



Technical Report

NEW LAWN CEMETERY

HYDROGEOLOGICAL ASSESSMENT



PROJECT NAME

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1.0 INTRODUCTION AND OVERVIEW

This technical note serves to provide advice in relation to the proposed New Lawn Cemetery on the Old Dublin Road, Galway City.

The note takes account of the readily available information from Geological Survey Ireland (GSI) and EPA, and relevant site reports and site investigation data, listed as follows:

- Reports
 - Blue Rock Environmental, 2022. Proposed New Lawn Cemetery, Old Dublin Road, Galway Tier 2 Hydrogeological Risk Assessment Report
 - Causeway Geotech, 2020. Old Dublin Road, Galway City – Tier 2 Hydrogeological Investigation.
- Site investigation data includes
 - 4 no. Monitoring Wells
 - 6 no. Trial pits (GCC, 2020)
 - 5 no. Trial pits (BREL, 2020)
 - Percolation tests (BRE digest type)
 - Particle size distribution data
 - Topographic data.

The work in Ireland related to investigations and site design and requirements for grave yards and cemeteries in Ireland relies on the following documentation:

- EPA, 2011. Guidance on the authorisation of discharges to groundwater.
- EPA, 2010. Code of Practice: Wastewater Treatment Systems for Single Houses.
- UK Guidance on Cemeteries and burials: prevent groundwater pollution: available here: <https://www.gov.uk/guidance/cemeteries-and-burials-prevent-groundwater-pollution>
- EA, 2004. Assessing the Groundwater Pollution Potential of Cemetery Developments.

2.0 LOCATION, PHYSICAL SETTING, SITE CHARACTERISTICS

Site Topography:

- Topographically, the site slopes from c. 21 m AOD along the eastern site boundary to 15 m AOD along the western site boundary. Groundwater flow directions appear to conform with the topography, flowing east-west across the site.
- The site is categorised as a drumlin dominated by limestone tills.

Soil and Subsoil characteristics:

- Much of the city is mapped as made ground (GSI), with pockets of soil and subsoils interspersed. At the New Lawn site, the soils are classified as **BminDW**, *i.e.*, deep well drained mineral soils (GSI). Site specific information reports that the topsoil is not uniformly present across the site, and that made ground occupies much of the 'playing area, to a depth of 0.75mbgl in places and is generally reworked till comprising '*sandy gravelly clay*' or '*silt*'. The topsoil in five of the six GCC trial pits is considered to be a 'brown earth' which has a high drainage capacity. The topsoil of the remaining trial pits likely consists of made ground.
- Based on the results of the PSD analysis the subsoil is categorised as SILT/CLAY which has a subsoil permeability of 'Low' to 'Moderate'.
- The mapped **groundwater vulnerability** is 'Moderate', in the southeastern third of the site, to 'High', in the remained two thirds of the site (GSI). Based on the depth to bedrock encountered in the boreholes and trial pits, the groundwater vulnerability may be

considered to range from 'Extreme' to 'High' to 'Moderate' as the depth to bedrock increases southwards across the site.

- Based on examination of the trial pit photographs, the soils and subsoils appear unmottled throughout. .
- The site investigation report states that the subsoils became stiffer with depth.
- The subsoils were found to range between 2m to 6m in thickness. The shallowest subsoils were identified along the eastern site boundary at BH 4. The depth to bedrock (top of the rock) includes the weathered bedrock at each of the boreholes (Table 1, Figure 2 and Figure 3).

Table 1 Depth to bedrock at the different boreholes (depicted on Figure 3)

ID	Depth to bedrock – Borehole logs
BH01	5.70m
BH02	3.70m
BH03	3.80m
BH04	2.00m

Table 2 Grain size analysis at each bluerock trial pit

Sample No	%Gravel (20mm adjusted)	%Sand (20mm adjusted)	%Fines (20mm adjusted)	%Clay (20mm adjusted)
TP01	21%	30%	49%	12%
TP02	25%	33%	42%	10%
TP03	23%	34%	43%	10%



Figure 1 Location of exploration boreholes and trial pits at New Lawn site.

Bedrock characteristics:

- The limestone bedrock is classified as **Rkd Aquifer**, which is regionally important aquifer in which flow is more diffuse and storage is higher. Estimated recharge to this aquifer is relatively high (>400 mm/yr).

Groundwater Levels

- Groundwater levels were monitored at 4 no. BHs in Nov 2020 – Feb 2021 and Dec 2021 – March 2022.
- The groundwater table maximum, minimum and total fluctuation observed at each borehole is summarised in Table 3. The water table fluctuations are higher in the boreholes on the eastern side of the site.
- Groundwater flow direction across is generally east to west.

