

Date: 20TH February 2026
Our Ref: P1629-1_0010

An Coimisiún Pleanála,
64 Marlborough Street,
Dublin 1,
D01 V902

Dear Sir/Madam,

Re: An Coimisiún Pleanála (ACP)

Hydrological and Hydrogeological Responses to ACP Further Information Request items relating to the proposed extension to the existing Burial Ground at Drumcliff Burial Ground located at the townland of Drumcliff, Ennis, Co. Clare.

ACP Planning Ref: 323742-25

Hydro-Environmental Services (HES) were requested by P. Coleman & Associates, acting on behalf of Clare County Council, to respond to the hydrological and hydrogeological Further Information Request (FIR) Items raised in An Coimisiún Pleanála's letter of 13th November 2025 relating to planning application reference 323742-25.

This FIR response letter addresses an invitation to Clare Co. Co. to respond to submissions on the observations in relation to a proposed burial ground extension at Drumcliff, Ennis, Co. Clare. This letter addressed those submissions which pertain to items relating to Hydrology and Hydrogeology. Please note that other FIR items which do not relate to hydrology and hydrogeology are being addressed by others.

1 STATEMENT OF EXPERIENCE

Hydro-Environmental Services (HES) are a specialist geological, hydrological, hydrogeological, and environmental practice that delivers a range of water and environmental management consultancy services to the private and public sectors across Ireland and Northern Ireland. HES was established in 2005, and our office is located in Dungarvan, County Waterford.

Our core areas of expertise and experience include geology, hydrology, hydrogeology, and karst hydrogeology and project construction and operational drainage design and management. We routinely complete impact assessments for hydrology and hydrogeology for a large variety of project types including public water supplies, group water schemes, quarries, wind farm and grid connection developments, and commercial and housing developments.

HES's experience also covers the key area of water quality and drainage management/controls and mitigation during the construction/operational phases of developments. HES work at EIAR/planning stage to assist with the development of the optimal site layout which involves the development of hydrological constraints maps and interaction with geotechnical and ecological specialists and with site designers. HES also provide a follow-on consultancy service (if planning is granted and the development proceeds to construction) of detailed drainage/mitigation design and construction management for drainage during the development construction stage. This practical on-site experience is invaluable as it has led to the development of improved preliminary and detailed drainage layouts and also many improvements/optimisations to standard quarry drainage mitigation measures.

All these experiences are particularly relevant to this project. This response has been prepared by Adam Keegan and Michael Gill. Adam and Michael prepared the Hydrological and Hydrogeological Assessment report for this project, and their respective qualifications, competencies, and experience are already presented in this report.

2 FURTHER INFORMATION RESPONSE

The further information request consists of 6 no. submissions, 5 of which contain items relating to hydrology/hydrogeology:

1. Mr Robert Behan
2. Mr Pat Tierney
3. Mr Dermot Queally
4. Uisce Eireann
5. Mr Michael Duffy

The submissions from Mr Behan, Mr Tierney and Mr Queally all relate to the potential effects of the proposed extension on local flooding, and as such are responded to in Response Item 1 below (refer to Section 2.1).

The submission from Uisce Eireann is addressed in Response Item 2 (refer to Section 2.2), while the submission from Mr Duffy is addressed in Response Item 3 (refer to Section 2.3)

2.1 RESPONSE ITEM 1

Response Item 1 relates to concerns by raised by 3rd parties, namely Mr Robert Behan, Mr Pat Tierney and Mr Dermot Queally that the proposed development will exacerbate existing flooding issues along the public road and impact upon them and their lands which are located close to the Drumcliff Burial Ground. They state that flooding around their respective properties was never an issue until recent times and they link this flooding to continuous work around the graveyard. They each note the inclusion of the 2 no. soakaways within the drainage design for the proposed extension, but maintain concerns that those will not suffice.

The drainage design for the proposed burial ground extension is based upon SuDS drainage principles and design, in accordance with the objectives outlined in the Clare County Development Plan 2023-2029 (CDP2.11(c)), which states:

“to ensure the implementation of Sustainable Drainage Systems (SuDS) and in particular, to ensure that all storm water generated in a new development is disposed of on-site or is attenuated and treated prior to discharge to an approved storm water system.”

The proposed drainage system incorporates the following elements:

- Surface water falling on green (grave) areas will infiltrate into green areas.
- Footpaths will be sloped toward adjacent green areas to allow for infiltration. Surface water from footpaths, which does not directly infiltrate to ground, will be collected by aco drains and directed to soakpits.
- Surface water from new roadway will generally be served by a french drain with land drain pipe the roadway. A soak pit area will be provided at the lowest point of the drainage run to accommodate any heavy flows of surface water than is not absorbed by the french drain itself.
- New gullies serving existing roadway/proposed roadway junction area are served by a soak pit.
- Main Pedestrian Access Ramp and stairs with non-porous finish to be accommodated by soak pit.

The proposed drainage system will be managed and maintained throughout the operational phase of the proposed development. The regular maintenance and cleaning of the SuDS features will ensure that adequate performance is maintained.

The design of the 2 no. soakaway pits has been informed by trial pitting and associated 5 no. soakaway tests to BRE digest 365 standard, with the soakaways being sized to accommodate runoff from the proposed extension by a competent consultant engineer (refer to Drawing 7421-200).

As such, it is considered that there is sufficient capacity within the drainage design to prevent any surface water runoff from the site and thus it is considered that the proposed development will not have a negative effect on local flooding.

2.2 RESPONSE ITEM 2

Item 2 relates to a submission by Uisce Éireann regarding 4 no. queries on the proposed development, namely:

1. *Given the sensitivity and importance of the underlying groundwater, Uisce Éireann requests that this risk is further assessed in accordance with published guidance, and that this assessment is submitted to Uisce Éireann for review prior to commencement. Whilst there is no published Irish guidance to assess the potential risk from graveyards, there is UK guidance that could be applied to the site:*
 - o *Northern Ireland – Cemeteries Department of Agriculture, Environment and Rural Affairs & AE1 19 573678 Practice Guide – Cemeteries, Burials and the Water Environment (2019).*
 - o *UK – Cemeteries and burials; groundwater risk assessments – GOV.UK; and Protecting groundwater from human burials – GOV.UK.*
2. *The documents submitted with the application assess potential impacts from contaminants associated with cemeteries noting both ammonia and nitrates. There are a number of additional potential contaminants of concern associated with graveyards that should also be considered as part of a revised assessment to be submitted to Uisce Éireann prior to commencement. This includes (but not limited to) chloride, sulphate, potassium, phosphorous and formaldehyde.*
3. *The documents submitted with the application outline and draw attention to low reported concentrations of ammonia and nitrate at Drumcliff springs, referencing data from 2003-2004, which is over 20 years ago. A more up to date review of data relating to the underlying groundwater quality should be undertaken to consider the potential risk to groundwater, and submitted to Uisce Éireann prior to commencement. The EPA monitors the Ennis groundwater body at Drumcliff springs and data from 2010-2025 is available for download.*
4. *A revised Site Investigation report providing associated photographs referenced to each of the detailed trial pit logs undertaken as part of the intrusive investigation, shall be submitted to Uisce Éireann prior to commencement.*

