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CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

GORT HISTORICAL LANDFILL SITE

TIER 3 ENVIRONMENTAL RISK ASSESSMENT HISTORICAL LANDFILL AT GORT, CO. GALWAY

Prepared for: Galway County Council

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TIER 3 ENVIRONMENTAL RISK ASSESSMENT
HISTORICAL LANDFILL AT GORT, CO. GALWAY

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

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1. INTRODUCTION

1.1 Overview

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

- GCC Tier 1 risk assessment findings and classifications.
- Tier 2 Risk Assessment (FT, 2020).

FT risk assessments were carried out in accordance with the Environmental Protection Agency (EPA) Code of practice (CoP) - Environmental Risk Assessment for Unregulated Waste Disposal Sites.

1.2 Tier 1 Risk Classification

The Tier 1 Assessment determined that the maximum risk score for Gort Historical landfill was 70%, resulting in a risk classification of **High (Class A)**. The highest score of 70% was applied to source-pathway-receptor (SPR) 9, referring to the potential for leachate migration to a surface water receptor, i.e. the Gort River. With the exception of SPR1 (risk of leachate migration to surface water via combined groundwater and surface water pathways) which had a risk score of 42% (Class B: Moderate) all other risks were calculated to be low (<40%).

1.3 Tier 2 Site Investigation

FT was previously appointed by Galway County Council to:

- Carry out site investigations and testing.
- Prepare a Tier 2 environmental risk assessment report on the Gort historical landfill, located at Gort, Co. Galway.

The site investigation included the following:

- Topographical Survey
- 1 No. Geophysical survey (2D resistivity, EM31 Ground Conductivity and seismic refraction profiling)
- 11 No. trial pits excavations
- Installation of 2 no. groundwater monitoring wells
- Installation of 1 no. leachate monitoring well
- Sampling of an existing groundwater monitoring well and leachate collection system
- Factual reporting

The findings of the site investigation showed that the waste material comprised mixed municipal waste material that was deposited in a single infill area with an estimated footprint of 16,500 m^2. Trial pitting confirms waste material is relatively close to the surface, generally located underlaying topsoil with a shallow layer of made ground capping material present. The waste body does not have an engineered cap constructed in accordance with EPA landfill design specifications. A deposited waste volume of 57,750 m^3 was estimated based on site investigations. Applying an assumed waste density of 1.6 t/m^3 this equates to approximately 92,500 tonnes of waste.

Previous remediation works at the site included embankments constructed along the river and a leachate collection system. The now non-operational leachate collection system comprised a network of sub-surface drainage, small pump control unit, leachate pump sump and rising main located to the north-west of the site. Leachate was pumped from the sump to the local sewer network to be treated at the Gort wastewater treatment plant (WWTP).

1.4 Tier 2 Risk Classification and Tier 3 SPRs

The Tier 2 site investigation risk assessment concluded that the risk rating of the site was High (Class A). Applying the EPA scoring matrix, the highest single risk rating for the site was calculated to be 70% for source-pathway-receptor (SPR) Linkage 8, which refers to leachate migration through a surface water pathway to surface water receptor (River Gort). Moderate scores of 49% and 44% were also calculated for SPR1 (leachate migration to surface water via combined groundwater and surface water pathways) and SPR7 (leachate migration to surface water via groundwater pathway) respectively. All other SPR risks were calculated to be low. A summary of the Tier 2 risk scores are shown in Table 1-1:

Table 1-1: Tier 2 SPR and Selected Tier 3 SPRs

SPR No.	Linkage	Normalised Score	Justification
Leachate migration through combined groundwater and surface water pathways			
SPR1	Leachate => surface water	**49%**	GSI describes the groundwater vulnerability as Rock near surface (X) and extreme (E), The bedrock groundwater comprises 'Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones', Gort River is located immediately adjacent to and bounds the site along its western and northern boundary
SPR2	Leachate => SWDTE	0%	The Coole-Garryland Complex SAC and pNHA (Site Code: 000252) is located c.1.1 km north-west of the site at its closest point
Leachate migration through groundwater pathway			
SPR3	Leachate => human presence (private well)	29%	GSI describes the groundwater vulnerability as Rock near surface (X) and extreme (E), The bedrock groundwater comprises 'Locally Important Aquifer - Bedrock which is

SPR No.	Linkage	Normalised Score	Justification
			Moderately Productive only in Local Zones', No buildings or structures are located directly above estimated waste footprint area. Nearest residential dwellings are located between 50m and 250m from the site, although it's expected due to the urban setting of these residences that drinking water supply is via public mains supply.
SPR4	Leachate => GWDTE	0%	GSI describes the groundwater vulnerability as Rock near surface (X) and extreme (E), The bedrock groundwater comprises 'Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones', The Coole-Garryland Complex SAC and pNHA (Site Code: 000252) is located c.1.1 km north-west of the site at its closest point.
SPR5	Leachate => Aquifer	26%	GSI describes the groundwater vulnerability as Rock near surface (X) and extreme (E), The bedrock groundwater comprises 'Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones'.
SPR6	Leachate => Public Supply	19%	GSI describes the groundwater vulnerability as Rock near surface (X) and extreme (E), The bedrock groundwater comprises 'Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones', The River Gort is part of the Coole ZOC Group Scheme Preliminary Source Protection Areas however water is abstracted from the Gort River upstream of the site. The site is c.1.1km from edge of groundwater source area for Coole Group Scheme. Defined scheme area is also underlain by a karst aquifer.
SPR7	Leachate => Surface Water	**44%**	GSI describes the groundwater vulnerability as Rock near surface (X) and extreme (E), The bedrock groundwater comprises 'Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones', Gort river is located immediately adjacent to the site.
Leachate migration through surface water pathway			
SPR8	Leachate => Surface Water	**70%**	Gort River is located immediately adjacent to and bounds the site along its western and northern boundary
SPR9	Leachate => SWDTE	0%	The Coole-Garryland Complex SAC and pNHA (Site Code: 000252) is located c.1.1 km north-west of the site at its closest point.
Landfill gas migration pathway (lateral & vertical)			
SPR10	Landfill Gas => Human Presence	35%	GSI shows a combination of tills derived from limestones, No buildings or structures are located directly above estimated waste footprint area. Nearest residential dwellings are located 50m south-west of the waste body.
SPR11	Landfill Gas => Human Presence	0%	No buildings or structures are located directly above estimated waste footprint area. Nearest residential dwellings are located 50m south-west of the waste body.

1.4.1 Leachate migration to surface water via groundwater and surface water pathways (SPR1, SPR7 and SPR8)

Historical landfills were constructed adopting the approach of "dilution and dispersion". Gort historical landfill does not include a line, engineered base but does include a leachate collection system. Although this leachate collection system is in place the presence of leachate at the landfill presents a potential risk of the migration of pollutants from the site to the Gort River, located immediately adjacent to the site.

Surface water monitoring conducted by FT as part of the Tier 2 assessment showed no significant difference between upstream and downstream samples, with all sample results remaining within the relevant surface water quality thresholds[1]. However, EPA surface water quality monitoring shows a decrease in biological water quality (Q-rating) between upstream monitoring stations (Q4- Good, 320m upstream) and downstream monitoring station (Q3-Poor, 760m downstream). Another 'investigative' EPA monitoring station is located on the Gort River, downstream of Gort WWTP effluent discharge point. Although no biological quality (Q-rating) is assigned to this monitoring station, chemical monitoring data indicates a deterioration in water quality, thereby suggesting that the measured decrease in Q-rating (as stated above) may be partially attributable to the WWTP discharge.

The potential risk the site may present to water quality in the Gort River is further assessed as part of this Tier 3 assessment.

[1] European Communities Environmental Objectives (Surface Waters) Regulations, 2009 (S.I. No. 272 of 2009), as amended 2012 (S.I. No. 327 of 2012), 2015 (S.I. No. 386 of 2015), 2019 (S.I. No. 77 of 2019)

2. TIER 3 QUANTITATIVE RISK ASSESSMENT

2.1 Tier 3 Overview

A Tier 3 assessment includes some form of quantitative risk assessment (QRA) for **Moderate or High-risk sites**, either as a Generic Quantitative Risk Assessment (GQRA) or as a Detailed Quantitative Risk Assessment (DQRA).

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

- SPR1 Leachate migration to surface water via combined groundwater and surface water pathways (44%).
- SPR7 Leachate migration to surface water body via groundwater (44%).
- SPR8 Leachate migration to surface water via surface water pathway (70%)

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

The 2020 site investigation findings and Tier 2 assessment concluded that the Gort site presents a **high risk** therefore a GQRA or a DQRA are required as part of this Tier 3 assessment.

This Tier 3 assessment report uses the following DQRA to further assess the risks to surface waters:

- An assimilative capacity assessment and a mass balance calculation were carried out to predict the potential impact on surface water quality from a leachate discharge to the adjacent river. Calculations were also conducted to assess the potential efficacy of remediation measures (specifically site capping) would have on mitigating the impact on surface water quality.

Based on the outcomes of the DQRA, suitable remediation measures and associated costs are presented in Section 3 of this report.

The DQRA rely on information gathered as part of the Tier 2 investigations. Relevant environmental characteristics considered in evaluating the site and carrying out this Tier 3 investigation are discussed below.

2.2 Existing Geological, Hydrogeological and Hydrological Environment

The risk to adjacent surface water was identified as the primary environmental risk associated with the site.

The application of the EPA risk calculation and scoring methodology is reliant on understanding the geological, hydrogeological and hydrological characteristics of the site and the surrounding environment.

The Tier 2 site investigation and risk assessment provided a firm understanding of the site and surrounding environs. A summary of the relevant environmental characteristics considered in evaluating the site and carrying out this Tier 3 investigation are discussed below.

The overall site covers an area of c.2 ha comprising an area located to the west of the L85075 road. The site is bound to the west and north by the River Gort with the L85075 road located along its eastern boundary. The site is in the ownership of GCC. The site can be accessed via the Station Road to the south. There are no dwellings located within the site however residential units are present within 200m of the site boundary, in Gort town. A commercial area is located immediately south of the site on the eastern side of the L85075 and station road.