Table 3 Summary of groundwater levels at the no. 4 boreholes

Borehole	Water table maximum (mbgl)	Water table minimum (mbgl)	Water table fluctuation (m)
BH01	2.91	6.69	3.78
BH02	2.51	6.46	3.95
BH03	2.39	8.59	6.2
BH04	2.46	8.87	6.41

Groundwater Quality:

- Overall results were recorded below their respective guideline levels with the exception of Ammoniacal Nitrogen, which exceeded the EU groundwater target value of 0.175 ug/l in BH3 (0.26 ug/l) and BH1 (0.29 ug/l) in March 2021 and June 2021, respectively.
- Manganese concentrations of 490 ug/l, in excess of the 50ug/l EPA interim guideline value, were reported in BH3, also in March 2021.
- Water quality analysis shows that there are trace concentrations for Formaldehyde which is unusual in groundwater. Given the half life for Formaldehyde, it is safe to assume that the source is from nearby. Some notable possibilities include a veterinary clinic, a dentistry and the Bon Secours hospital.

Site observations:

- A site walkover took place on 24/03/2023 in order to examine site conditions after a few consecutive wet days. The site showed no sign of water logging/saturation, which would suggest reasonable natural drainage.

3.0 DISCUSSION ON LIMITING FACTORS

Based on this desk-based review of the hydrogeological investigation done to date, the primary limiting factors appear to be the groundwater levels and the proximity of the Connacht Hotel abstraction.

The depth to bedrock:

The site information indicates that subsoil depths are adequate (>1.8 m) except at BH04, at the eastern boundary of the site. Subsoil depths appear to increase towards the southwest of the site, with nearly 6m of subsoils recorded at BH01 (see Figure 2).

