicinity of the proposed ICW are currently concrete post and barbed wire/chainlink fence, with some palisade fencing and gates. The area being investigated (north west and north of the landfill site) appeared to be largely undisturbed lands, apart from the obvious tracks and fences. Despite the extensive dry period throughout the summer, the peat layer near surface remained saturated, with a strong and rapid flow of water issuing into the excavations. The quarry area to the north east of the existing landfill (outside the licence boundary) comprised a peat-stripped condition, with extensive removal of the natural sandy clay glacial till which underlies it. These materials were excavated for use in landfill construction and capping during various phases of the site development. Rock was observed to be outcropping in numerous locations throughout the quarry area and comprised quartzite clast conglomerate, confirming the published GSI information.

3.2.3 Vegetation

The areas being examined for suitability for proposed ICW cell construction were characterised as bog and fen with densely vegetated peatlands comprising shrubs, grasses, ferns and native species.

The terrestrial invasive plant species Gunnera, (Gunnera Tinctoria) and Himalayan Knotweed (Persicaria Wallichii) were recorded on site via an invasive species survey completed during October 2018, and as documented in the *Invasive Plant Management & Herbicide Treatment Plan* developed by The Japanese Knotweed Company on behalf of Mayo Co. Co. (Doc. File Name 011/18-01. This is included in Appendix C.

3.2.4 Accessibility

Dense vegetation was present at some locations within the site area investigated. Potential exploratory hole locations were selected to minimise negative impacts on vegetation and existing infrastructure, including fences and access paths. Extensive archaeological investigation had been undertaken with long shallow trenches remaining open at the time of inspection, some of which contained standing water. Proposed exploratory hole locations were re-located to avoid the archaeological excavations and associated instability and/or disturbance.

3.3 Site Investigations

3.3.1 Description of Investigation Works

A trial pit investigation was undertaken between 8th and 9th August 2022 for the purpose of establishing the nature of the subsoils at the proposed ICW cell locations and potential borrow pit area. Ten no. trial pits were undertaken using a wide-tracked Volvo EC140D excavator and advanced to depths between 0.7m below ground level (bgl) and 3.5m bgl. Bulk samples of the subsoil beneath the peat layer were taken from all ten trial pits. Thirteen of those samples were scheduled for laboratory testing and analysis. One hand vane in-situ test was performed at 0.5m bgl in TP1. A value of 50 was recorded. In general, materials encountered and pit stability prevented widespread use of the hand vane in this investigation. Results of the investigation are included in Appendix D, along with a layout drawing included in Appendix E.

3.3.2 Ground Conditions Encountered

Peat was encountered in all trial pits with thickness varying between 0.3m and 3.2m. This layer was generally water-laden, despite a long spell of dry, warm weather. The peat was underlain by till derived from Devonian sandstones, consisting of soft to firm/loose to medium dense and dense pink brown mottled orange sandy gravelly CLAY/SILT or clayey silty gravelly SAND, both with varying amounts of cobbles and boulders. Possible rockhead was encountered in three of the trial pits (TP1, TP9, TP10) at depths between 0.75m bgl and 3.5m bgl. Moderate to strong inflow of water was encountered in nine of the ten pits. Some of the water was derived from water stored in the peat and some was categorised as groundwater. Both water sources contributed to instability of the pit

sides, with collapse preventing advancement of some pits. Samples were taken for laboratory analysis to confirm the classification of the soils.

3.3.3 Comment on Findings

TP3 was undertaken adjacent to the access track and was the only dry and stable pit. In general, the thickness of the peat layer increased in an easterly direction, with thicknesses between 2.5m and 3.2m bgl in trial pits TP2, TP4 and TP5. Trial Pits TP6 and TP10 indicate that the peat layer also thickens in a northerly direction with thicknesses between 1.1m bgl and 1.2m bgl. Ground conditions prohibited further advancement in the northerly direction and the increasing depth of peat confirmed that there was no merit in pursuing efforts to achieve this. Trial pits TP1, TP3 and TP9 had the thinnest peat layer, being between 0.3m and 0.4m bgl. The area to the west of the existing landfill and proposed ICW location was perfectly positioned to win materials for use in landfill construction being in close proximity and containing the thinnest layer of peat. This quarry area has been stripped of much of the glacial till, with rock outcropping and exposed at this location.

3.4 Laboratory Testing and Results

Classification tests were performed on thirteen bulk samples taken from the ten trial pits. Testing was undertaken by Causeway Geotech Ltd. Moisture content, Atterberg Limits and Particle Size Distribution Tests (both wet sieve and hydrometer) were undertaken.