Quaternary sediments at the site comprise a combination of tills derived from limestones (western area) and bedrock outcrop or subcrop (eastern area). Alluvium deposits are also shown to be present along River Gort. The bedrock beneath the site comprises two different formations, Waulsortian Limestones (CDWAUL) and Ballysteen Formation (CDBALL). Further to the north, west and south of the site is the Tubber Formation. GSI mapping indicates the presence of bedrock outcrop within the wider area. A significant number of bedrock outcrops and karstified bedrock outcrops are also shown along the banks of the River Gort.

Bedrock was encountered at 2.80m (19.38 mAOD) and 1.0m (22.55 mAOD) BGL during the installation of boreholes GW01 and GW02 as referenced in the CGL borehole logs.

Bedrock groundwater beneath site is classified as a 'Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones'.

GSI mapping shows a record of a well, located c.1km from the site and relating to a local authority managed public water supply. Although the record refers to a well, aerial imagery suggests that this record may relate to abstraction of water from the Gort River. There are no Groundwater Drinking Water Protection Areas within the site boundaries according to GSI, however the River Gort is part of the Coole ZOC Group Scheme Preliminary Source Protection Areas, the abstraction point is located upstream of Gort Bridge and the site.

The groundwater body (GWB) underlying the site is the Caherglassaun Turlough GWB, a poorly productive bedrock aquifer. The most recent (2013-2018) Water Framework Directive quality status for the GWB is 'Poor'. The WFD risk to groundwater quality was most recently classified as 'At Risk'.

The vulnerability of groundwater to contamination is classified as being 'Rock at or close to surface' and 'Extreme' across the entire site. The classification was confirmed by the site investigation.

The River Gort (EPA River Section Name: Cannahowna_010), which forms the western and northern boundary of the site, is the most significant water feature near the site. As the Gort River is immediately adjacent to the site this location presence a potential direct pathway for leachate migration to the river. The River Gort flows in a northerly direction discharging to the Castletown River (Kilchreest_010) before eventually discharging to the Atlantic, at Kinvarra Bay, north-west of Gort Town. Surface water quality monitoring has historically been conducted by GCC at Gort Bridge, c. 320m upstream of the site, and this is also the closest EPA surface water monitoring station to the site. Monitoring is conducted c.760m downstream of the site at EPA monitoring station (ID: RS29C010200 - at Old Mill No of Gort).

The most recent biological Q-Rating for surface water quality at Gort Bridge (2018) was Q4, 'Good' status while the most recent (2018) biological (Q-rating) downstream of the site was Q3, Poor. Another 'investigative' EPA monitoring station is located on the Gort River, downstream of Gort WWTP effluent discharge point. Although no biological quality (Q-rating) is assigned to this monitoring station, chemical monitoring data indicates a deterioration in water quality, thereby suggesting that the measured decrease in Q-rating (as stated above) may be partially attributable to the WWTP discharge.

2.3 Conceptual Site Model (CSM)

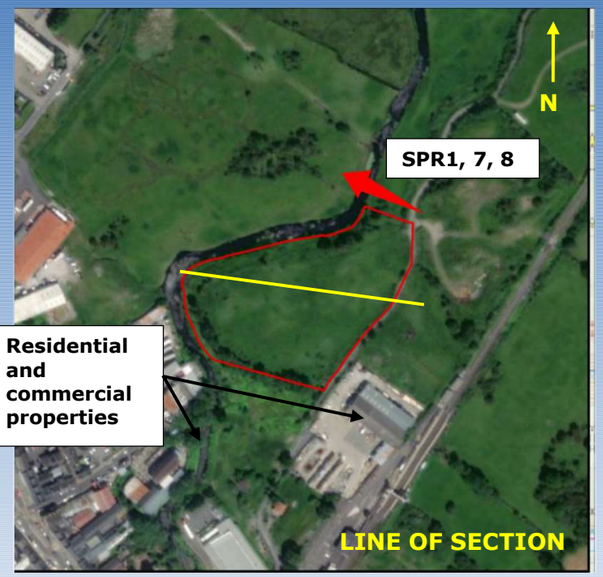
A revised conceptual site model has been prepared as part of the Tier 2 assessment and is included below for reference. The revised CSM illustrates the identified potential groundwater and surface water pathways from the site.

GROUNDWATER LEVEL

WASTE BODY

LANDFILL GAS

LEACHATE MIGRATION



Residential and commercial properties

River Gort

Soil and Rock Fill

TP01

Soil Cap

LH01
22.11mOD

TP07

WASTE BODY
Average thickness 3.5m

~17.8 mAOD

~17.50 mAOD

Alluvium soil

Limestone tiils

Estimated groundwater flow direction (E to W)

Bedrock: Dark, muddy limestone - Waulsortian Limestones and Ballysteen Formation

LOCALLY IMPORTANT AQUIFER - MODERATELY PRODUCTIVE
GW VULNERABILITY - EXTREME, ROCK AT OR NEAR SURFACE

FIGURE 2.1 GORT HISTORIC LANDFILL CONCEPTUAL SITE MODEL

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2.4 Impact of Leachate on Receiving Surface Waters

The potential impact of leachate emissions to the Gort River along the western and northern boundary of the site was identified as being a primary risk associated with the site. Although surface water monitoring did not indicate that the site was causing a deterioration in water quality, the proximity and potential sensitivity of the river to the emission from the site required a further quantitative risk assessment. Monitoring at leachate well LH01 as part of the Tier 2 site investigation showed elevated concentrations of ammoniacal nitrogen indicating that a source of pollutants remains at the site thereby presenting a potential risk to the Gort River. Furthermore, the EPA CoP requires a conservative approach to be adopted when conducting a QRA.

2.4.1 Potential Leachate Generation and Discharge

The GSI online mapping indicates that the site location is partially underlain by a both a 'Regionally Important Aquifer – Karstified (diffuse)' and a 'Locally Important Aquifer – Bedrock which is Moderately Productive only in Local Zones'. The aquifer vulnerability is classified as being high at the site, indicating that the aquifer at this location is highly vulnerable to and highly influenced by rainwater infiltration at the site, and as subsequently by any pollutants migrating vertically to the bedrock aquifer. The generation of leachate via infiltration of rainwater through the shallow soil cap and underlying waste and migration of that leachate to the underlying groundwater and possible migration to surface water is a risk.

As part of the Tier 2 site investigation static groundwater levels within groundwater monitoring wells BH1, GW01, GW02 and leachate levels at LH01 were measured on two occasions in July and August 2020 yielding average static water levels of 22.6 mAOD, 20.5mAOD, 22.0 mAOD and 18.4 mAOD at each well respectively. This measurement indicates that groundwater may be slightly below the waste body and is not transecting waste material. It is noted however that groundwater levels fluctuate seasonally and in response to precipitation regionally and so the static groundwater level may be below the waste or at higher elevations within the waste, contributing to leachate generation and migration.

The generation and subsequent vertical migration of leachate is driven predominantly by rainfall percolation inputs through the waste body as opposed to the lateral movement of groundwater through the waste body.

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

The vertical infiltration of rainfall on the site to the underlying groundwater aquifer is determined by the groundwater recharge rate at this site. The recharge coefficient applied by GSI for the area is 60%, based on the classification of the subsoil permeability as moderate, high groundwater vulnerability. Applying an effective rainfall rate of 719 mm/yr equates to a recharge rate of 431 mm/year.

Leachate Generation at 60% recharge

60% x 719mm/year = 431 mm/year or 0.431m/year (available rainfall for recharge over the landfill area

Aquifer Recharge Volume = Recharge x area of landfill

Aquifer Recharge Volume = 0.431 m/year x 16,500 m^2[estimated waste footprint area]

Aquifer Recharge Volume over landfill area = 7,111m^3/year ***[19 m^3/day] [0.22 l/s]***

Leachate Generation at 10% recharge

10% x 719mm/year = 71.9 mm/year or 0. 719 m/year (available rainfall for recharge over the landfill area

Aquifer Recharge Volume = Recharge x area of landfill

Aquifer Recharge Volume = 0.0719 m/year x 16,500 m2[estimated waste footprint area]

Aquifer Recharge Volume over landfill area = 1,186/year [3.3 m3/day] [0.038 l/s]

The potential impact of the site on this receiving waterbody was determined by conducting an assimilative capacity assessment and mass balance calculation with ammoniacal nitrogen chosen as a representative potential pollutant. The leachate breakout/discharge rate is based on the above estimated leachate generation rates. This assessment represents a worst-case scenario whereby it is conservatively assumed that the entire volume leachate is entering the river and at the same rate that it is being generated. This calculation does not take into account attenuation of pollutants within the underlying geology and groundwater. The calculations also assume low flow conditions within the Gort river, i.e., less dilution.

2.4.2 Assimilative Capacity Assessment

The following analysis was applied to determine the assimilative capacity of the receiving waterbody, see Appendix 1.