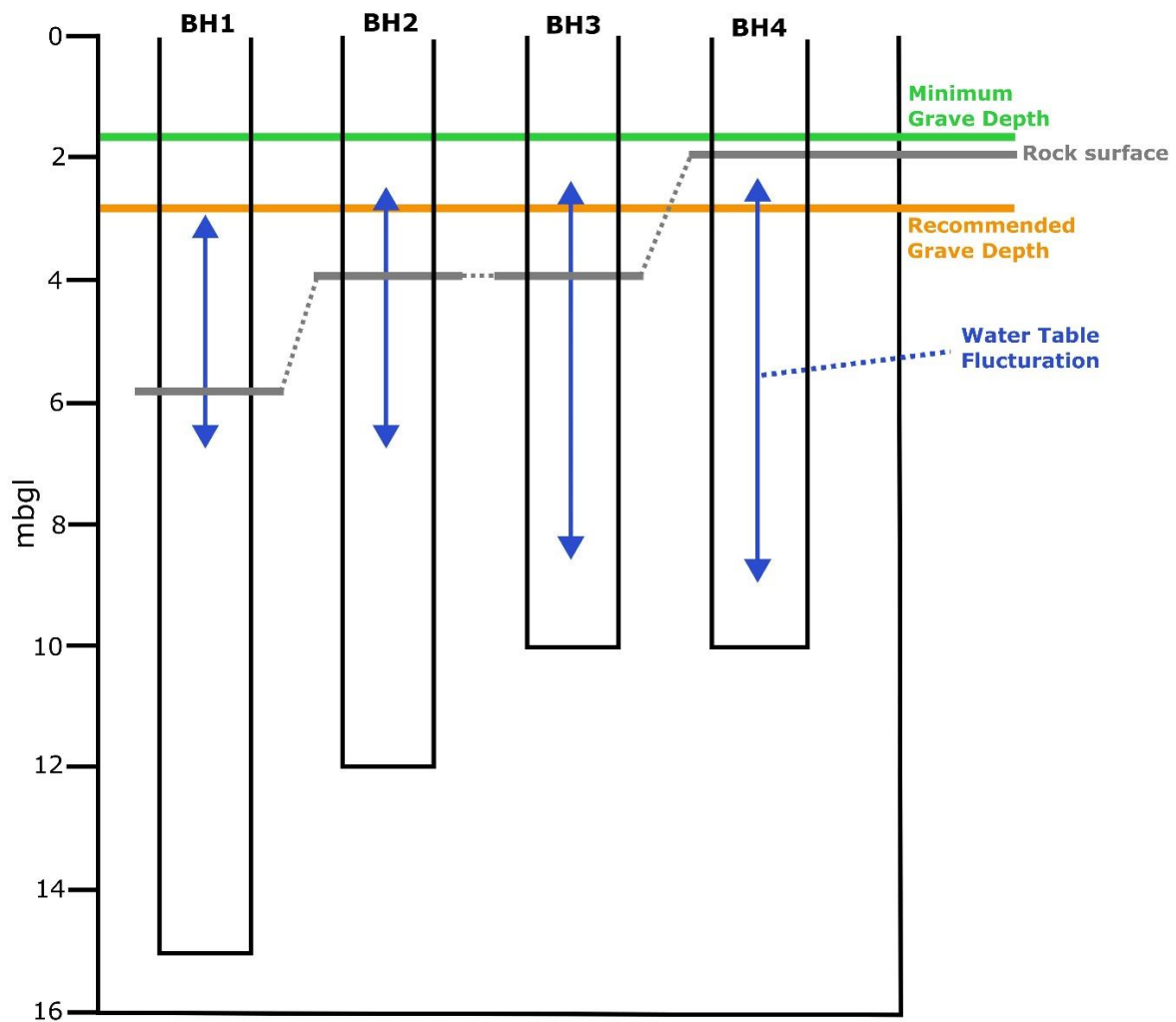


Figure 2 Schematic of the borehole depths and water table fluctuations

The depth to the water table:

Based on the recorded water levels in the four monitoring boreholes, across most of the site, the water table rebounds to above the top of the rock into the overburden (see Figure 2 and Figure 3).

The groundwater table maximum at each of the boreholes as per the logger data reported in the Bluerock report, is shown on Figure 3. Groundwater levels at each of the boreholes consistently rise into recommended unsaturated zone beneath the grave bottoms (<2.8 mbgl), although do not appear to exceed the minimum grave depth of 1.8 mbgl.



Figure 3 Watertable maximum observed in the 4 no. boreholes as per the BREL 2022 report

Nearby receptors:

The well for the neighbouring Connacht Hotel is considered as a potential receptor. The Uniform Flow Equation (Todd, 1980) was used in order to determine the downgradient extent of the abstraction. The Uniform Flow Equation is:

$$xL = Q / (2 \pi * T * I) \text{ where}$$

Q is the daily pumping rate, derived from reported usage of 100 m³/week.

T is the Transmissivity, derived from the 2014 pumping test.

I is the background non-pumping gradient.

The uniform flow equation suggests the influence of the well is from 45-55m downgradient based on the current daily usage of 129 m³/day, a transmissivity value of 10-13-m²/day and a natural groundwater gradient of 0.035. A 50m buffer around the Connacht Hotel borehole is shown in Figure 4.