Moisture content values ranged from 7.9% to 28%, with lower values corresponding to observably drier locations with a thinner layer of peat. Moisture content results should be viewed with caution due to the two origins of water: strong seepage into the pit from the peat layer and groundwater seepages through the till and/or associated with the approach of rockhead.

Examination of the grading curves from Particle Size Distribution reveals the range of particle sizes in the samples tested, with the majority of the samples representing a well-graded material. Variability between samples locally can be observed and this is also demonstrated by the range of fines content which is between 4% and 26.5%. The percentage clay content is between 2.6% and 7.5%

Atterberg limit tests were performed on nine samples. The results classified six of the samples as CLAY; two of the samples as SILT and one sample as SILT/CLAY. This reveals that despite the relatively low percentage of clay particles, the majority of the samples tested behaved like a clay under test conditions.

4 ENVIRONMENTAL REQUIREMENTS

4.1 Environmental Assessment Requirements

The site assessment is based on the Irish guidance document for ICWs published by the Department of Environment, Heritage and Local Government, Ireland (Integrated Constructed Wetlands Guidance Document for Farmyard Soiled Water Domestic Wastewater Applications, 2010).

This assessment includes the following:

- Existing and potential hydraulic loading;
- Hydrogeological conditions of the proposed site;
- Geology & topography of the proposed site;
- Natural & cultural heritage considerations;
- Proximity of human activities and housing; and
- Surface water quality.

Following the site investigations there are some constraints, with the main items being;

- Limited land availability within the licence boundary
- Ground conditions (soils and water) that constrain works and require on-site soils to be supplemented with imported soils.
- The topography of the site may require the need to pump flows to the ICW (subject to cell elevation).

The development of an ICW at the facility will provide enhancements, including

- Surface water quality
- Biodiversity and habitats

4.2 Outline of Requirements to Satisfy Licence Conditions

The customised approach taken to each ICW design relies on several key factors including:

- Hydraulic loading;
- Concentration of contaminants in influent;
- Average annual rainfall;
- Topography;

- Ground conditions;
- Receiving water capacity; and
- Licence boundaries and limits

As outlined above, one of the key parameters that needs to be considered when designing an ICW is the loading. This parameter helps inform the quality and quantity of incoming wastewater and subsequently the treatment area required to achieve water quality objectives. It has been determined through the assessment of information provided that the proposed ICW system will need to be designed to facilitate a loading of up to 110 m^3 per day.

The development of an ICW provides a significant reduction in all contaminants including nutrients, heavy metals and pathogens. Due to the varying volume of leachate produced at the landfill (weather related) the volumetric discharges to the ICW and from the system will also be variable.

5 PROPOSED PRELIMINARY DESIGN

5.1 Outline of Design

The main aims for an ICW system at Derrinumera are:

- achieve high treatment efficiency and meet minimum threshold limits in the discharge
- deliver a sustainable long-term leachate treatment system
- eliminate risks and costs, including carbon costs associated with transport and treatment off-site
- To remediate groundwater contamination over time

In addition to the above aims, an ICW will provide a range of ecosystem services, including:

- carbon sequestration (storage)
- avoidance of quick discharge of intercepted water by releasing water slowly from intercepting ICW cells
- retrieval (recycling) of water-vectored materials such as metals and organic matter
- develop new wetland-dependent resources
- facilitate biodiversity and reanimation of habitats
- facilitate awareness of the values of wetlands and act as a form of education.

5.1.1 ICW Area Calculation

The leachate concentration prior to treatment through the ICW is provided in Table 1 below.

Table 1 – Leachate concentration (Influent)

Leachate concentration (L5)									
Parameter	**BOD**	**SS**	**TON**	**pH**	**Conductivity**	**Ammonia**	**Total P**	**Ortho-p**	**COD**
Average	36.33333	25.37037	3.243875	7.828571	1810.857	86.16429	0.468214	0.181357	96.29167
Min	1	2	0.1	7.5	1004	20.9	0.07	0.01	31
Max	226	137	23.6	8.1	5900	430	2.72	2.22	321

The recommended ICW area for the treatment of leachate at Derrinumera Landfill is 200m^2/m^3. This scaling (200m^2/ 110m^3) would require c. 2Ha of functional/treatment area. This scaling is based on existing performance of similar ICWs and the Guidance Document for Farmyard Soiled Water and Domestic Wastewater Applications', published 2010 by the Department of Environment, Community and Local Government, together with over 30 years of research and operational ICW sites designed by VESI Environmental Ltd.