Table 2-1 shows the assimilative capacity of receiving waters in relation to ammoniacal nitrogen to be **2.18 kg/day**:

Table 2-1: Gort River Assimilative Capacity Assessment

Assimilative capacity (AC) = (C_{max} – C_{back}) x F95 x 86.4 kg/day		
Where:	Value	Source
C_{max} = maximum permissible concentration (EQS – 95%ile value) (mg/l)	0.14	95%-ile 'good' status threshold as per S.I No. 77 of 2019 - European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019
C_{back} = background upstream concentration (mg/l mean value)	0.050	Applied 2017 baseline total ammonia concentration at EPA monitoring station at Gort Bridge (Station ID: RS29C010100) upstream of the site.
F95 = the 95%ile flow in the river (m^3/s)	0.28[1]	Obtained from online EPA Hydrotool for river segment/catchment upstream of site.
Assimilative Capacity kg/day	**2.18**	AC (kg/day) = (0.14 - 0.050) x 0.28 x 86 .4

Note 1: *95%-ile value obtained from EPA hydrotool mapping and was for a point on the Gort River c.2.5km south-east of the site, and therefore is likely not fully representative of 95%ile flows of the Gort River immediately upstream of the site. However, for the purpose of determining a conservative estimate of assimilative capacity it is considered appropriate.*

2.4.3 Potential Impacts of Leachate Breakouts on Receiving Surface Waters

To determine potential impact that leachate surface breakouts from the historical landfill could have on the assimilative capacity of the receiving surface water body, the mass of ammonia discharging from the site is calculated applying the equation:

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

Assumed criteria:

- *Flow range of assumed leachate breakouts:* *19 m^3/day, 3.3 m^3/day*
- *Concentration of ammonia in leachate:* *59 mg/l NH_4 (maximum concentration measured at leachate well LH01)*
- *Significant pollution threshold if:* *> S.I. No. 77 of 2019 ('Good' status 95%-ile 0.140 mg/l)*

As shown in Table 2-1 this calculation conservatively assumes low flow conditions (95%-ile) flow conditions within the receiving river. In applying the 95%-ile flow, the assessment assumes the worst-case scenario whereby minimum dilution of the discharge is assumed within the receiving river waterbody.

Assumed leachate breakout and discharge flows (*19 m^3/day and 3.3 m^3/day*) based on potential leachate generation rates were applied and the percentage of the assimilative capacity removed following discharge to the receiving water was also calculated (Daily Mass Emission ÷ Assimilative Capacity). It is noted that no leachate breakout was observed by FT during the site walkover and the following assessment is a conservative assessment of the potential impacts on the water quality of the Gort River should leachate breakout at assumed discharges occur.

A conservative discharge ammoniacal nitrogen concentration of 59 mg/l (maximum ammoniacal nitrogen concentration detected in 2020 monitoring at leachate well LH01) was assumed for this calculation. This concentration is also within the range of typical ammonia concentration in landfill leachate. The calculated mass emissions and the impacts on the assimilative capacity, for assumed discharge rates based on potential generation rates at the site of the receiving water are shown in Table 2-2.

2.4.4 Mass Balance Assessment

A mass balance calculation determines the potential change in ammonia concentration within the receiving water downstream of the discharge. The following calculation as shown in Table 2-2 was applied:

Table 2-2: Mass Balance Calculation

T = (FC + fc)/(F + f)		
Where:		*Source*
F is the river flow upstream of the discharge (95%ile flow m^3/s);	0.28	Obtained from online EPA Hydrotool for river segment upstream of site

T = (FC + fc)/(F + f)			
C is the concentration of pollutant in the river upstream of the discharge (mean concentration in mg/l);	0.050		Applied 2017 baseline total ammonia concentration at EPA monitoring station at Gort Bridge (Station ID: RS29C010100) upstream of the site.
f is the flow of the discharge (m^3/s);	0.00022	19 m^3/day	Assumed discharge rate based on conservative estimates of leachate generation and breakout to surface water and 90% reduction in rainfall infiltration to waste.
	$3.8194x10^{-5}$	3.3 m^3/day	
C is the maximum concentration of pollutant in the discharge (mg/l);	59		Maximum concentration detected in groundwater monitoring well LH01
T is the concentration of pollutant downstream of the discharge.	Varies for discharge flows		n/a
Water Quality Standard (mg/l)	0.140		'Good' Status 95%-ile as per S.I No. 77 of 2019 (95% of results are below this concentration)

Table 2-3: Assimilative Capacity and Mass Balance Calculation Results

Assumed Leachate Breakout Flow (m^3/day)	Daily Mass Emission (kg/day) assuming ammoniacal nitrogen concentration 59 mg/l	% Impact Breakout has on of Assimilative Capacity (% consumed)	Estimated Downstream Concentration Ammoniacal nitrogen (mg/l)
19	1.121	51%	0.096
3.3	0.195	2%	0.051

Note 1: *Water quality standard as per S.I. No. 77 of 2019 ('Good' status 95%-ile 0.140 mg/l).*
Note 2: *Assimilative capacity estimated to be 2.18 kg/day ammonia (Table 2.1)*

2.4.5 Discussion of Results

Table 2-3 results show that at a leachate discharge flow rate of 19 m^3/day the predicted downstream concentrations are compliant with S.I. No. 77 of 2019 'Good' status 95%-ile (<0.140 mg/l) with a predicted downstream concentration of 0.096 mg/l (63% increase from background concentration). This corresponds with the assimilative capacity calculation which determined that, assuming low flow conditions in the river at a discharge rate of 19 m^3/day 51% of the assimilative capacity for ammoniacal nitrogen/total ammonia would be consumed.

A review of EPA catchment mapping and monitoring data shows an 'investigative' water quality monitoring station located downstream of the historical landfill, approximately 100 m downstream of the Gort wastewater treatment plant effluent discharge location on the River Gort (Station Name: Downstream of TPEFF1200D0195SW001).

EPA monitoring data for this location in 2017 shows a base concentration of 0.734 mg/l total ammonia and in 2018 a mean concentration of 0.149 mg/l total ammonia.

Both concentrations are greater than those predicted by the mass balance calculation. It is likely that elevated total ammonia concentrations are associated with the effluent discharge from the WWTP as these concentrations are significantly greater (2017 baseline: 184%, 2018 mean concentration: 170%) than those recorded at the EPA upstream monitoring location at Gort bridge (2017 baseline: 0.030 mg/l, 2018 mean concentration: 0.012 mg/l).

Another EPA monitoring station (Station Name: At Old Mill N. of Gort) is located c.850m downstream of the historic landfill and c.430m downstream of the Gort WWTP discharge point. Monitoring data for this location shows a 2017 baseline concentration of 0.077 mg/l total ammonia and a 2018 mean concentration of 0.043 mg/l. The 2017 baseline concentration is above the mean 'good' status concentration threshold value of ≤0.065 mg/l total ammonia but below the 95%-ile threshold value of ≤0.140 mg/l total ammonia.

These results indicate there is further dilution of ammoniacal nitrogen occurring between the two monitoring locations reducing the concentration further downstream. Both concentrations are below those predicted by the mass balance calculation.

The application of the reduced rainfall infiltration rate (with an engineered cap) of 3.3 m^3/day shows that the predicted downstream concentration remains below the 95%-ile threshold value of 0.140 mg/l ammoniacal nitrogen with a predicted downstream concentration of 0.051 mg/l. This equates to a 2% concentration increase from the applied background concentration of 0.050 mg/l. This demonstrates that with the installation of an engineered cap achieving a significant reduction in rainfall infiltration to the waste, the potential impact to water quality would be low.

Based on monitoring conducted as part of the Tier 2 site investigations and calculations above, in isolation the site does not present a direct high risk to the water quality of the Gort River. However, the site is still considered to be a potential negative environmental pressure on the river and a potential contributor to nutrient loading and a source of pollutants that may be discharging the river. As there are other potential pressures downstream of the site i.e. the Gort WWTP effluent discharge the potential contribution of the historical landfill to any deterioration in water quality should be limited as much as possible.

2.5 Conclusions

2.5.1 Impact of Leachate of Surface Water

The assimilative capacity assessment and mass balance calculations indicate that:

- Assimilative capacity calculations showed that leachate discharges to the River Gort, assuming low flow conditions and at discharge rates and concentrations applied have the potential to consume 50% of the existing assimilative capacity in the river with respect to ammoniacal nitrogen.

- At the applied discharge rates and concentration, discharge from the site is predicted to increase the downstream ammoniacal nitrogen concentration in the Gort River however, these downstream concentrations remain below the water quality threshold value of 0.140 mg/l.
- EPA monitoring conducted upstream of the site and at locations downstream of the site suggest that the effluent discharge from the Gort WWTP may be causing and has previously caused a deterioration in water quality immediately downstream of the WWTP discharge point as evident by elevated ammoniacal nitrogen concentrations recorded by the EPA.
- The historical landfill is still considered to be a potential source for the emission of pollutants to the Gort River and a contributor to pressure on the river with respect to water quality.
- The reduction in rainfall infiltration and subsequent leachate generation would significantly reduce the potential impact on assimilative capacity and reduce any deterioration in water quality.

2.5.2 Site Capping

Tier 2 site investigations showed that the site comprises a soil cap (minimum: 0.2m, maximum: 1.6m, average: 0.8m thickness). A derelict leachate collection system is also in place to convey leachate to the Gort wastewater treatment plant.

2.5.3 Mitigation of Risks to Surface Waters

The Tier 1 and 2 risk assessments deemed the site to have a High Risk (Class A) rating because of the proximity of the site to the Gort River and the potential for leachate migration to the river.

The existing shallow cap, unlined waste body and proximity to the River Gort have potential to:

- Allow rainfall ingress to potentially produce leachate that may subsequently contaminate receiving surface and groundwaters.
- Facilitate flushing of contaminants into the adjacent Gort River

Detailed quantitative risk assessments carried out as part of the Tier 3 investigation deemed that the environmental impacts to receiving surface waters presented low risks owing to the:

- Existing assimilative capacity of the Gort River to accept modelled discharges.
- Modelled discharges will have a low impact on the assimilative capacity of the Gort River and predicted increases in downstream concentrations will remain below the ‘good’ status water quality threshold values.

3. REMEDIAL ACTION PLAN

Based on the findings of the modelling exercises and quantitative risk assessment the following measures are proposed to mitigate the identified risks to surface waters from leachate.

3.1 S-P-R Linkages

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 surface water pathways and groundwater pathways. Proposed remedial measures for each of these linkages are discussed below.

3.1.1 Leachate Migration to surface via groundwater and surface water pathways (SPR1, SPR, SPR8)

The Gort River is located immediately adjacent to the historical landfill and bounds the site to the north and west.