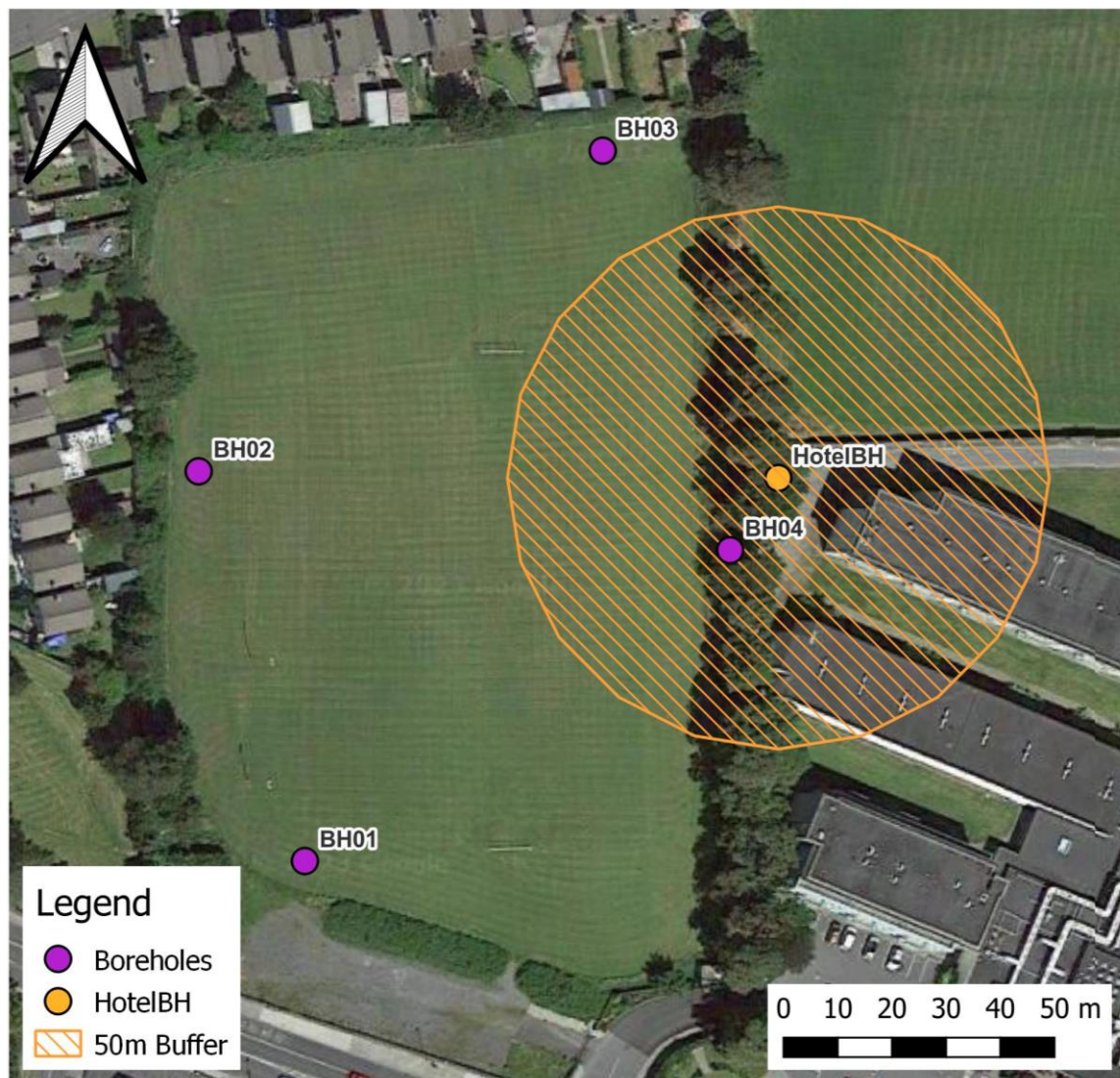


Figure 4 50 m buffer around the Connacht Hotel Borehole

Contaminant Loading:

In terms of possible contamination, an approximate number of burials per year at the New Lawn site is required.

In terms of contamination loading, there are not many pollutants in a human corpse.

When examining a human corpse in terms of their rate of degradation, it is seen that 60% of the material is readily degradable, 15% is moderate degradable, 20% is slowly degradable and 5% is non-degradable. Those portions that are non-degradable, as well as that is slowly degradable, may be considered inert (e.g. ashes forming final stable residue etc.) (EA, 2004).

The primary process governing the production, release and potential migration of pollutants from a buried corpse is microbial decay. The rate of decay depends on the extent of microbial growth and activity, which is in turn affected by availability of nutrients and moisture, climate, soil lithology and burial practice. Therefore, in Ireland's relatively wet, temperate climate, the vast majority of the mass of a human body is readily degradable, given that a well-drained, porous subsoil medium forms the receiving environment.

The die off of pathogens will occur naturally and will rapidly decrease in concentration with increasing distance from the grave.

A human corpse normally decays within 10 – 12 years. It is estimated that over half of the pollutant load leaches within the first year and halves in year on year (EA, 2004). Less than 0.1% of the original loading may remain after 10 years.

A general guide is that 20 graves per year approximates the contaminant loading from one domestic waste water treatment system (DWWTS) for a 6-person house (*per comms*, R. Meehan, 3 April 2023).

Given the current death rate in Galway of 500 per year, the current cremation rate of 20% and the fact that there are two additional cemeteries in Galway, a worst case scenario in the first year is approximately 300 burials at the New Lawn site, which approximates 15 x 6 p.e. DWWTS.

It is worth noting that there are no drinking water abstractions in close vicinity of the New Lawn site.

4.0 CONCLUSIONS

Based on the data accumulated to date via the boreholes, the trial pits and the results of the PSD analysis, the majority of the site (south, west and north quarters) are considered to be fit for use as a burial site for the following reasons:

- The PSD analysis combined with knowledge of the tills in Galway in general¹ (*per comms*, R. Meehan, 3 April 2023) suggest that the drainage is adequate;
- The depth to bedrock appears to be adequate at BH1, BH2 and BH3; and
- The watertable does not appear to rebound to a level of concern.

Based on site conditions observed at BH4, the primary area of concern is along the eastern boundary. This is due to a combination of an insufficient depth to bedrock, relatively high groundwater levels and the presence of the 50m downgradient ZOC from the Connacht Hotel. This same area may be influenced by additional runoff and shallow groundwater flow arising from surface water runoff from the grounds of the Connacht Hotel.

The current recommendation for the portion of the cemetery along the eastern boundary is to either:

- i) designate this part of the cemetery to 'green' graves. Green burials offer a quicker decomposition time and as such require a maximum subsoil depth of 1.4 m, which is currently the case: or
- ii) build up the depth of the subsoils in this area by importing additional material.

In conclusion, in the setting of Galway, the New Lawn cemetery is considered to be appropriate. The site is on a drumlin of relatively well draining subsoils, the depth to bedrock and watertable is considered adequate across most of the site. Particular care should be taken when considering graves along the eastern boundary of the site, where BH4 is located, which currently is appropriate for green graves. Imported material is required in this area should traditional graves be required.

¹ Tills in Galway are typically very fissile with sub-horizontal partings (shear structures), which can be seen in many of the trial hole photographs. This means that in wetter periods, that there will be some seepages of water through this sediment after rain. There is a lot of sub-horizontal movement of infiltrated rainwater down through the glacial sediment.

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