2.2.1 Response Item 2 (Query 1)

Prior to the first planning submission for the Drumcliff burial ground extensions, an extended period of consultation with Uisce Éireann was undertaken to determine their

requirements for hydrological/hydrogeological assessment in relation to potential effects on the underlying groundwater body (and the nearby Drumcliff Spring abstraction).

These consultations included a memo from HES (included as **Appendix I**) on the site investigations carried out, the conceptual site model of the site based on these findings (which found the site to be underlain by thick [8.5-13m] glacial deposits of boulder clay which protected the underlying aquifer) and the resulting potential risk to the Drumcliff Spring abstraction.

The summary of information provided to Uisce Éireann by HES at the time included the following:

- The geology of the proposed development site consists of boulder clays with low-moderate permeability and range in thickness between 8.5-13.5m. The intrusive site investigation works and the geophysical survey support this interpretation.
- No karst features were observed within the proposed development site during intrusive investigations, nor interpreted as underlying the site during the geophysical investigation. The Limestone bedrock underlying the site is described as fresh and unweathered.
- There are no direct hydrological connections between the site and downgradient surface water bodies, including the Poulacorey karst feature (250m north of site). Standard separation distances (50m) to surface water features are maintained by the proposed cemetery.
- Recommended separation distances to the drinking water supplies, as outlined in SEPA guidelines (refer to Footnote) are maintained (250m).
- There will be no surface water drainage discharged from the site, all surface water will be directed to the 5 no. proposed soakaways on site.
- There has been no impact on the Poulacorey swallow hole or Drumcliff spring as a result of the existing Drumcliff cemetery. Average nitrate levels at Poulacorey swallow hole and Drumcliff Spring are 1.8mg/L and 2.0 mg/L respectively.
- The low burial rate at the proposed development site (~25 annual burials) means the nutrient loading due to decomposition is low and in-line with existing nutrient inputs in the operational Drumcliff cemetery.
- The impact assessment process has concluded that there will be no significant effects on downgradient surface water bodies (including Poulacorey swallow hole) as a result of the proposed development; and,
- An impact assessment of potential groundwater effects has also been completed. Due to the underlying thickness of subsoils, which provide a substantial protective layer to the underlying aquifer and the geophysical inference of good, clean, non-karstified limestone underlying the proposed extension site, the conclusion of the assessment process is that there will be no significant effects on groundwater quality as a result of the proposed development.

Following this submission to Uisce Éireann, this memo was reviewed internally and also externally by an appointed, independent hydrogeological consultant (TOBIN) for feedback and comment on the conclusions of the HES memo. This review was formulated in the form of a memo by TOBIN, included as **Appendix II** to this response, which accepted the assessment with the following conclusions:

The investigations carried out by HES was evaluated with reference to DAERA NI (2019) Practice guide for cemeteries, burial and the water environment, and EPA (2011) Guidance on the authorisation of discharges to groundwater.

The information obtained does not appear to highlight concern with regard risk to the Drumcliff springs.

- *The site boundary for the proposed burial plots are >250 m away from the Drumcliff springs.*
- *There are no surface water features within 50 m of the site boundary and there is no risk of flooding.*
- *There are no field drains within 10 m of the site boundary.*
- *Bedrock and groundwater is indicated in the investigation reports to be greater than 1 m below the base of the burial pit.*
- *No sand or gravel subsoils were encountered within the survey area and there was no groundwater encountered within the trial pits.*
- *The interpreted thickness and the subsoil texture suggest moderate groundwater vulnerability.*

The TOBIN review did note that the trial pits were excavated to a depth of 2m, while a depth of 2.8m would have been preferable in order to definitively determine the soil profile at a depth of 1m below the proposed burial depth (1.8m). However, this was not feasible due to limited access and the inability to track a larger machine through the site. Nonetheless, the trial pit information has been correlated with the geophysical survey information to provide further information on the soil/subsoil profile, with the boulder clay layer interpreted to a depth of 9.5-13.5mbgl.

As such, the hydrogeological assessment and groundwater risk assessment contained within Section 4 of the HES Hydrological and Hydrogeological Assessment Report (2025) conforms to the methodology set out in the Northern Ireland guidelines¹ for the assessment of burial grounds on groundwater (as confirmed by Uisce Éireann's own independent consultant), as well as the UK guidance documents on groundwater risk assessments with respect to cemeteries and burials².

As noted, there is no formal Irish guidance on groundwater risk assessments for cemeteries or burials, however the Northern Ireland and UK guidance documents were reviewed and these guidance documents influenced the scope of the hydrogeological risk assessment, along with direct consultation with Uisce Eireann. The Northern Ireland guidance² was determined the most applicable, given the similar ground conditions and climate, and the following text from this document, in relation to the hydrogeological risk assessment, was used to inform the scope of the HES report.

"The risk assessment will be based upon data and knowledge gained from the desktop assessment and the intrusive site investigation. The scope of the risk assessment required will be dependent on site specific factors such as intended annual burial rate, the local vulnerability of groundwater and the scale of the site proposed."

As such, we submit to ACP that the submitted hydrological/hydrogeological assessment has followed relevant guidance documents and provided a site-specific groundwater risk assessment, based on site-specific information and a hydrogeological conceptual model of the site. This assessment was reviewed previously by Uisce Eireann and the consultants (TOBIN). We submit there is no requirement to update or amend the report, as the existing report conforms to the methodologies contained in both the Northern Ireland and UK guidance documents on the subject.

¹ Northern Ireland – Cemeteries Department of Agriculture, Environment and Rural Affairs & AEI 19 573678 Practice Guide – Cemeteries, Burials and the Water Environment (2019)

² UK – Cemeteries and burials; groundwater risk assessments – GOV.UK; and Protecting groundwater from human burials – GOV.UK

2.2.2 Response Item 2 (Query 2)

As detailed above, a period of consultation with Uisce Éireann was undertaken and the scope and methodology of the groundwater risk assessment was put forward for review by both Uisce Éireann and their appointed independent consultant.