Two rounds of surface water monitoring did not show a deterioration in surface water quality between upstream and downstream locations. However, the assimilative capacity and mass balance calculations demonstrated that, given the remaining source of pollutants at the site there is potential for a continuous leachate discharge from the site to consume up to 89% of the current assimilative capacity of the river with respect to ammoniacal nitrogen/total ammonia. The mass balance calculations predicted increases in downstream ammoniacal nitrogen concentrations of 63% and 89% from the background, upstream concentrations.

To examine the potential effect the installation of an engineered cap may have on mitigating the risk to surface water quality of the Gort River, a reduced rainfall rate and subsequent reduced leachate generation was applied to the assimilative capacity and mass balance calculations. The results showed that, with a reduced volume of rainfall contacting the waste body and generating leachate the potential impact to surface water quality is low, showing only a 2% increase from the applied background concentration.

In order to mitigate or eliminate this potential risk remedial measures are proposed. As indicated, the primary cause of leachate generation at the site is through vertical infiltration of precipitation through the waste body, and subsequent lateral migration from the site.

The following mitigation measures proposed to mitigate the potential risk to the Gort River.

3.1.1.1 Landfill Capping

The proposed capping works will be subject to Certificate of Authorisation, detailed design and agreement with existing site users and private landowner(s) and will be cognisant of the future site use.

A fully engineered landfill cap is proposed for the site. The landfill cap will be designed in accordance with the EPA Landfill design manual for non-inert, non-hazardous landfills.

The capping will typically consist of the following:

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

The proposed landfill cap will significantly reduce the generation of leachate via percolation of rainwater and subsequently the potential migration of leachate to surface water. The capping design should be consistent with the future uses of the site for agricultural grazing purposes. The subsoil layer will therefore be adequately specified to ensure it is free draining to support grazing.

3.1.2 Landfill Gas Management

The installation of a landfill cap can have the secondary effect of altering the preferential pathway for landfill gas migration. A shallow soil cap directly above the waste may be currently causing passive, diffuse vertical migration of landfill gases, limiting the potential for lateral migration of gas outside of the waste body. The complete capping of a landfill can inhibit vertical migration and cause increased lateral migration of landfill gases.

As such, as the proposed remediation of the site includes the construction of an appropriately design landfill cap additional measures are required to reduce the risk of lateral migration to nearby human receptors.

It is proposed that passive ventilation measures and vertical landfill gas interception trenches be used to mitigate the risk of landfill gas migration. The proposed measures are discussed in further detail below.

3.1.2.1 Passive Ventilation

It is proposed that capping will include a landfill gas drainage layer, the drainage layer will be directly connected to collection network and a series of vertical standpipes venting to atmosphere at 2-3m above the final ground level.

The vertical standpipes will provide a preferential pathway for LFG to escape to atmosphere mitigation risks associated with migration to offsite receptors.

Installed ventilation standpipes will include a carbon filtration packs to “scrub” any odour and low concentrations of methane from the landfill gas prior to venting. Wind driven rotating cowls will also be used to induce a negative pressure within the standpipe improving potential LFG flow.

3.1.3 Landfill Gas Interception Trench (SPR11)

A landfill gas interception trench is proposed along the south-eastern site boundary, parallel to Station Road.

The interception trench will comprise a deep vertical cut of barrier installed to prevent gas migration laterally to the adjoining building. The barrier will be installed to a depth of approximately 2.0; subject to detailed design and further site investigation.

3.1.4 Environmental Monitoring: Existing Locations

It is recommended that groundwater, leachate and surface water monitoring continue as follows:

- Groundwater (Groundwater Quality and Landfill Gas Migration):
  - GW01
  - GW02
- Leachate Monitoring:
  - LH01
- Surface Water (Surface Water Quality):
  - SW1
  - SW2
- Landfill Gas:
  - LH01
  - GW01
  - GW02

Continued environmental monitoring should be undertaken on an annual basis up until the recommendations of the Certificate of Authorisation are known and remediation works are complete.

Monitoring data should be available prior to detailed remediation design to confirm the findings of this report and for use post remediation as baseline data for comparative analysis.

3.1.5 Environmental Monitoring: Proposed New Locations

The following additional landfill gas migration monitoring locations are recommended:

- LFG1 – Southern Boundary
- LFG2 – South-eastern Boundary

The EPA Landfill Monitoring landfill manual outlines recommended, minimum monitoring requirements for groundwater, surface waters and leachate. These parameters are shown in Table 3-1 below and are as presented in Table C.2 of the EPA's *Landfill Manuals - Landfill Monitoring, 2nd Edition (2003).*

Groundwater monitoring shall be carried out at existing wells GW01 and GW02 and leachate monitoring at leachate well LH01 in accordance with parameters listed in Table 3-1.

Surface water monitoring shall be carried out at the existing surface water monitoring locations SW1 and SW2, upstream and downstream of the historical landfill in accordance parameters listed in Table 3-1.

Landfill gas monitoring (using a gas analyser) should be conducted at existing leachate well LH01, monitoring wells GW01 and GW02 and proposed landfill gas monitoring wells LFG1 and LFG2 in accordance with Table 3-1:

Table 3-1: Parameters for Monitoring of Groundwater, Surface Water, Leachate and Landfill Gas

Monitoring Parameter[2]	**Frequency**	**Surface Water**	**Groundwater**	**Leachate**	**Landfill Gas**
Location		**SW1, SW2**	**GW01, GW02**	**LH01**	**GW01, GW02, LH01, LFG1, LFG2**
Fluid Level	Quarterly[3]	-	-	-	-
Flow Rate		-	-	-	
Temperature		✓	✓	✓	
Dissolved Oxygen		✓	-	-	
pH		✓	✓	✓	
Electrical Conductivity[4]		✓	✓	✓	
Total suspended solids		-	-	-	
Total dissolved solids		-	✓	-	
Ammonia (as N)		✓	✓	✓	
Total oxidized nitrogen (as N)		✓	✓	✓	
Total organic carbon		-	✓	-	
Biochemical Oxygen Demand		✓	-	✓	
Chemical Oxygen Demand		✓	-	✓	
Metals[5]		✓	✓	✓	
Total Alkalinity (as $CaCO_3$)		✓	✓	-	

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

[3] Monitoring is proposed to be conducted on a quarterly basis with possible reduction to annually should no negative effects be observed (subject to agreement with the EPA as the relevant regulatory authority).

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

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

Monitoring Parameter[2]	Frequency	Surface Water	Groundwater	Leachate	Landfill Gas
Location		**SW1, SW2**	**GW01, GW02**	**LH01**	**GW01, GW02, LH01, LFG1, LFG2**
Sulphate		✓	✓	✓	
Chloride		✓	✓	✓	
Molybdate Reactive Phosphorous[6]		✓	✓	✓	
Cyanide (Total)		✓	✓	✓	
Fluoride		✓	✓	✓	
Landfill Gas					
Methane (CH_4)					
Carbon Dioxide (CO_2)				-	✓
Oxygen (O_2)					
Atmospheric Pressure		-	-		
Temperature					

3.2 Remediation Design

The preliminary remediation design is presented in the following drawings:

- P2282-0000-0100-0001 Drawing Schedule (Gort Historic Landfill)
- P2282-0100-0001 Site Location Map (Gort Historic Landfill)
- P2282-0100-0002 Existing Site Survey (Gort Historic Landfill)
- P2282-0100-0003 Proposed Landfill Capping Area (Gort Historic Landfill)
- P2282-0100-0004 Existing and Proposed Monitoring Locations (Gort Historic Landfill)
- P2282-0500-0001 Proposed Subsurface & Surface Water Drainage (Gort Historic Landfill)
- P2282-0700-0001 Proposed Passive Gas Collection System (Gort Historic Landfill)
- P2282-0900-0001 Sections A - A, B - B & D - D (Gort Historic Landfill)
- P2282-0900-0002 Sections C - C & E - E (Gort Historic Landfill)

Drawings are included in Appendix 2 to this document.

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

3.2.1 Landfill Capping Works

Whilst quantitative risk assessments determined the risks associated with leachate impacting receiving surface to be low, remedial capping works are recommended to ensure the site complies with the Landfill Directive and Environmental Protection Agency (EPA) publication landfill manual - Landfill Site Design which for a non-hazardous landfill requires a capping of at least 1m total thickness.

The proposed capping works shall be subject to detailed design and agreement with existing site users and private landowner(s) and shall be cognisant of the future site use.

A standard 1m capping layer is recommended across the site in line with the EPA Landfill Design Manual Guidance for non-inert, non-hazardous landfills and as outlined in Section 3.1.1.1.

The plan area of the proposed capping is shown on Drawing nr. P2282-0100-0003 and details are shown on Drawing nr. P2282-0900-0001 and P2282-0900-0002.

The proposed sub-surface drainage system will comprise of a herring bone drainage network across the site. The network shall comprise sub-surface drains within the capping area connected with French drains external to the capping area.

Plan details are shown on Drawing nr. P2282-0500-0001.

The subsurface drainage shall be extended vertically as land drains to accommodate future agricultural uses. The network will outfall at two outfall locations as shown on Drawing nr. P2282-0500-0001. Inspection chambers will be located at all drain junctions for future maintenance and inspection.

3.2.2 Landfill Gas Management

It is proposed that passive ventilation measures and vertical landfill gas interception trenches be used to mitigate the risk of landfill gas migration.

Plan details are shown in Drawing nr. P2282-0700-0001.

Section details for the proposed landfill gas interception trench along the south-eastern site boundary are shown in Drawing nr. P2282-0900-0001.

3.2.3 Objectives of the Proposed Remediation Plan

The proposed remediation plan objectives will be to:

- Facilitate use of land for agricultural grazing purposes and maintain the amenity potential of the river.
- Reduce deep percolation inputs into the waste body to reduce the volume of leachate being produced using surface and subsurface drainage systems.
- Facilitate passive management of landfill gas via the existing cap to encourage oxidation by using the subsurface drainage system and a dedicated venting outlet.
- Monitor potential gas migration using shallow perimeter boreholes to be installed at the southern and south-eastern boundary of the historical landfill.