5.1.2 Design Elements

The main factors discussed in Section 4.2 above are considered when preparing an ICW design. With reference to drawing 21452_2_02 (included in the Appendix E), the proposed layout and features of the ICW development at Derrinumera Landfill include the following.

- Construction of an ICW, comprising of four treatment cells;
- Interconnecting pipework between treatment cells;
- Pipework to convey leachate to ICW;
- Discharge pipework/outfall to receiving watercourse;
- Access and service roads to and around the ICW;
- Fencing (optional); and
- Sampling and monitoring equipment.

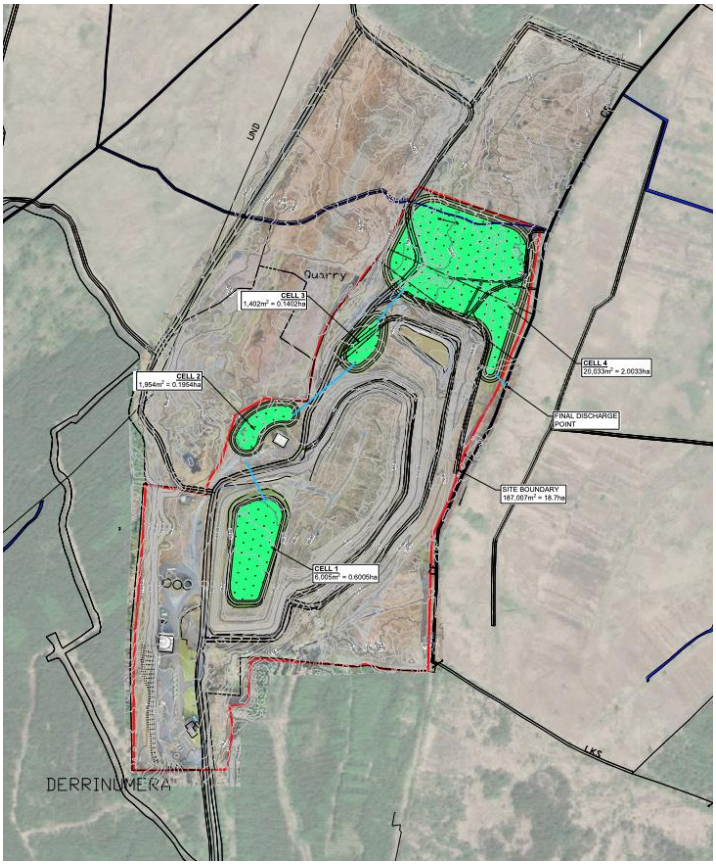

Figure 2 – Preliminary ICW layout

ICW Soil liner

The critical requirement on site will be to ensure that there is a minimum of 1000mm thickness of compacted/cohesive material at the base of each cell, with the upper 500mm having a permeability of less than $1x10^{-8}$m/s. The existing upper soil layer is peat, with subsoils comprised of sand, Silt and Clay. The main constraints on site is the depth of peat and the composition of the subsoils. In order to achieve the minimum requirements for the construction of the ICW, additional soils (imported) and/or addition of materials to enhance the structure of the site soils will be required. This will be explored further as part of the next stages of the development.

Contaminated Groundwater Treatment

It is envisaged that there is potential to accommodate between 20 to $30m^3$ per day of contaminated groundwater within the ICW between the months of May to August, with lower availability outside those months due to rainfall volumes. During these periods of lower rainfall, contaminated groundwater could be extracted and treated within the ICW system. This process would be managed on a day-to-day basis with controls placed on concentrations of critical elements to ensure the continued performance of the ICW and the overall system. The contaminated groundwater would be extracted when there is spare capacity within the system and introduced into the storage lagoon prior to pumping into the system. This can be further assessed at detailed design stage, subject to agreement with the EPA.

5.2 Proposed Treatment of Discharge Effluent to Meet Licence Conditions

Preliminary assimilative capacity calculations have been undertaken on the proposed discharge from the ICW to the receiving waters (Glaishwy stream).

The maximum expected discharge flow from the ICW will be variable over the course of any given year, due to the open nature of the system. This flow rate into and from the system will at times be similar, however it is likely that there will be no flow from the site during summer months, with higher flows during winter and heavy rainfall events.