At that time, it was accepted that the methodology and risk assessment proposed was appropriate/agreed. The site investigation data demonstrated that groundwater vulnerability at the site was low. Based on this hydrogeological conceptual model, along with the low burial rate of ~2 burials per year, there was an agreed very low risk to the Drumcliff water supply and as such further in-depth modelling of individual potential contaminants was not carried out.

At this point, almost two years after the original consultation with Uisce Éireann occurred, we are surprised by the current submission, and we conclude perhaps that the knowledge of the original consultation and feedback may have been lost through change of personnel.

As such, we revert back to our clarification on item 2.1, and that the groundwater risk assessment completed for this proposed extension to the Drumcliff burial ground, was completed in line with the methodologies agreed with Uisce Éireann following the original consultation and the existing submitted hydrological/hydrogeological assessment forms clear conclusions regarding the risks to the Drumcliff source.

2.2.3 Response Item 2 (Query 3)

The HES report (2025) lists the concentration of Nitrate as 1.8 mg/L at Poulacorey swallow hole and 2.0 mg/L at Drumcliff spring. The more recent data referred to by the applicant relates only to the Drumcliff spring location, and records a Nitrate concentration ranging between 0.1 – 1.7mg/L as N.

Similarly, the Ammonia value reported by HES (2025) ranged between 0.01- 0.04 mg/L, while the most recent data ranges between 0.01 – 0.055 mg/L.

Although the data used within the HES assessment related to previous available sampling data, the outcome of the assessment contained in Section 4.4.2 of the report remains true, with the residual effect of the proposed development being considered negative, imperceptible, indirect, medium-term, highly unlikely impact on the Poulacorey swallow hole (and associated linked Drumcliff spring abstraction), the Ennis GWB, the River Fergus and all associated downgradient potential receptors listed within this report.

2.2.4 Response Item 2 (Query 4)

Supporting photographs to address UE request are included in **Appendix III**.

2.3 RESPONSE ITEM 3 (SUBMISSION BY MR MICHAEL DUFFY)

The submission by Mr Michael Duffy details a total of 27 points, over 11 no. pages, with a majority of these points relating to hydrology/hydrogeology and the HES report of this environment either directly or indirectly. For brevity, we have responded below to the points made which are factually incorrect or misrepresent the proposed development and its environs, as well as responding to queries raised which are repeated to some extent in further points.

Point 1

"This is a disingenuous assessment in a karst environment where surface water and groundwater regularly interact"

Point 1 HES Response

The author is correct in stating that the local area is mapped as a karst environment, where interactions between surface water and groundwater do exist, such as at Poulacorey swallow hole, however the site investigation data carried out demonstrates that the proposed site is situated on the flanks of a drumlin, underlain by a thick layer of glacial boulder clay (8.5-13.5m deep), and as such is not situated on karstified bedrock but is in an area of low groundwater vulnerability. As such, we refute the idea that this assessment is disingenuous, as the assessment is based on site-specific data rather than regional scale desk-based mapping.

Point 3

"The subject site is located contiguous to SAC:002165 – Lower River Shannon SAC and connected directly by a recorded subterranean conduit."

Point 3 HES Response

The subject site is not contiguous to this SAC, it is mapped 600m from the Lower River Shannon SAC boundary. The subject site is not connected directly by a recorded subterranean conduit, all the site investigation data demonstrates that the site is underlain by 8.5-13.5m of boulder clay, with no evidence of any karst features below this clay interpreted from the geophysics survey.

There is a swallow hole located at Poulacorey, 250m north of the proposed site, and there is a mapped tracer test to the Drumcliff spring, but there is no scientific evidence from the intrusive site investigation data nor from the geophysical surveying carried out, of a karst conduit or any form of karst feature at depth beneath the proposed site.

Point 4 & Point 21

"..potential pressure is leachate from the proposed graves to the subterranean conduit which is the direct feed to the downstream Drumcliff Spring, a 30,000 m³/day potable source"

"In [HES Report] 2.4., it states an extraction of 12,000 m³/d. My information is that this is 30,000 m³/d and that figure is approximately 15 years old."

Point 4 & Point 21 HES Response

HES have worked directly with Uisce Eireann on the Drumcliff Plant water source and can confirm an average abstraction rate of 12,000 m³/day. We understand the scheme serves a population of ~30,000.

Point 7

"There is no assessment of infiltration, potentially directly to the karst conduit, feeding the potable source at Drumcliff Spring."

Point 7 Response

Section 4.4.1 of the HES report details the Operational Phase Impact assessment on potential surface water quality impacts from the proposed surface water drainage system. This section specifically lists the Poulacorey karst feature (and associated Drumcliff Spring PWS) as one of 4 no. potential receptors.

This section goes on to describe the proposed drainage system at the subject site and the drainage measures employed to ensure that there will be no likely negative effects on potential receptors. These measures include:

- Surface water falling on green (grave) areas will infiltrate into green areas.
- Footpaths will be sloped toward adjacent green areas to allow for infiltration. Surface water from footpaths, which does not directly infiltrate to ground, will be collected by aco drains and directed to soakpits.
- Surface water from new roadway will generally be served by a french drain with land drain pipe the roadway. A soak pit area will be provided at the lowest point of the drainage run to accommodate any heavy flows of surface water than is not absorbed by the french drain itself.
- New gullies serving existing roadway/proposed roadway junction area are served by a soak pit.
- Main Pedestrian Access Ramp and stairs with non-porous finish to be accommodated by soak pit.

As a result of these design measures, the residual effect on the Poulacorey karst feature and Drumcliff Spring PWS was assessed to be a negative, imperceptible, indirect, medium-term, highly unlikely effect on these receptors.

Point 8

"There is no factual basis for this perception that there is 8.8-13.5m of thick, clay rich subsoils. Gravediggers in Drumcliff regularly encounter rock".

Point 8 Response

Site investigations at the site include:

- 5 no. trial pits to a maximum depth of 1.9mbgl, conducted by GII in 2022;
- EM31 ground conductivity, 2-D resistivity and seismic refraction geophysical investigations, conducted by Minerex Geophysics Ltd. in 2022; and,
- A further 7 no. trial pits to a depth of 2.4m below final proposed level (equating to actual excavated depths of 2.9 – 5.4m below existing ground level.

There was no bedrock encountered in any of the trial pits, and the geophysics report of the site interprets bedrock (competent Limestone) between 8.5-13.5mbgl, with boulder clay deposits (as per the trial pits) overlying the Limestone. The available site-specific ground investigation data directly contradicts the unsupported claims made by Mr Duffy.