In the event that subsequent landfill gas emissions increase beyond those observed during the Tier 3 assessment, appropriate control measures shall be selected in accordance with the EPA Guidance document: *Management of Low Levels of Landfill Gas*.

3.3 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.

The cost estimate for Gort Historical Landfill was prepared based on similar recent works completed by FT. The remediation cost estimate is presented in Table 3.2. The proposed remediation works are in line with the EPA Landfill Design manual recommendations as presented previously.

Table 3-2: Remediation Cost Estimate for Gort Historical Landfill

Item	Quantity	Unit	Rate, €	Cost
-		-	-	
Design	-	-	-	
-	-	-	-	
Allowance for New Monitoring Well Installation	1	Rate	€7,500.00	€7,500.00
Detailed Design and Supervision	1	Rate	€75,000.00	€75,000.00
-	-	-	-	
General Site Clearance and Demolition Works	***1.7***	***ha***	-	
-	-	-	-	
General Site Clearance	1.7	ha	€5,000.00	€8,500.00
Excavation Works	17000	m^2		
-				
Excavation of Existing Capping for Reuse/Filling	17000	m^3	€1.50	€25,500.00
Landfill Capping Works	17000			
Preparation of Excavated Surfaces	17000	m^2	€0.50	€8,500.00
Supply and Installation of 50mm Protection Layer	17000	m^2	€1.70	€28,900.00
Supply and Installation of Landfill Gas Collection Layer	17000	m^2	€4.00	€68,000.00

Item	Quantity	Unit	Rate, €	Cost
Installation of 1mm LLDPE Cap	17000	m^2	€5.00	€85,000.00
Installation of Sub Surface Water Collection Layer	17000	m^2	€4.00	€68,000.00
Importation of 800mm Subsoil Capping Layer	17000	m^2	€10.50	€178,500.00
Importation of 200mm Topsoil Capping Layer	17000	m^2	€3.50	€59,500.00
Allowance Landfill Gas Migration Network	17000	m^2	€3.00	€51,000.00
Allowance Sub surface Water Drainage	17000	m^2	€4.00	€68,000.00
Independent CQA	1	Sum	€15,000.00	€15,000.00
Miscellaneous				
New Palisade Fencing to Site Perimeter	500	m	€110.00	€55,000.00
Landscaping Allowance	1	Sum	€10,000.00	€10,000.00
Sub-Total 1				**€811,900.00**
Add 10% Contractor Prelims	10.0%			€81,190.00
Sub-Total 2				**€893,090.00**
Add 12.5% Contingency	12.5%			€111,636.25
Grand Total (excl VAT)				**€1,004,726.25**

In making this Cost Estimate FT advises the following:

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

Prices may change subject to prevailing market conditions.

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APPENDIX 1

Assimilative Capacity Assessment Calculations

Gort Tier 3 Assimilative Capacity Assessment

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

Ammoniacal Nitrogen

Where:

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

C_{back} = background upstream concentration (mg/l mean value) — 0.05

Q95 = the 95%ile flow in the river (m^3/s) — 1.64

Note: (60x60x24)/1000 = 86.4

AC kg/d	=	**(Cmax**	-	**Cbak)**	x	**F95**	x	**86.4**
	=	0.14	-	0.05	x	1.64	x	86.4
	=		0.09		x	1.64	x	86.4
AC kg/d	=	**12.75**	**kg/day**					

Emission Concentration (mg/l)		59			
m3/s	**l/s**	**Flow (m3/day)**	**Daily Mass Emission (kg/day)**	**%-age of AC**	
0.0002	0.22	19	1.121	9%	
0.0004	0.38	33	1.947	15%	
3.82E-05	0.04	3.3	0.195	2%	

Mass balance Equation:

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

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

F =	1.64	m^3/sec
C =	0.05	mg/l
f =	19	m^3/day
	0.000	m^3/sec
c =	59.000	mg/l

where:

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

T =	**F**	**x**	**C**	+	***f***	**x**	**c**		
	F	**+**	***f***						
1	1.64	x	0.05	+	0.000	x	59.000		
	1.64	+	0.000						
2	0.082			+	0.002				
	1.6400								
3	0.084								
	1.640								
4	**T =**	**0.051**	**mg/l**						

EQS (mg/l)

0.14 *Good' Status 95%-ile EQS*

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APPENDIX 2

Remediation Plan Drawings

DRAWING SCHEDULE	
DRAWING NUMBER	DRAWING TITLE
P2282-0000-0100-0001	DRAWING SCHEDULE (GORT HISTORIC LANDFILL)
P2282-0100-0001	SITE LOCATION MAP (GORT HISTORIC LANDFILL)
P2282-0100-0002	EXISTING SITE SURVEY (GORT HISTORIC LANDFILL)
P2282-0100-0003	PROPOSED LANDFILL CAPPING AREA (GORT HISTORIC LANDFILL)
P2282-0100-0004	EXISTING AND PROPOSED MONITORING LOCATIONS (GORT HISTORIC LANDFILL)
P2282-0500-0001	PROPOSED SUBSURFACE & SURFACE WATER DRAINAGE (GORT HISTORIC LANDFILL)
P2282-0700-0001	PROPOSED PASSIVE GAS COLLECTION SYSTEM (GORT HISTORIC LANDFILL)
P2282-0900-0001	SECTIONS A - A, B - B & D - D (GORT HISTORIC LANDFILL)
P2282-0900-0002	SECTIONS C - C & E - E (GORT HISTORIC LANDFILL)

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Rev.	Description	App By	Date
A	FOR INFORMATION	JON	20.01.21

PROJECT
ERA GALWAY HISTORIC LANDFILLS

CLIENT
GALWAY COUNTY COUNCIL

SHEET
DRAWING SCHEDULE (GORT HISTORIC LANDFILL)

Date	Project number	Scale (@ A3)
20.01.21	P2282	1:1000
Drawn by: POR	Drawing Number: P2282-0000-0100-0001	Rev: A
Checked by: AB		

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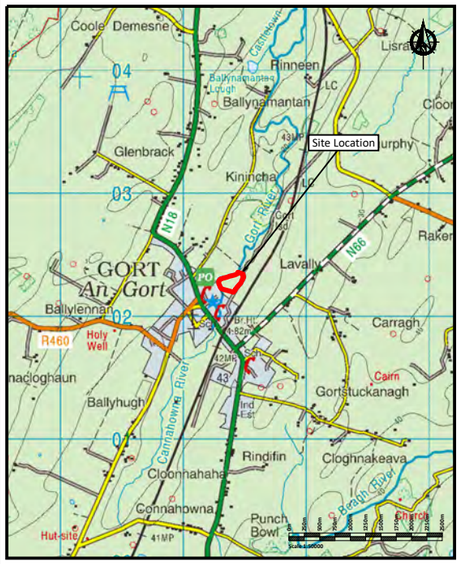
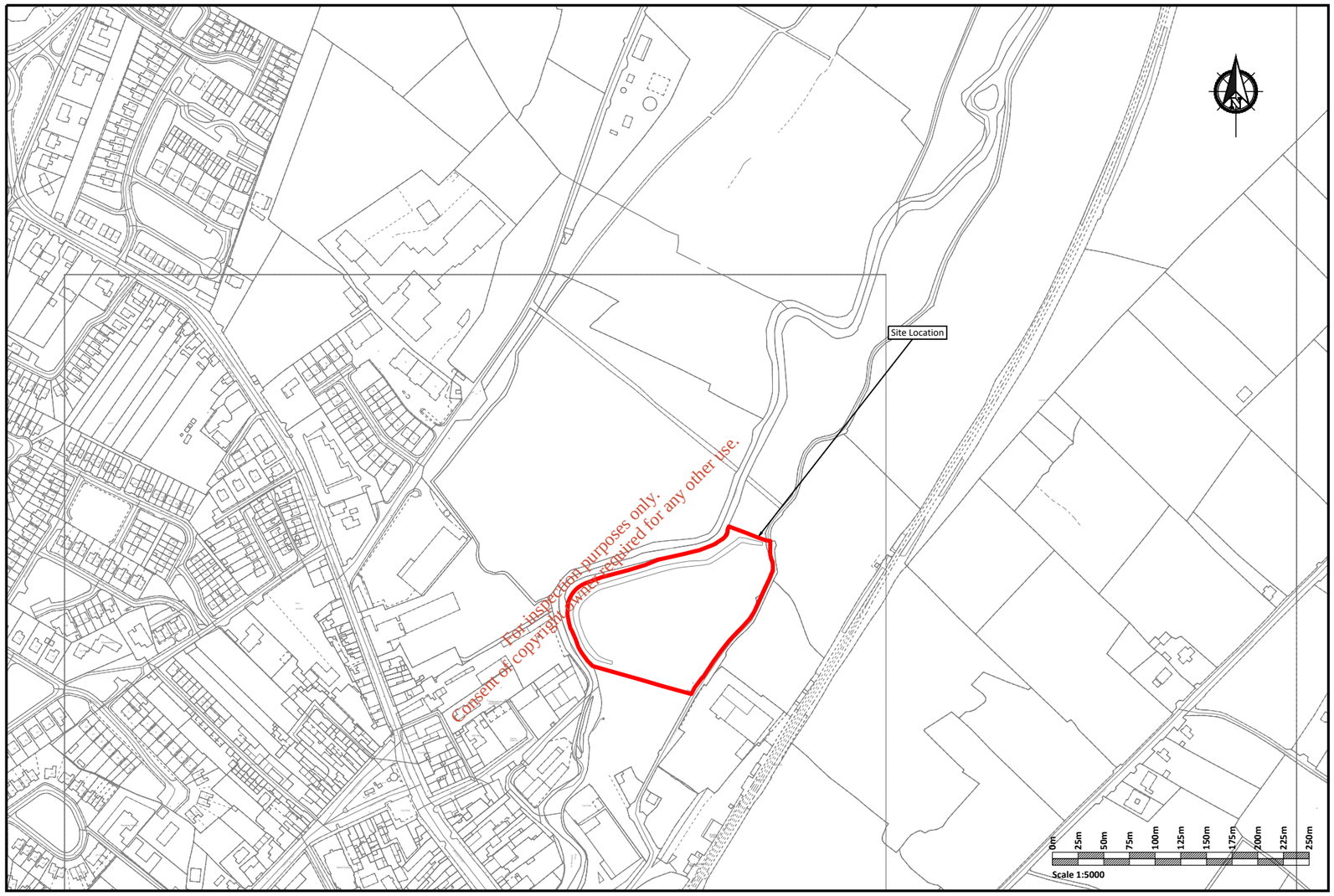
Wednesday 20 January 2021