The dense vegetation in the ICW treatment cells is such that a substantial volume of water will be lost to the atmosphere on a daily basis. Certain key plant species used within the wetland can transpire ~1,000mm/ha of water annually. This level of atmospheric loss plays a critical part of the ICW performance. Table 2 outlines the expected effluent water quality from the ICW.

Table 2 – Predicted effluent quality

Predicted effluent quality	
Parameter	**Concentration**
Outfall Flow (Q) (l/s)	1.273
BOD	5.00
COD	30.00
Ammonia	2.00
Ortho-Phosphate	0.10
Suspended Solids	10.00

The Glaishwy was assessed based on 95%, 30% and mean flow events. Given the nature of the ICW and the expected discharge relative to the influent flow Q30 flow event was assessed as most appropriate to represent conditions. Table 3 provides the background parameters based on Good Surface Water Regulations. Table 4 provides the combined effect based on Q30 flows on the Glaishwy. Table 5 provide the results for the range of flow events in the receiving waters.

Table 3 – Glaishwy background

Glaishwy background (Good surface water Reg.) quality	
Parameter	**Concentration**
Outfall Flow (Q) (l/s)	206.00
BOD	2.2
COD	-
Ammonia	0.14
Ortho-Phosphate	0.75
Suspended Solids	-

Table 4 – Combined quality at Q30 flow

Combined (Good surface water Reg.) quality at Q30 flow	
Parameter	**Concentration**
Outfall Flow (Q) (l/s)	207.273
BOD	2.217
COD	-
Ammonia	0.151
Ortho-Phosphate	0.075
Suspended Solids	-

Table 5 – Mass balance calculation

Mass Balance calculation			
Glaishwy	**95%ile**	**Q30**	**mean**
Stream Flow (Q) (l/s) *	19.000	206.000	107.000
BOD	2.200	2.200	1.300
COD	-	-	-
Ammonia	0.140	0.140	0.065
Orthophosphate	0.075	0.075	0.035
Suspended Solids	-	-	-
Outfall Flow (Q) (l/s)	1.273	1.273	1.273
BOD	5.000	5.000	5.000
COD	30.000	30.000	30.000
Ammonia	2.000	2.000	2.000
Orthophosphate	0.100	0.100	0.100
Suspended Solids	10.000	10.000	10.000
Combined flow(l/s)	20.273	207.273	108.273
BOD	2.376	2.217	1.344
COD	-	-	-
Ammonia	0.257	0.151	0.088
Orthophosphate	0.077	0.075	0.036
Suspended Solids	-	-	-

*Based on good surface water regulations

6 RECOMMENDATIONS

6.1 Recommendations and next steps

A number of surveys have been undertaken and information reviewed as part of this feasibility study. Further surveys are required including (but not limited to):

- Water quality monitoring of the Glaishwy Stream.
- Flow monitoring on the Glaishwy Stream.
- Detailed topographical ground survey of current site and extents of proposed development.
- Detailed site investigation works and testing to inform earthworks design of scheme and management of ground and groundwater risks.

In relation to the project environmental assessment requirements, an Appropriate Assessment Screening has been completed for the proposal, covering both the construction and operation of the ICW. This is included in Appendix F. The screening assessment concludes that there is a potential for significant effects to QI habitats and species of the Newport River SAC and Clew Bay Complex SAC, and therefore a Natura Impact Statement (NIS) much be completed. The above surveys shall be used to suitably inform the completion of the NIS.

Mayo Co. Co. have advised that the proposal is deemed to be Exempted Development for the purposes of the Planning and Development Act 2000 (as amended). The proposed activity is deemed to constitute a development that is specifically exempted by Article 7(2) of the Planning and Development Regulations, 2011 (as amended) in that is has the purpose of giving effect to conditions attached to a licence granted under the Waste Management Act 1996. A copy of the correspondence provided by Mayo Co. Co. Planning Department is included in Appendix F.

7 CONCLUSIONS

This feasibility report has been prepared to assess the suitability of developing an ICW for the treatment and management of leachate from the closed Derrinumera landfill. ICWs have been developed on other closed landfill sites (e.g. Churchtown, Donegal and Dungarvan, Waterford) and operate successfully and meet their licence conditions.

The lands within the licence boundary together with adjacent lands (owned by Mayo County Council) have been assessed through a desk based and on site studies. Lands have been identified within the landfill boundary as potential options for an ICW.