Point 24

"The Appendix 3 soakaway results are incomplete and do not provide appropriate information for the making of a decision. For example, if a site suitability assessment was submitted such as this for an on-site wastewater treatment, it would be summarily rejected. A site suitability assessment would have been a better option for this site but might not have provided the information to suit the applicant's cause. The results achieved are not consistent with the T value of 18 achieved in planning permission P20/297, which is 630m away. Neither are they consistent with what must have been achieved in order to grant permission in P03/1047 which includes an on-site wastewater treatment system located 120m from the subject site."

Point 24 Response

The appropriate and relevant guideline has been used for the hydrological/hydrogeological assessment, i.e. Northern Ireland – Cemeteries Department of Agriculture, Environment and Rural Affairs & AE1 19 573678 Practice Guide – Cemeteries, Burials and the Water Environment (2019).

There is no wastewater treatment system proposed at this site, therefore a site suitability assessment was not submitted. There is no requirement for a site suitability assessment and it would not be appropriate, nor necessary to submit such an assessment. The soakaway design instead is based on the infiltration rates generated by the 5 no. soakaway test performed on site.

It is not surprising that infiltration rates from a site 630m away differ to those recorded at the proposed site. The proposed site is situated on an area of elevated ground on the flanks of a drumlin.

Site specific data from trial pits and soakaway tests were used in the completed assessment. Where site-specific data is available the suggested use of data from remote sites is illogical.

3 RESPONSE SUMMARY

In summary and in response to An Coimisiún Pleanála's Further Information Request:

- A robust and detailed hydrological and hydrogeological assessment report for the Proposed Development was submitted with the planning application;
- This assessment was guided by direct consultation with Uisce Eireann over a two year period, along with a review of the Northern Ireland and UK guidance documents on groundwater risks to cemeteries and burials;
- The conceptual site model was based on site-specific information and included a detailed assessment of potential impacts of the Proposed Development on the local hydrological and hydrogeological environment including potential groundwater risk to the Poulacorey swallow hole and the nearby Drumcliff Public Water Supply abstraction. This assessment was reviewed and accepted by Uisce Eireann (and their specialist consultants) prior to the planning application;
- Detailed drainage design drawings have been submitted with the application, which propose to direct any potential surface water runoff to 2 no. soakaways. These soakaways have been designed based on the results of 5 no. soakaway tests carried out at the proposed site and will ensure that there is no surface water runoff from the proposed development

site and as such there will be no effects on flooding downgradient of the site; and,

- Ultimately, the proposed development is an extension to an existing burial ground at the Drumcliff burial grounds, one which has been in operation for many years with no measurable impact on the local groundwater environment. Site investigation data demonstrates that the site is situated on deep boulder clay subsoil (8.5-13.5m deep), overlying competent Limestone. As such, the site is situated in an area of low groundwater vulnerability. This low vulnerability, coupled with the low proposed burial rate (~2 burials/year), presents a very low risk to the hydrogeological environment. Mitigation measures have been proposed within the Section 4.3 and 4.4 of the HES (2025) report which will ensure there will be no significant negative effects on the groundwater environment.

4 CLOSURE

We trust that the above response meets your requirements. Please contact the undersigned if you have any questions regarding the above.

Yours sincerely,



Michael Gill PGeo
Civil Engineer and Hydrogeologist
B.A., B.A.I., M.Sc., Dip Geol, MIEI, MCIWEM

APPENDIX I: HES memo to IW 03/03/2023

Memo: Drumcliff PWS and Proposed Drumcliff Burial Ground

Proposed Development Site:	Drumcliff Burial Ground
Nearest IW Public Water Supply:	Drumcliff Springs PWS (1km southwest of proposed development site)
Memo completed by:	Hydrogeology (HES): Michael Gill & Adam Keegan

1.1. DEVELOPMENT DESCRIPTION

The proposed development comprises improvement works to St Brigids Section E and the development of an extension to the existing Burial Ground at Drumcliff, Ennis, Co Clare.

The development (Figure A) will include:

- An addition of circa 350 double plots including provision for ash plots.
- Access road improvements including lay-bys, turning circle and traffic calming measures.
- 3) Parking; 23 standard spaces, 6 Wheelchair accessible spaces.
- Footpaths.
- Drainage.
- Planting and landscaping including Columbarium and Reflectance Garden.
- Associated Site Works.