SITE LOCATION

Scale 1:50000



SITE LOCATION

Scale 1:5000

Legend:

Site Boundary

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Rev.	Description	App By	Date
A	FOR INFORMATION	JON	20.01.21

PROJECT	ERA GALWAY HISTORIC LANDFILLS
CLIENT	GALWAY COUNTY COUNCIL
SHEET	SITE LOCATION MAP (GORT HISTORIC LANDFILL)
Date	20.01.21
Project number	P2282
Scale (@ A3)	1:5000
Drawn by	POR
Drawing Number	P2282-0100-0001
Rev	A
Checked by	AB

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Wednesday 20 January 2021

Legend:

Site Boundary

0m 5m 10m 15m 20m 25m 30m 35m 40m 45m 50m

Scale 1:1000

PLAN

Scale 1:1000

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A	FOR INFORMATION	JON	20.01.21

PROJECT: ERA GALWAY HISTORIC LANDFILLS

CLIENT: GALWAY COUNTY COUNCIL

SHEET: EXISTING SITE SURVEY (GORT HISTORIC LANDFILL)

Date: 20.01.21	Project number: P2282	Scale (@ A3): 1:1000	
Drawn by: POR	Drawing Number: P2282-0100-0002		Rev: A
Checked by: AB			

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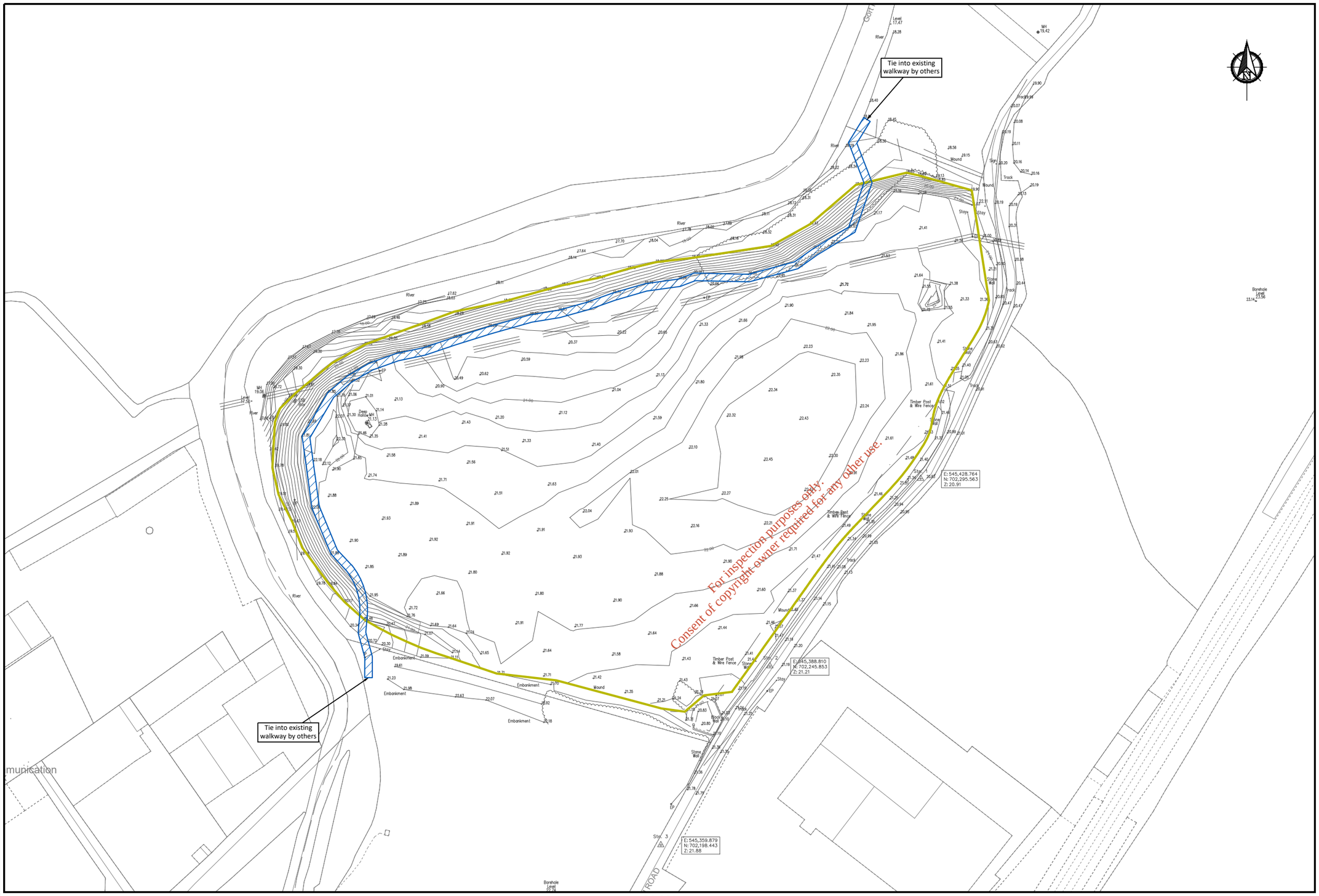
Wednesday 20 January 2021



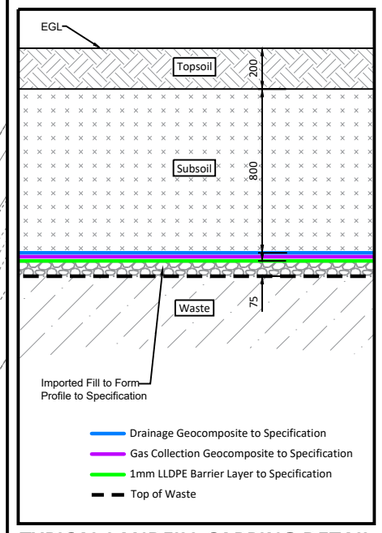
PLAN

Scale 1:1000

Legend:

- Proposed Landfill Capping Area 17,078m²
- Proposed Walkway

Note -
Proposed walkway to be accommodated in detailed design stage. Exact walkway route and foundation to be agreed at detailed design stage.



TYPICAL LANDFILL CAPPING DETAIL

Scale 1:30

0m 5m 10m 15m 20m 25m 30m 35m 40m 45m 50m

Scale 1:1000

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Rev.	Description	App By	Date
A	FOR INFORMATION	JON	20.01.21

PROJECT	ERA GALWAY HISTORIC LANDFILLS
CLIENT	GALWAY COUNTY COUNCIL
SHEET	PROPOSED LANDFILL CAPPING AREA (GORT HISTORIC LANDFILL)
Date	20.01.21
Drawn by	POR
Checked by	AB
Project number	P2282
Scale (@ A3)	1:1000
Drawing Number	P2282-0100-0003
Rev	A

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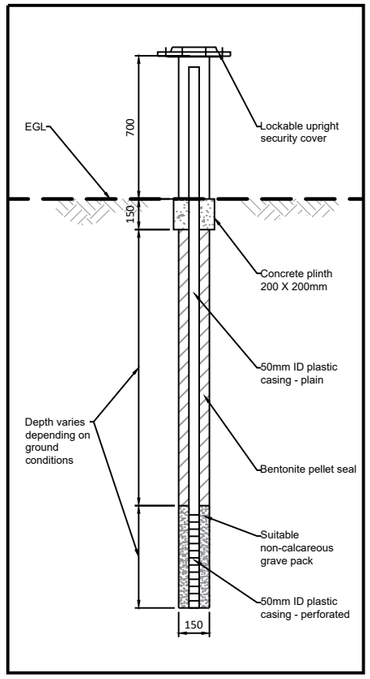
Monday 25 January 2021

PLAN

Scale 1:1500

Legend:

- LH... / GW... — Existing Monitoring Well
- LFG... — Proposed Monitoring Well
- SW... — Surface Water Monitoring Locations
- Site Boundary



MONITORING WELL - TYPICAL DETAIL

Scale 1:30

0m 8m 15m 23m 30m 38m 45m 53m 60m 68m 75m

Scale 1:1500

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PROJECT: ERA GALWAY HISTORIC LANDFILLS

CLIENT: GALWAY COUNTY COUNCIL

SHEET: EXISTING AND PROPOSED MONITORING LOCATIONS (GORT HISTORIC LANDFILL)

Date: 20.01.21
Project number: P2282
Scale (@ A3): 1:1500
Drawn by: POR
Drawing Number: P2282-0100-0004
Rev: A
Checked by: AB