A preliminary layout is prepared as part of this feasibility to outline potential treatment area and layout. A series of cells to the north western boundary and northern boundary are deemed most suited, due primarily to available land, with the remaining site being utilised by the landfill and its associated access and storage areas. Preliminary site investigations and topographical surveys (drone) have been undertaken to understand the ground conditions and topography of the site. Further surveys and investigations will be essential in the design process.

The development of an ICW will require the importation of suitable soils to augment the ground conditions on-site. Construction costs have not been detailed at this stage, however will be developed in the next stages of the project. Generally ICW capital costs are less when compared with conventional treatment systems, with operational costs being considerably less.

Given the current environmental challenges and biodiversity crisis, energy instability and public perception and needs, this proposal should not only be assessed in monetary terms, and thus should be considered on all aspects. An ICW will naturally sequester carbon for decades, and assist in meeting carbon commitments that are likely to be implemented.

The benefits of an ICW will provide on-site treatment for the leachate and eliminate the transport and treatment off-site. The ICW will be designed to meet any licence discharge limits and ensure that the receiving aquatic and terrestrial environment are protected. Furthermore, an ICW will provide a wide range of ecosystem services. The ICW delivers on many fronts in terms of climate action targets, focus on nature-based solutions and application of circular economy aims. These many ancillary benefits are provided explicitly.

Appendix A – Aerial Imagery

Figure A.1 – OSI Aerial Imagery 1995 (ref. www.osi.ie)

Figure A.2 – OSI Aerial Imagery 1999-2003 (ref. www.osi.ie)

Figure A.3 – OSI Aerial Imagery 2004-2006 (ref. www.osi.ie)

Figure A.4 – OSI Aerial Imagery 2005-2012 (ref. www.osi.ie)

Figure A.5 – OSI Aerial Imagery 2011-2013 (ref. www.osi.ie)

Figure A.6 – OSI Aerial Imagery 2013-2018 (ref. www.osi.ie)

Appendix B – Archaeological Report

Archaeological testing at Derrinumera Landfill Site

License number 22E0488

Dr. Bernard Guinan

The area tested under licence number 22E0488 at the Derrinumera landfill site, Co. Mayo is a peat-filled area to the north of the current area of operations on the site. It is proposed by the environment section of Mayo County Council to use this site as an Integrated Constructed Wetland for the treatment of Leachate which has been generated at Derrinumera.

Landscape

The 2.5 hectare proposed location for the constructed wetland is within an area of rolling ice-moulded sediments containing drumlin and ribbed moraine topography (GSI Physiographic description). The sandstone, conglomerate & mudstone bedrock is overlain by low level blanket bog and sandstone till.

Plate 1: Overview of the Proposed Constructed Wetland Area with unrecorded possible Mound circled

Site Description

The Derrinumera site was subject to an archaeological assessment by Michael Gibbons in 1998, he identified a feature within this proposed wetland site as a possible burial mound. "*The Mound could be a pre-historic burial mound (2000 BC – 500 AD) or may be a natural feature*" (1998,1). It was described as sub-circular with diameter of *ca*. 20m and maximum height on E of about 2m. He recommended pre-development testing in advance of any future work that might impact this possible Mound. The location of the proposed wetland and the Mound within it are shown in Plates 1 and 2.

Plate 2. Possible Mound from ESE

Archaeological Testing

A methodology was proposed by Bernard Guinan in 2022 to test the possible Mound and its surrounding lands by digging archaeological test trenches across the site, some of which would traverse this Mound. This digging to be carried out using a mechanical excavator fitted with a toothless or ditching bucket and under archaeological supervision. This work was commenced in August 2022 using a medium sized excavator with wide tracks suitable for boggy environments. It quickly became apparent that the ground conditions were extremely challenging. The area was overgrown with shrubs and trees and the ground underfoot was uneven and swampy.

In order to elucidate the properties of the possible Mound at the earliest, work was commenced in its vicinity. This involved digging the first trench ca 10m from its SSW edge. A 1m wide cut was made running from SE to NW across the site, it traversed rough uneven boggy ground with underlying natural clay diamict at varying depths. Throughout the site the peat was dark brown and fairly featureless. The underlying clay was initially revealed as a light brown to cream coloured boulder clay or till with occasional broken sandstone and gravel. At

NW end of the trench peat was a depth of .30m which initially deepened to .52m as it ran towards SE. Where the trench neared the vicinity of the possible Mound there was a noticeable rise in the level of the natural base. This culminated in a depth of only .10m below top of peat directly opposite to the possible Mound. It appears that this SSW end of the Mound extends to a point here giving it a teardrop or oval shape which is exposed underneath the peat covering in this trench. The material making up this end of the mound was pinkish fine-grained gravel with a few rounded stones and pebbles