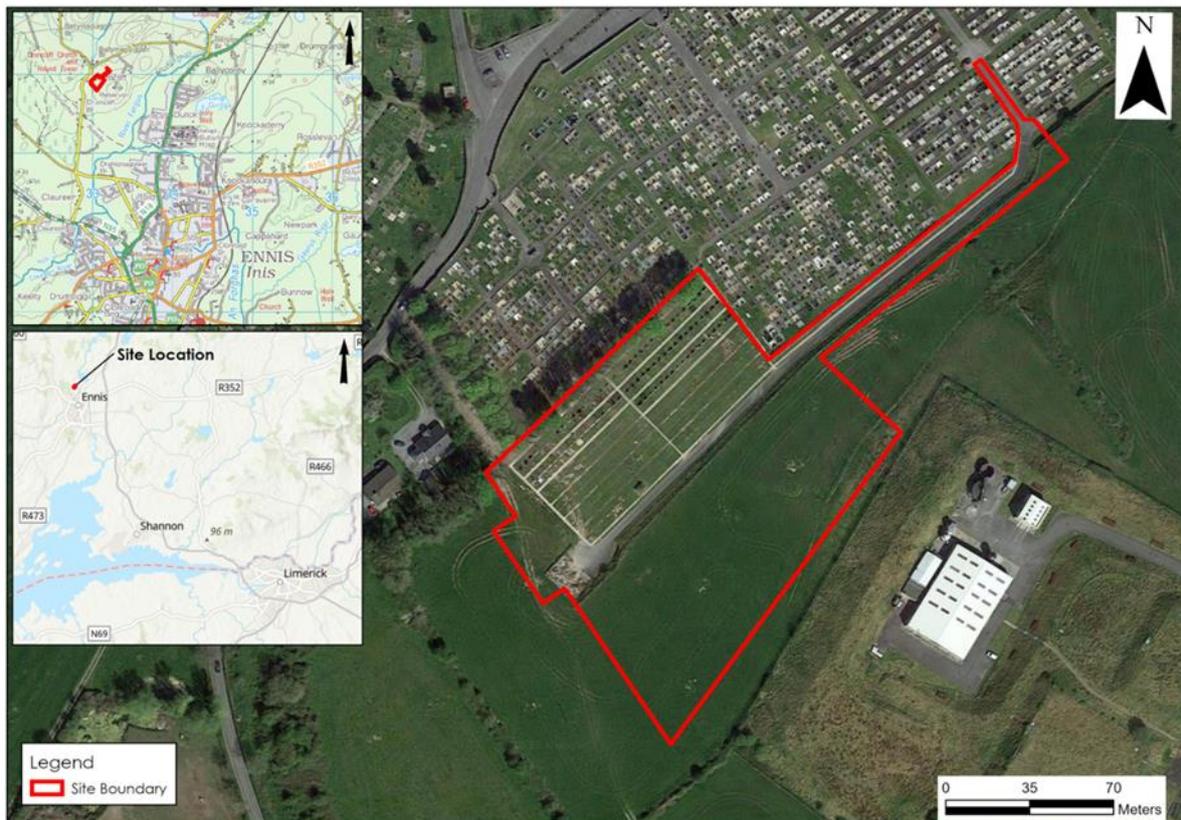


Figure A: Proposed Drumcliff Burial Ground

1.2. NEARBY WATER SUPPLIES

The nearest public water supply is the Drumcliff Springs PWS. The Source Protection Zone is defined for this public water supply and shown below in **Figure B**, along with the proposed development site location. The Drumcliff PWS WTP/Intake location is situated 1km southwest of the proposed development.



Figure B: Drumcliff Spring PWS Source Protection Zone

The nearest mapped karst feature to the site is the Poulacorey swallow hole, located ~200m north of the existing burial grounds, and ~250m north of the proposed development site. A dye tracer test was performed at Poulacorey swallow hole, with a positive detection at Drumcliff springs, indicating a direct groundwater connection from this swallow hole to the Drumcliff Spring.

1.3. PROPOSED DEVELOPMENT SITE GEOLOGY

1.3.1 Intrusive Site Investigations

Geology

A site investigation has been completed by Ground Investigations Ireland (GII) (April, 2022)¹. The scope of the work undertaken for this project included the following:

- Site walkover to observe existing ground conditions;
- Excavate 5 No. Trial Pits to a maximum depth of 1.90mbgl; and,
- Perform 5 No. Soakaways to determine a soil infiltration value to BRE digest 365.

A full copy of the site investigation report is attached as **Appendix I**. A summary of the site investigation data for the site is presented as follows:

- Topsoil was encountered in all the exploratory holes and was present to a maximum depth of 0.25m BGL;
- Made ground deposits were only encountered in IF1 between 0.15 - 0.70m and were described as grey very clayey sandy sub-rounded to rounded fine to coarse Gravel; and,
- Cohesive deposits were encountered beneath the Made Ground and were described typically as reddish brown slightly sandy gravelly CLAY with occasional cobbles or grey/brown slightly sandy gravelly CLAY. The secondary sand and gravel constituents varied across the site and with depth, with granular lenses occasionally present in the glacial till matrix. These deposits had some, occasional or frequent cobble and boulder content. The top of the cohesive deposits was logged as 0.7m in IF1 and between 0.15 – 0.25m in IF2-IF5. The cohesive deposits were logged to the base of each trial pit, which varied in depth between 1.7 – 1.9m.

Groundwater

No groundwater was noted during the investigation however the exploratory holes did not remain open for sufficiently long periods of time to establish the hydrogeological regime and groundwater levels would be expected to vary with the time of year, rainfall, nearby construction and other factors. Surface water was present in close proximity to IF3, likely due to the impermeable nature of the Topsoil in that area.

Soakaway Design

Infiltration rates of $f=6.257 \times 10^{-6}$ m/s, $f=4.685 \times 10^{-6}$ m/s, $f=4.446 \times 10^{-6}$ m/s and 2.771×10^{-6} m/s respectively were calculated for the soakaway locations SA01, SA03, SA04 and SA05. At the location of SA02 the water level dropped too slowly to allow calculation of the soil infiltration rate (indicating very low permeability).

¹ Drumcliff Burial Grounds Clare Co. Council, Ground Investigation Report dated April 202, Project No 11545-03-22, Ground Investigations Ireland

1.3.2 Geophysics

Minerex Geophysics LTD. (MGX) were commissioned to carry out a geophysical survey of the proposed development at Drumcliff, Co. Clare. The survey consisted of EM31 ground conductivity, 2D-Resistivity and seismic refraction (p-wave) investigations. The main objectives of the geophysical survey were:

- To determine the ground conditions underlying the site;
- To determine the depth to rock and the overburden thickness;
- To estimate the strength or stiffness or compaction of overburden materials and the bedrock quality;
- To determine the type of overburden and bedrock;
- To detect possible karstified zones within the bedrock or karst features; and,
- To identify potential groundwater flow paths under the site.
- The MGX report is attached as **Appendix II**.

EM31 Conductivity Survey

The EM31 ground conductivity survey was carried out over the area indicated in Map 1 (Appendix II) on lines nominally 10m apart. EM31 ground conductivity determines the bulk conductivity of the subsurface over a typical depth between 0-6mbgl.

The natural conductivity levels are very uniform across the survey area ranging from 5 to 9 mS/m. This indicates a boulder clay overburden across the survey area with little variation in composition.

The resistivities cover a range typical for materials from clay rich overburden (low resistivities) to fresh strong unweathered bedrock (high resistivities). The ranges have been taken into the consideration for the interpretation. The overburden on this site is dominated by medium resistivity values (125 - 500 Ohmm) which typically indicate a boulder clay. High resistivities at depth (>500 Ohmm) indicate a clean limestone bedrock.

Resistivity Survey

2D-Resistivity lines were surveyed with electrode spacing of 3m, up to 64 electrodes per set-up. The penetration depth of a resistivity set-up increases towards the centre where it reaches depths of over 15m. 2D-Resistivity has previously proven zones of anomalous or karstified rock with lateral extents of 5m and more.

The modelled seismic data has created the following layered ground model:

- Layer 1: has a thickness of up to 2m and seismic velocities of 200 - 300m/s. This overburden would be soil with a soft or loose stiffness or compaction.
- Layer 2: was modelled with a velocity of 1600m/s and reaches a depth between 2.5 and 5.5m. The velocity indicates overburden material with very stiff strength or compaction.
- Layer 3: velocities of 2400m/s indicate predominantly overburden with hard strength or compaction. The thickness or depth varies between 4 and 9.5 m.