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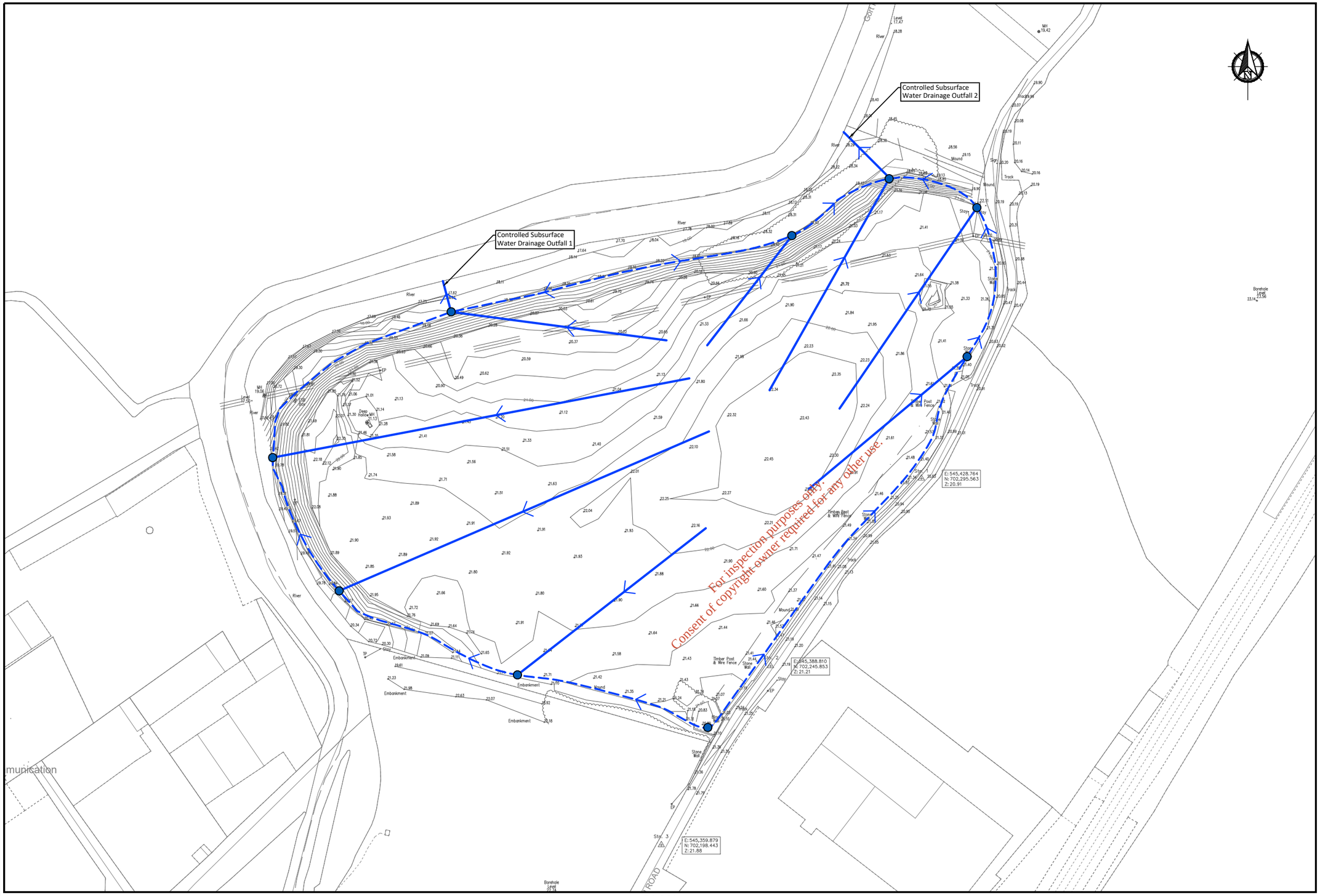
Wednesday 20 January 2021

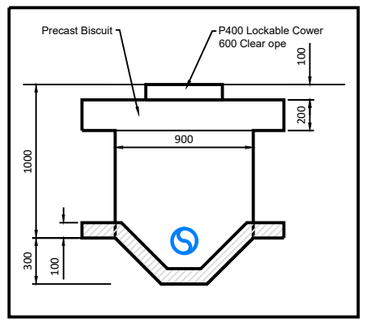


PLAN

Scale 1:1000

Legend:

- 160Ø Slotted HDPE SDR17 Subsurface Drain
- 160Ø Slotted HDPE SDR17 Subsurface Water Collection Pipe in French Drain
- Drainage Flow Direction
- PCC Chamber



TYPICAL PPC CHAMBER DETAIL

Scale 1:40

0m 5m 10m 15m 20m 25m 30m 35m 40m 45m 50m

Scale 1:1000

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A	FOR INFORMATION	JON	20.01.21

PROJECT: **ERA GALWAY HISTORIC LANDFILLS**

CLIENT: **GALWAY COUNTY COUNCIL**

SHEET: **PROPOSED SUBSURFACE & SURFACE WATER DRAINAGE (GORT HISTORIC LANDFILL)**

Date 20.01.21	Project number P2282	Scale (@ A3) 1:1000	
Drawn by POR	Drawing Number P2282-0500-0001		Rev A
Checked by AB			

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Monday 25 January 2021

PLAN

Scale 1:1000

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A	FOR INFORMATION	JON	20.01.21

PROJECT
ERA GALWAY HISTORIC LANDFILLS

CLIENT
GALWAY COUNTY COUNCIL

SHEET
PROPOSED PASSIVE GAS COLLECTION SYSTEM (GORT HISTORIC LANDFILL)

Date 20.01.21	Project number P2282	Scale (@ A3) 1:1000	
Drawn by POR	Drawing Number P2282-0700-0001		Rev A
Checked by AB			

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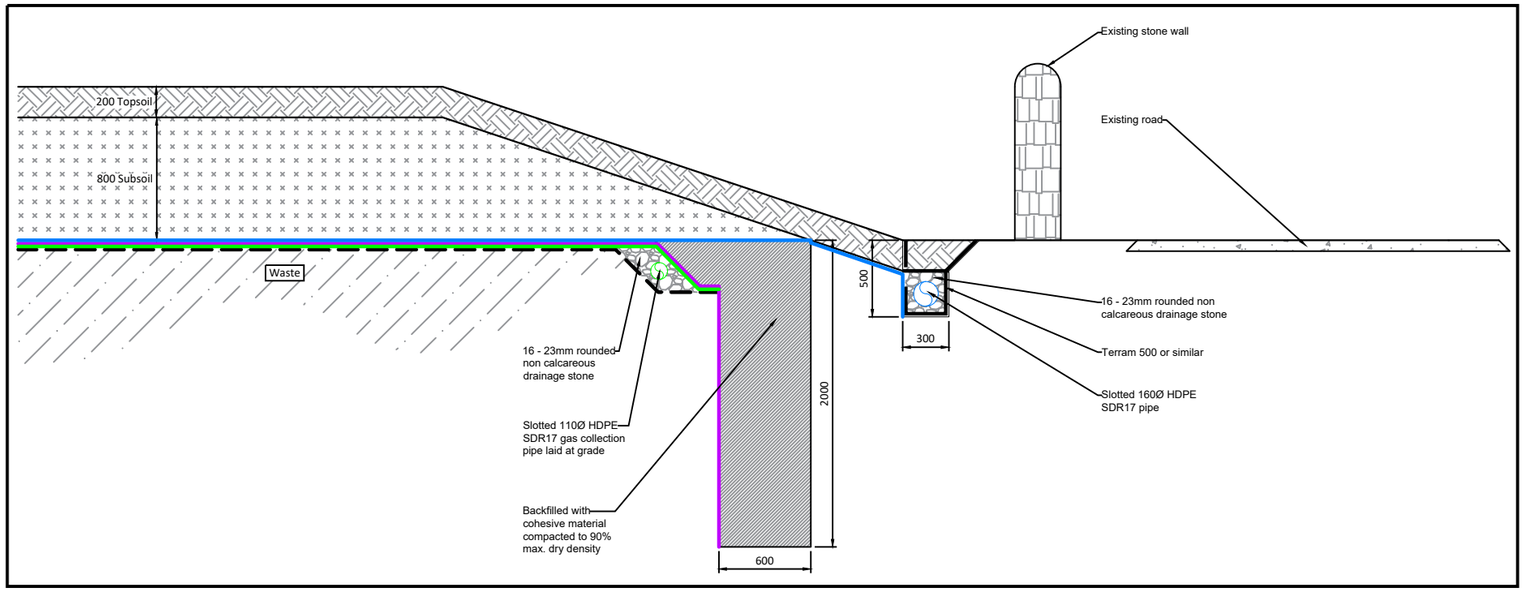
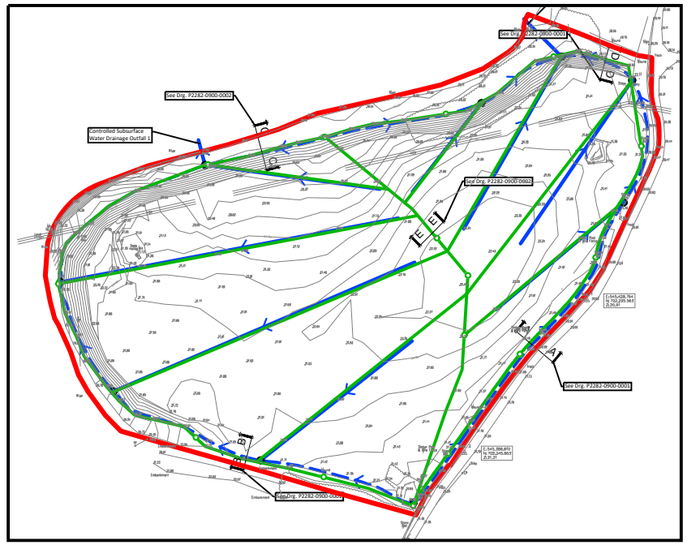
Monday 25 January 2021