Plate 3.1 Clay, diamict rising prominently in Tr.1. with possible Mound in background to NNE

Plate 3.2. Significant rise in base of natural in Tr.1 as it runs towards NW

As the trench progressed beyond the area of the possible Mound towards NW the diamict base fell away to a depth of about .30m again and reverted to pale brown dauby till. Further towards NW as this natural base continued to slope downwards, the depth of peat overlying natural deepened considerably, it reached a maximum depth of 1.20m before flooding made it impossible to continue. The trench had to be stopped at a length of *ca.* 125m.

This first trench exposed the SSW end of the Mound and its make-up of pinkish gravel & stone, and the probability that it was oval or teardrop in shape with long axis running NNE – SSW. The next trench was dug to examine the nature of the mound itself and confirm these initial indications.

Testing of possible Mound

This second trench (also 1m wide) was commenced from NW and ran towards SE across the top of the Mound. Where the work was adjacent to and on this possible Mound, excavation was very carefully carried out. The digging was very gradual and shallow to ascertain the depth of peat and carefully reveal any Mound-related features it might contain. Similar to the previous trench the NW end contained very deep peat (maximum depth 1.05m) and the trench filled with water very quickly. As it progressed towards SE and the Mound, the clay and diamict natural base of the trench rises to a depth of .45m, the base here is a pale brown or cream dauby boulder clay with no features indicating activity associated with the Mound.

Plate 4. Trench 2 at NW end filling with water

Plate 5. Trench 2 as it runs up the NW side of the Mound

Where the trench gets nearer the possible Mound its base of natural clay gets shallower and at the Mound there is a higher proportion of stones mixed through it. On the side of the Mound the peat was about .30m in depth, this was up to .50m depth on the flat top of the Mound. Across the area of the Mound the peat was underlain by orange/brown fine gravel with decayed sandstone inclusions, indicating a different makeup in the Mound to the boulder clay / till across the wider site.

Plate 6. Test Trench 2 from top of possible Mound running towards NW

Plate 7. Test Trench 2 on top of possible Mound running towards SE

The SE-facing side of the possible Mound slopes downhill steeply, peat depth on top of it varies from .30m - .40m. Towards the SE end of this trench deep peat again develops.

Plate 8. Test Trench 2 on SE face of possible Mound.

At the SE end of this trench again getting into very deep peat so the trench very quickly filled with water. As it was so steep it wasn't possible to get a depth measurement.

Plate 9. Trench 2 running towards SE from top of possible Mound. Flooded at SE end

The peat and underlying clay and gravel revealed in this trench contained no features indicating human activity associated with this possible Mound. The clay, stones and gravel revealed suggest that this mound is a natural feature.

The third trench was again dug across the possible Mound to confirm the findings from the previous trench. It ran from NW to SE, 1m in width and was commenced ca. 15m NW of the possible Mound, peat depth varied between .30m and .40m. Peat removal revealed brownish grey to cream coloured boulder clay or diamict with some decayed sandstone inclusions. There were some larger flattish stones in the base of the trench where it was near the possible Mound.

Plate 10. Trench 3 running from NW and up face of possible Mound

Plate 11. Natural clay & gravel base of Trench 3 is stonier and orange-stained at Mound top

Where the trench crossed the top of the mound peat depth was *ca.* .30m, the basal clay and gravel was orange-stained with a greater stone content than seen across the site. As the possible Mound slopes steeply downhill to SE the peat cover deepens to about .40m

Plate 12. Trench 3 as it runs down SE side of possible Mound.

Conclusion of mound testing

The results from both these trenches indicate the possible Mound is comprised of naturally occurring pinkish orange-stained fine gravel with mainly rounded sandstone inclusions. It differs in composition from the rest of the tested area where the underlying natural clay was pale brown or cream-coloured diamict which has a more fine-grained dauby consistency. These differences could indicate that the possible Mound feature was created in a separate deposition event (by ice-transport processes) than when the boulder clay was laid down.

Plate 13. Trenches 2 & 3 crossing possible Mound, from NW.

Plate 14. Trenches 2 & 3 crossing possible mound from SE

Plate 15. SE end of trenches 2 & 3 showing flooding in deeper peat.

Plate 16. NW end of trenches 2 & 3 filled with water from deep peat.