- Layer 4: Strong rock is indicated by seismic velocities of 4500m/s and the top of this strong rock varied between 8.5 and 13.5m.

Geophysics Conclusion

- The geophysical surveys carried out for the Drumcliff Cemetery extension consisted of EM31 Ground Conductivity, 2D-Resistivity and seismic refraction surveying.
- At all locations there was a strong correlation between all three geophysical survey methods.
- The EM31 Ground Conductivity data shows a consistent boulder clay overburden throughout the survey area.
- The 2D-Resistivity data shows thick boulder clay across all three lines. High resistivities at depth indicate a clean limestone bedrock.
- The seismic refraction data was modelled with a total of four layers (as discussed above).
- The data is very uniform across the survey area with only small variations in the overburden composition and rock depth across the survey area.
- The thick layer of clay dominated boulder clay would cause low ground water permeability.
- Within the rock layer there is no indication of karstified limestone. The thick overlying highly consolidated glacial till will provide good protection from any underlying karstified limestone that may be present deeper than the survey depth.

The presence of 8.5-13.5m of overburden puts the site within the Low-Moderate Risk Rating for groundwater vulnerability (as outlined in Section **Error! Reference source not found., Error! Reference source not found.**). A subsoil thickness of >10m is the threshold for Low vulnerability, which is likely the average thickness across the site based on the geophysical cross sections, and the supporting data from the shallower trial pits.

1.4. IMPACT ASSESSMENT

Based on site geology and available data, we have assessed the potential impacts on the Drumcliff source during construction and operational phases of the proposed burial ground development, including:

- Impacts from drainage (during construction & operation)
- Impacts from hydrocarbons (construction)
- Impacts from cement-based products (construction)
- Impacts of burial and leaching (operation)

In each case, mitigation measures have been implemented into the proposed development design in order to avoid potential effects on downgradient hydrological receptors, including the Poulacorey Swallow hole and Drumcliff PWS.

Management of surface water runoff and subsequent treatment before release off-site will be undertaken during construction work as follows:

- lines of silt fencing will be constructed along the northern boundary of the site during construction;
- All stockpiles will be damped down or covered in a sheet of polythene, as required, which will prevent the creation of nuisance dust, and will also prevent sediment runoff in times of heavy precipitation; and,
- Restricting construction to within well marked areas, adherence to the non-carrying out of construction after or during heavy rainfall.

The following measures in relation to the management of hydrocarbons and related oils/fuels will be implemented:

- All plant and machinery will be serviced before being mobilised to site;
- No plant maintenance will be completed on site, any broken down plant will be removed from site to be fixed;
- Refuelling will be completed in a controlled manner using drip trays at all times;
- Any fuel and chemical stores including tanks and drums will be regularly inspected for leaks and signs of damage;
- Drip-trays will be used for fixed or mobile plant such as pumps and generators in order to retain oil leaks and spills;
- Only designated trained operators will be authorised to refuel plant on site;
- Procedures and contingency plans will be set up to deal with emergency accidents or spills; and,
- An emergency spill kit with oil boom, absorbers etc. will be kept on-site for use in the event of an accidental spill.

The following measures in relation to the management of cement-based products will be implemented:

- No batching of wet-cement products will occur on site. Ready-mixed supply of wet concrete products and where possible, emplacement of pre-cast elements, will take place;
- No washing out of any plant used in concrete transport or concreting operations will be allowed on-site;
- The contractor will use weather forecasting to plan dry days for pouring concrete; and,

- The pour site will be free of standing water, and plastic covers will be ready in case of a sudden rainfall event.

In terms of the proposed burial of human remains at the site, the following assessment has been made:

The existing cemetery, which has been in operation for many years, does not appear to have had any effect on local groundwater quality. The average annual nitrate levels at Poulacorey swallow hole is 1.8 mg/L and is 2.0 mg/L at Drumcliff Springs. Ammonia was measured at the Drumcliff Springs (2003-2004) and the data indicates low reported values ranging between 0.01 – 0.04 mg/L.

The thick subsoils present at the site, as part of the drumlin formation have been investigated. The soils/subsoils have been logged during site investigations, with subsoils described as reddish brown slightly sandy gravelly CLAY with occasional cobbles or grey/brown slightly sandy gravelly CLAY. Soakaway tests have demonstrated a low-moderate infiltration range of 2.7×10^{-6} to 6.25×10^{-6} m/s. The geophysical interpretation describes 3 no. subsoil layers of increasing strength/compaction to a depth of 8.5-13.5m. Good, fresh Limestone is interpreted below this, with no karst anomalies identified below the proposed extension site.

Groundwater inflows was not recorded during any of the trial pit investigations, and as such the 1m unsaturated zone beneath the base of a grave site is expected to remain throughout the year.

The ability of the proposed development site to impact on groundwater quality is limited due to the sites quaternary geology, which overlies the limestone aquifer system. This thick layer of subsoils, with low-moderate infiltration rates provides an adequate buffer to the underlying aquifer.

The surface water drainage system will provide soakaway areas for runoff from paved areas and roads to infiltrate through, bypassing any grave areas. The diversion of this surface water to the soakaway pits reduces the volume of water infiltrating through any grave areas, thus diminishing any potential effect further.

Further control measures are not considered necessary due to:

- The thickness of subsoils present at the site (8.5-13.5m), which places the site within an area of Low-Moderate groundwater vulnerability (as per Error! Reference source not found.);
- The low-moderate infiltration rate;
- The elevated nature of the extension site relative to surrounding surface water bodies;
- The lack of groundwater presence at grave base depth (~1.8m); and,
- The historical data on groundwater quality at Pouladower swallow hole, indicating good quality water, with no increased levels of Ammonia (Poulacorey swallow hole ammonia rates were lower than Drumcliff Spring).