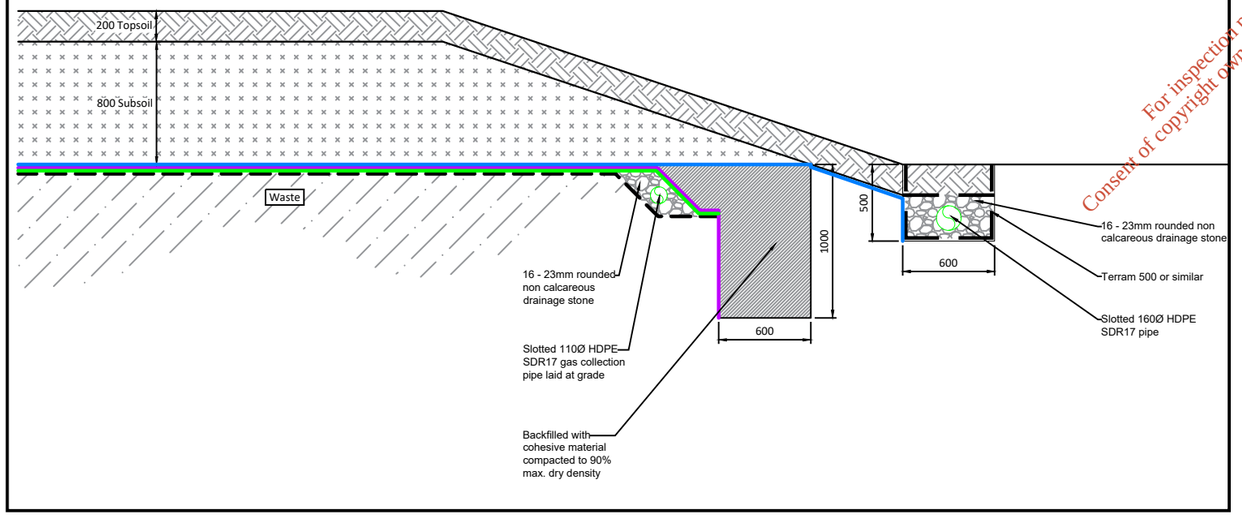
SECTION A - A

Scale 1:40



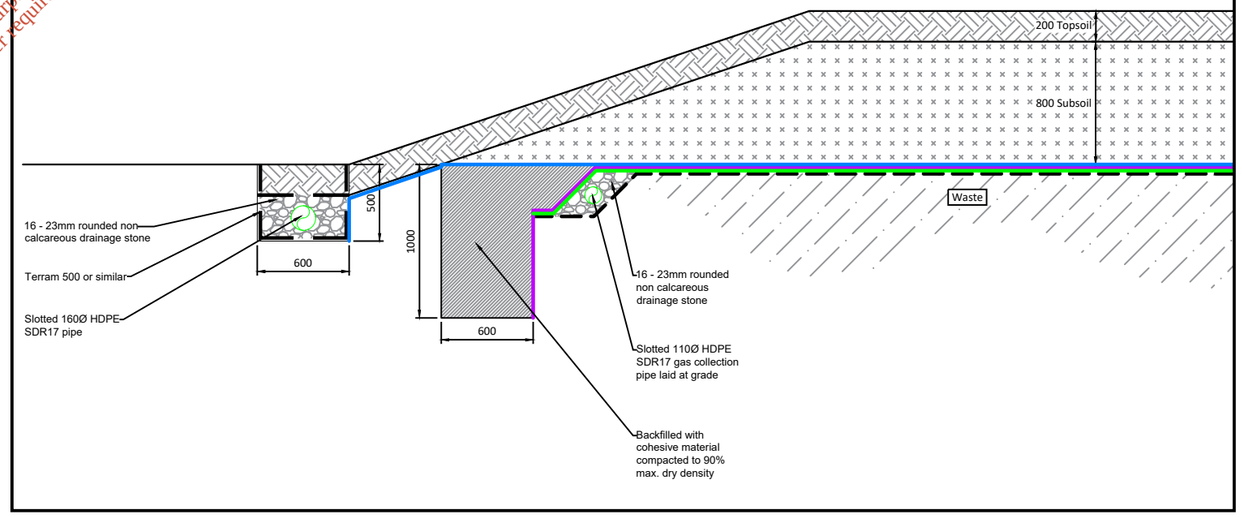
KEYPLAN

Scale 1:2000



SECTION B - B

Scale 1:40



SECTION D - D

Scale 1:40

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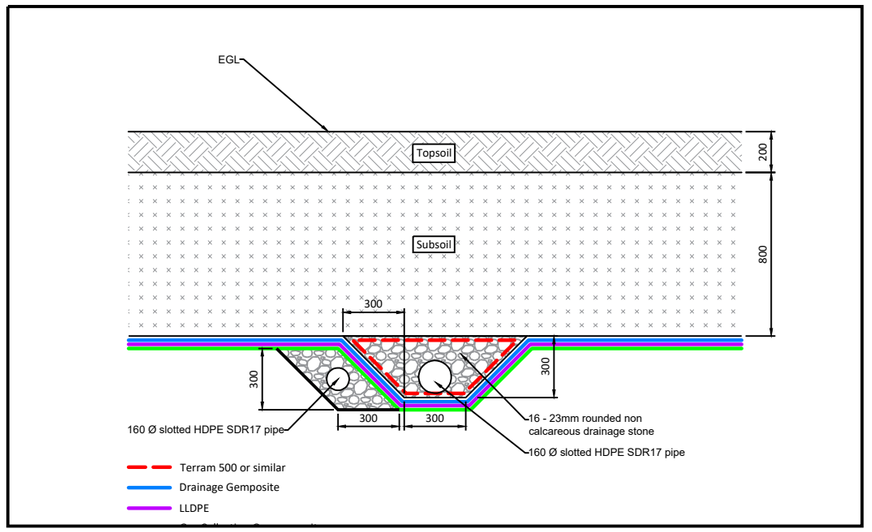
Rev.	Description	App By	Date
A	FOR INFORMATION	JON	20.01.21

PROJECT	ERA GALWAY HISTORIC LANDFILLS
CLIENT	GALWAY COUNTY COUNCIL
SHEET	SECTIONS A - A, B - B & D - D (GORT HISTORIC LANDFILL)
Date	20.01.21
Project number	P2282
Scale (@ A3)	1:40
Drawn by	POR
Checked by	AB
Drawing Number	P2282-0900-0001
Rev	A

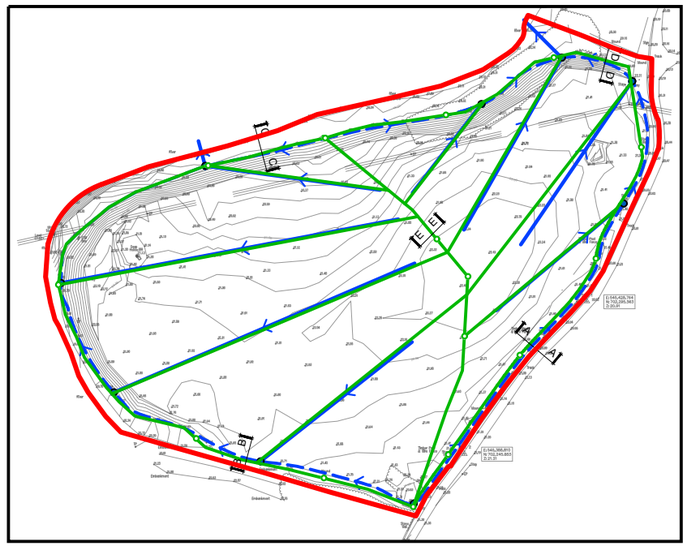
O:\ACAD\2020\P2282\P2282-0900-0001

Monday 25 January 2021



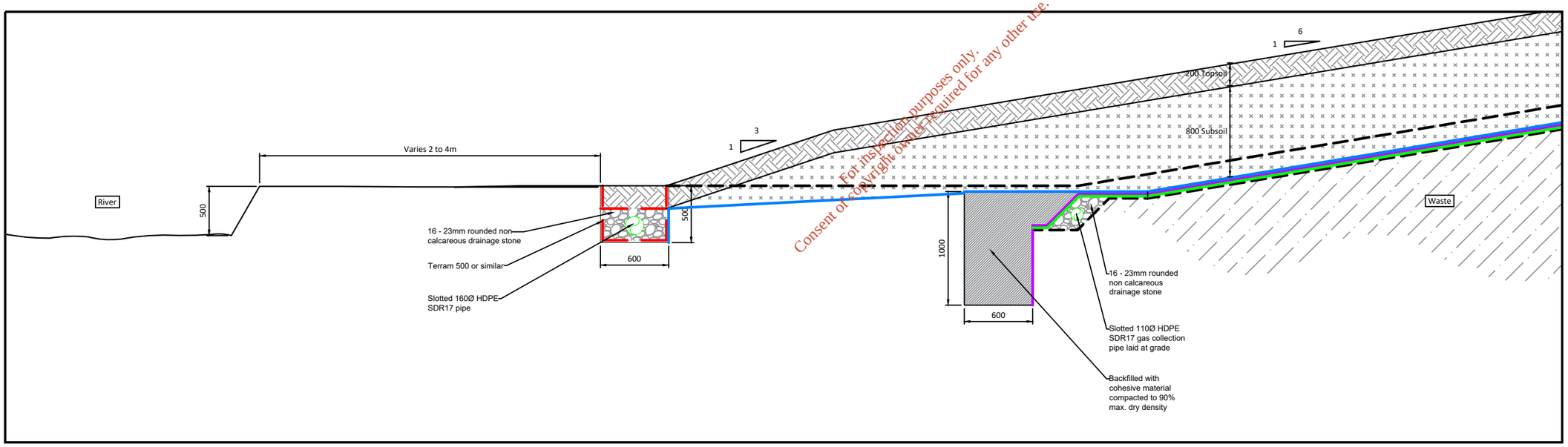
SECTION E - E

Scale 1:30



KEYPLAN

Scale 1:2000



SECTION C - C

Scale 1:40

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Rev.	Description	App By	Date
A	FOR INFORMATION	JON	20.01.21

PROJECT	ERA GALWAY HISTORIC LANDFILLS
CLIENT	GALWAY COUNTY COUNCIL
SHEET	SECTIONS C - C & E - E (GORT HISTORIC LANDFILL)
Date	20.01.21
Project number	P2282
Scale (@ A3)	1:40
Drawn by	POR
Drawing Number	P2282-0900-0002
Rev	A
Checked by	AB

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Monday 25 January 2021

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