Rest of proposed development site

Trench 4 was dug as part of testing the wider site across the NNE edge of the site (see Plate 1) and running from NNW towards SSE. This 1m wide trench is adjacent to a constructed firebreak on its NNW side which has impacted the nature of the peat deposits here. The NNW end of the trench commenced below a raised area that has been truncated by this firebreak

Plate 17. Trench 4 from NNW, firebreak obvious beside NNE side of trench

Peat varied in depth in this trench, initially it appeared very shallow at no more than .10m depth and exposing pinkish gravel with rounded sandstone inclusions.

Plate 18. NNW end of Trench 4 showing shallow peat and gravelly & stony base.

As the trench progressed towards SSE the peat deepened and shallowed sharply between depths of .75m and .30m. Plastic inclusions were also noted within the trench sides.

Plate 19. Varying levels of peat and gravel "natural" in Trench 4 and plastic in trench side.

Midway along the length of this trench very deep bog was encountered which was up to 2.50m in depth. This was initially not obvious as it was overlain by a layer of what was assumed to be the trench base of gravelly "natural" diamict. It became obvious that there was dumped material in this area probably associated with the construction of the firebreak area.

Plate 20. Redeposited gravel and stony diamict mixed through peat in Trench 4

As this mixed material was removed to reveal peat the trench kept filling with water which required constant backfilling to prevent it from collapsing under the digger. The redeposited fill encountered in this trench is similar to the gravelly material which made up the possible Mound. It may derive from the truncated elevated area at the NNW end of the trench where a road has been built (see Plate 1) and from the dugout area for the firebreak to NNE of trench.

Trench depth was up to 2.50m and due to flooding its contents were no longer visible. Trench 4 was suspended at about two thirds of its planned length

Plate 21. Backfilling and water rising in Trench 4

A fifth 1m wide trench was commenced about 20m to NE of the possible Mound (also to NE of Trench 1), it ran from NW to SE and cut through featureless black peat. At the beginning of the trench there was some pinkish-coloured natural gravel which changed towards SE to

pale cream-coloured boulder clay or fine-grained marly till with some grey and orange staining.

Plate 22. Trench 5 from South showing boulder-clay base.

Initial peat depth was about .55m, as the trench progressed towards SE the depth of peat increased between .60m and .75m. This deeper peat coincided with the pale clay or till base. This clay was partially dug out and revealed similar pinkish-coloured gravel to that which had been encountered in the possible Mound and in other areas of the proposed wetland site. The overgrown nature of the ground and flooding in this trench which made it unstable led to the abandonment of this trench after a length of about 65m.

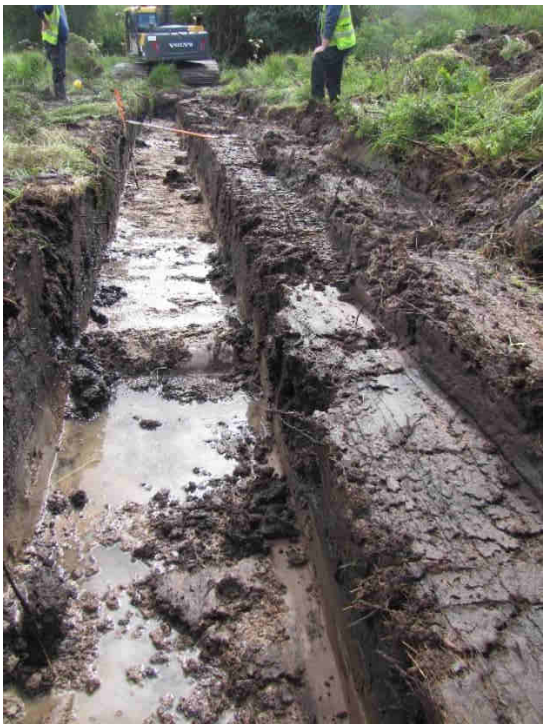

Plate 23. Trench 5 from NW

Conclusion

This possible mound is set within a landscape described by the Geological Survey of Ireland as Rolling ice-moulded sediments and mapped as “Drumlin and Ribbed Moraine topography” in the GSI map viewer.