1.5. SUMMARY

- The geology of the proposed development site consists of boulder clays with low-moderate permeability and range in thickness between 8.5-13.5m. The intrusive site investigation works and the geophysical survey support this interpretation.
- No karst features were observed within the proposed development site during intrusive investigations, nor interpreted as underlying the site during the geophysical investigation. The Limestone bedrock underlying the site is described as fresh and unweathered.
- There are no direct hydrological connections between the site and downgradient surface water bodies, including the Poulacorey karst feature (250m north of site). Standard separation distances (50m) to surface water features are maintained by the proposed cemetery.
- Recommended separation distances to the drinking water supplies, as outlined in SEPA guidelines (refer to Footnote 2) are maintained (250m).
- There will be no surface water drainage discharged from the site, all surface water will be directed to the 5 no. proposed soakaways on site.
- There has been no impact on the Poulacorey swallow hole or Drumcliff spring as a result of the existing Drumcliff cemetery. Average nitrate levels at Poulacorey swallow hole and Drumcliff Spring are 1.8mg/L and 2.0 mg/L respectively.
- The low burial rate at the proposed development site (~25 annual burials) means the nutrient loading due to decomposition is low and in-line with existing nutrient inputs in the operational Drumcliff cemetery.
- The impact assessment process has concluded that there will be no significant effects on downgradient surface water bodies (including Poulacorey swallow hole) as a result of the proposed development; and,
- An impact assessment of potential groundwater effects has also been completed. Due to the underlying thickness of subsoils, which provide a substantial protective layer to the underlying aquifer and the geophysical inference of good, clean, non-karstified limestone underlying the proposed extension site, the conclusion of the assessment process is that there will be no significant effects on groundwater quality as a result of the proposed development.

* * * * *

² SEPA – Guidance on assessing the impacts of Cemeteries on Groundwater

Appendix I – Site Investigation



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Ground Investigations Ireland

Drumcliff Burial Grounds

Clare Co. Council

Ground Investigation Report

April 2022





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DOCUMENT CONTROL SHEET

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Engineer	SDS
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Project No	11545-03-22
Document Title	Ground Investigation Report

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A	Final	T McIntyre	E Byrne	A McDonnell	Dublin	22 April 2022

Ground Investigations Ireland Ltd. present the results of the fieldworks and laboratory testing in accordance with the specification and related documents provided by or on behalf of the client. The possibility of variation in the ground and/or groundwater conditions between or below exploratory locations or due to the investigation techniques employed must be taken into account when this report and the appendices inform designs or decisions where such variation may be considered relevant. Ground and/or groundwater conditions may vary due to seasonal, man-made or other activities not apparent during the fieldworks and no responsibility can be taken for such variation. The data presented and the recommendations included in this report and associated appendices are intended for the use of the client and the client's geotechnical representative only and any duty of care to others is excluded unless approved in writing.



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APPENDICES

Appendix 1	Site Location Plan
Appendix 2	Trial Pit Records
Appendix 3	Soakaway Results



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1.0 Preamble

On the instructions of SDS Engineers, a site investigation was carried out by Ground Investigations Ireland Ltd., in April 2022 at the site of the proposed Burial ground extension in Drumcliff, Co. Clare.

2.0 Overview

2.1. Background

It is proposed to extend the current burial ground with associated plots and access roads at the proposed site. The site is currently greenfield.

2.2. Purpose and Scope

The purpose of the site investigation was to investigate subsurface conditions utilising a variety of investigative methods in accordance with the project specification. The scope of the work undertaken for this project included the following:

- Visit project site to observe existing conditions
- Carry out 5 No. Trial Pits to a maximum depth of 1.90m BGL
- Carry out 5 No. Soakaways to determine a soil infiltration value to BRE digest 365
- Report with recommendations

3.0 Subsurface Exploration

3.1. General

During the ground investigation a programme of intrusive investigation specified by the Consulting Engineer was undertaken to determine the sub surface conditions at the proposed site. Regular sampling and in-situ testing was undertaken in the exploratory holes to facilitate the geotechnical descriptions and to enable laboratory testing to be carried out on the soil samples recovered during excavation and drilling.

The procedures used in this site investigation are in accordance with Eurocode 7 Part 2: Ground Investigation and testing (ISEN 1997 – 2:2007) and B.S. 5930:2015.

3.2. Trial Pits

The trial pits were excavated using a 3T tracked excavator at the locations shown in the exploratory hole location plan in Appendix 1. The locations were checked using a CAT scan to minimise the potential for encountering services during the excavation. The trial pits were sampled, logged and photographed by a Engineering Geologist prior to backfilling with arisings. Notes were made of any services, inclusions, pit

stability, groundwater encountered and the characteristics of the strata encountered and are presented on the trial pit logs which are provided in Appendix 2 of this Report.

3.3. Soakaway Testing

The soakaway testing was carried out in selected trial pits at the locations shown in the exploratory hole location plan in Appendix 1. These pits were carefully excavated and filled with water to assess the infiltration characteristics of the proposed site. The pits were allowed to drain and the drop in water level was recorded over time as required by BRE Digest 365. The pits were logged prior to completing the soakaway test and were backfilled with arising's upon completion. The soakaway test results are provided in Appendix 3 of this Report.

3.4. Surveying

The exploratory hole locations have been recorded using a KQ GEO Technologies KQ-M8 System which records the coordinates and elevation of the locations to ITM as required by the project specification. The coordinates and elevations are provided on the exploratory hole logs in the appendices of this Report.

4.0 Ground Conditions

4.1. General

The ground conditions encountered during the investigation are summarised below with reference to insitu and laboratory test results. The full details of the strata encountered during the ground investigation are provided in the exploratory hole logs included in the appendices of this report.

The sequence of strata encountered were consistent across the site and generally comprised;

- Topsoil
- Made Ground
- Cohesive Deposits

TOPSOIL: Topsoil was encountered in all the exploratory holes and was present to a maximum depth of 0.25m BGL.

MADE GROUND: Made ground deposits were encountered in IF1 to a depth of 0.70m and were described as *grey very clayey sandy sub-rounded to rounded fine to coarse Gravel*. Occasional or frequent cobble and boulder content is present where noted on the exploratory hole logs.

COHESIVE DEPOSITS: Cohesive deposits were encountered beneath the Made Ground and were described typically as *reddish brown slightly sandy gravelly CLAY with occasional cobbles* or *grey/brown slightly sandy gravelly CLAY*. The secondary sand and gravel constituents varied across the site and with depth, with granular lenses occasionally present in the glacial till matrix. These deposits had some, occasional or frequent cobble and boulder content where noted on the exploratory hole logs.

4.2. Groundwater

No groundwater was noted during the investigation however we would point out that these exploratory holes did not remain open for sufficiently long periods of time to establish the hydrogeological regime and groundwater levels would be expected to vary with the time of year, rainfall, nearby construction and other factors. Surface water was present in close proximity to IF3, however this likely due to the impermeable nature of the Topsoil in that area.

5.0 Recommendations & Conclusions

5.1. General

The recommendations given and opinions expressed in this report are based on the findings as detailed in the exploratory hole records. Where an opinion is expressed on the material between exploratory hole locations, this is for guidance only and no liability can be accepted for its accuracy. No responsibility can be accepted for conditions which have not been revealed by the exploratory holes. Limited information has been provided at the ground investigation stage and any designs based on the recommendations or conclusions should be completed in accordance with the current design codes, taking into account the variation and the specific details contained within the exploratory hole logs.