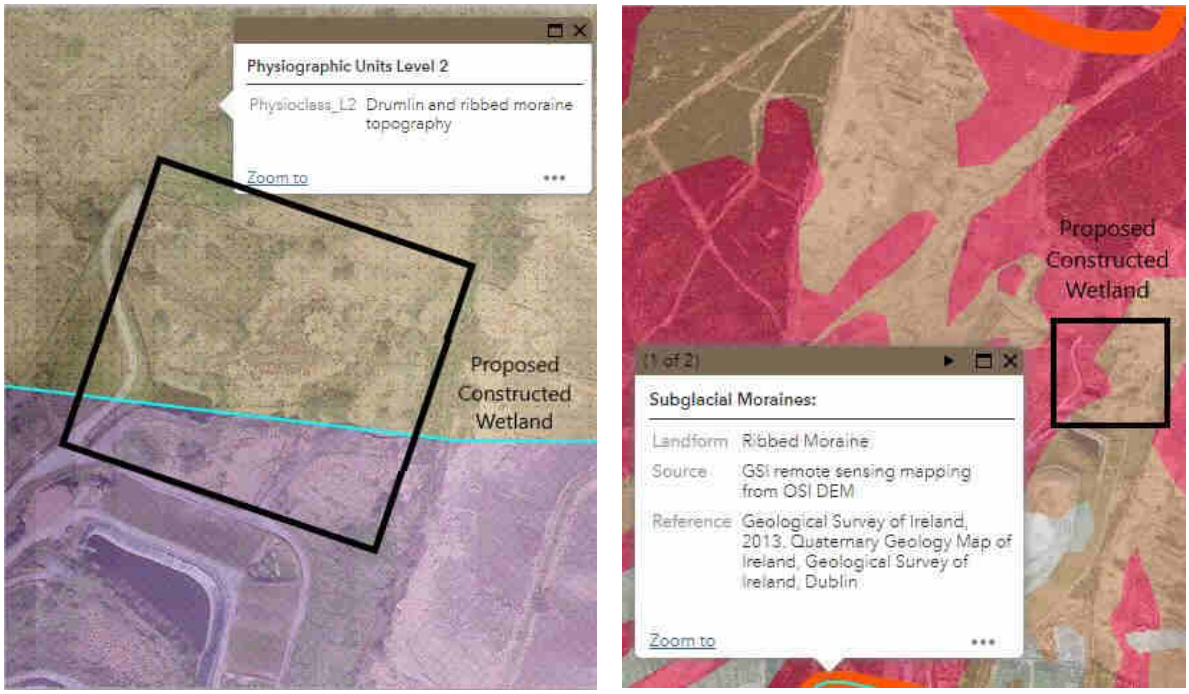

Plate 23. Annotated map sections from GSI Viewers showing Physiographic units and Quaternary Sediments and Geomorphology. Proposed Wetland area in black outline

The wider landscape around the Proposed Wetland site contains small oval shaped drumlins partially buried in the later developed peat (see Plate 24). This mound is similar in its morphology; fairly low with an oval-shaped outline. The Mound is not out of place in this landscape.

The portions of the mound revealed in the test trenches 2 and 3 show its makeup as natural till at basal areas, rising to coarser-grained pinkish gravel across its higher levels. These are naturally occurring Quaternary Sediments which were encountered across the site in other test trenches and were familiar to the personnel who have worked on the Derrinumera site in the past (Pers. Comm.).

There are no traces of archaeological features, deposits or artefacts associated with this “Mound” and it is a feature common to the wider local landscape. This feature poses no archaeological issue for the Proposed Constructed Wetland at this location.

Plate 24. Drumlin and ribbed moraine topography in the background of Trench 3.

The testing methodology included the plan to test the whole area of the Proposed Constructed Wetland. As described above, the boggy ground conditions made trench-digging very difficult. The dug-over ground quickly became unstable and flooded which made continued mechanical excavation difficult. The continuous flooding of the trenches sometimes obscured the nature of the sediments uncovered.

It was not possible to continue with additional test trenches as the boggy ground was so overgrown and unstable once excavation commenced. Such work would need more mechanical support and infrastructure such as temporary routes and other groundworks to access the wider site. This type of support and level of excavation would be more available during the construction phase of the Proposed Wetland. Therefore, it is recommended that the construction of the Proposed Wetland be subject to archaeological monitoring as an alternative to continuing excavating unstable boggy ground in a less supported work environment.

References

Gibbons, M. 1998 *Archaeological Report for the formulation of a waste Licence Application for the Derrinumera landfill County Mayo.* Unpublished Report prepared for Mayo County Council.

GSI Viewer - Physiographic units

https://dcenr.maps.arcgis.com/apps/webappviewer/index.html?id=afa76a420fc54877843aca1bc075c62b

GSI Viewer Geology - Quaternary Sediments and Geomorphology

https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228