5.2. Excavations

Short term temporary excavations in the cohesive deposits will remain stable for a limited time only and will require to be appropriately battered or the sides supported if the excavation is below 1.25m BGL or is required to permit man entry.

Excavations in the soft Cohesive Deposits will require to be appropriately battered or the sides supported due to the low strength of these deposits.

The groundwater and stability noted on the trial pit logs should be consulted when determining the most appropriate construction methods for excavations.

5.3. Soakaway Design

Infiltration rates of $f=6.257 \times 10^{-6}$ m/s, $f=4.685 \times 10^{-6}$ m/s, $f=4.446 \times 10^{-6}$ m/s and 2.771×10^{-6} m/s respectively were calculated for the soakaway locations SA01, SA03, SA04 and SA05. At the location of SA02 the water level dropped too slowly to allow calculation of 'f' the soil infiltration rate.

APPENDIX 1 - Site Location Plan

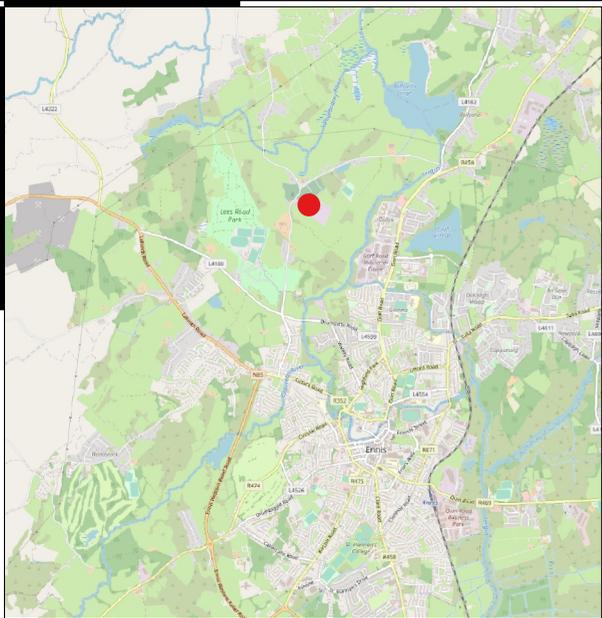


532800E

532950E

533100E

680100N



680100N

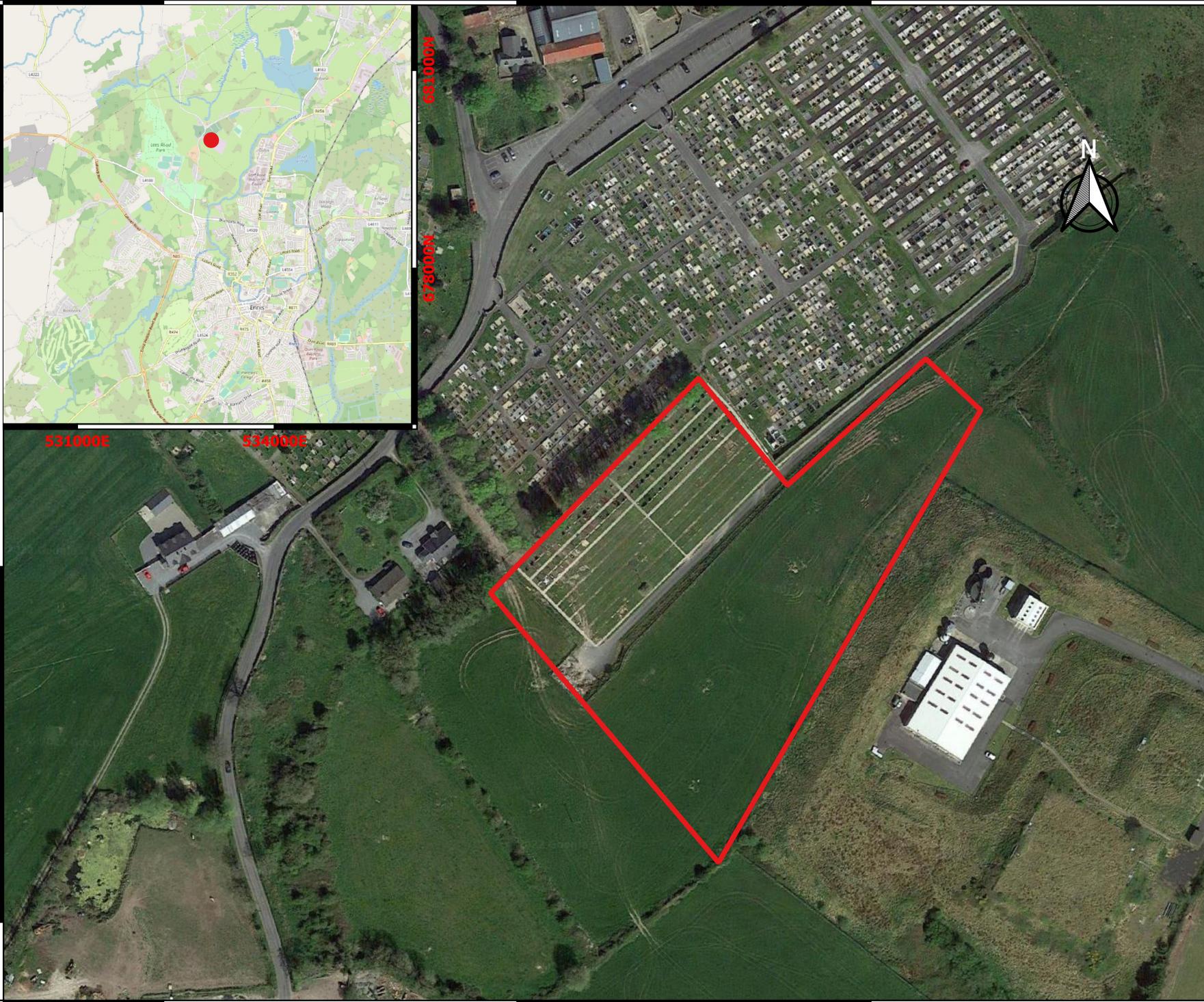
678000N

531000E

534000E

679950N

679800N



Legend

-  Indicative Site Boundary
-  Site Location

Client:



Project Code:
11545-03-22

Project Title:
Burial Grounds, Drumcliff

Drawing Title:
Figure 1 - Site Location



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0 15 30 45 60 75 m

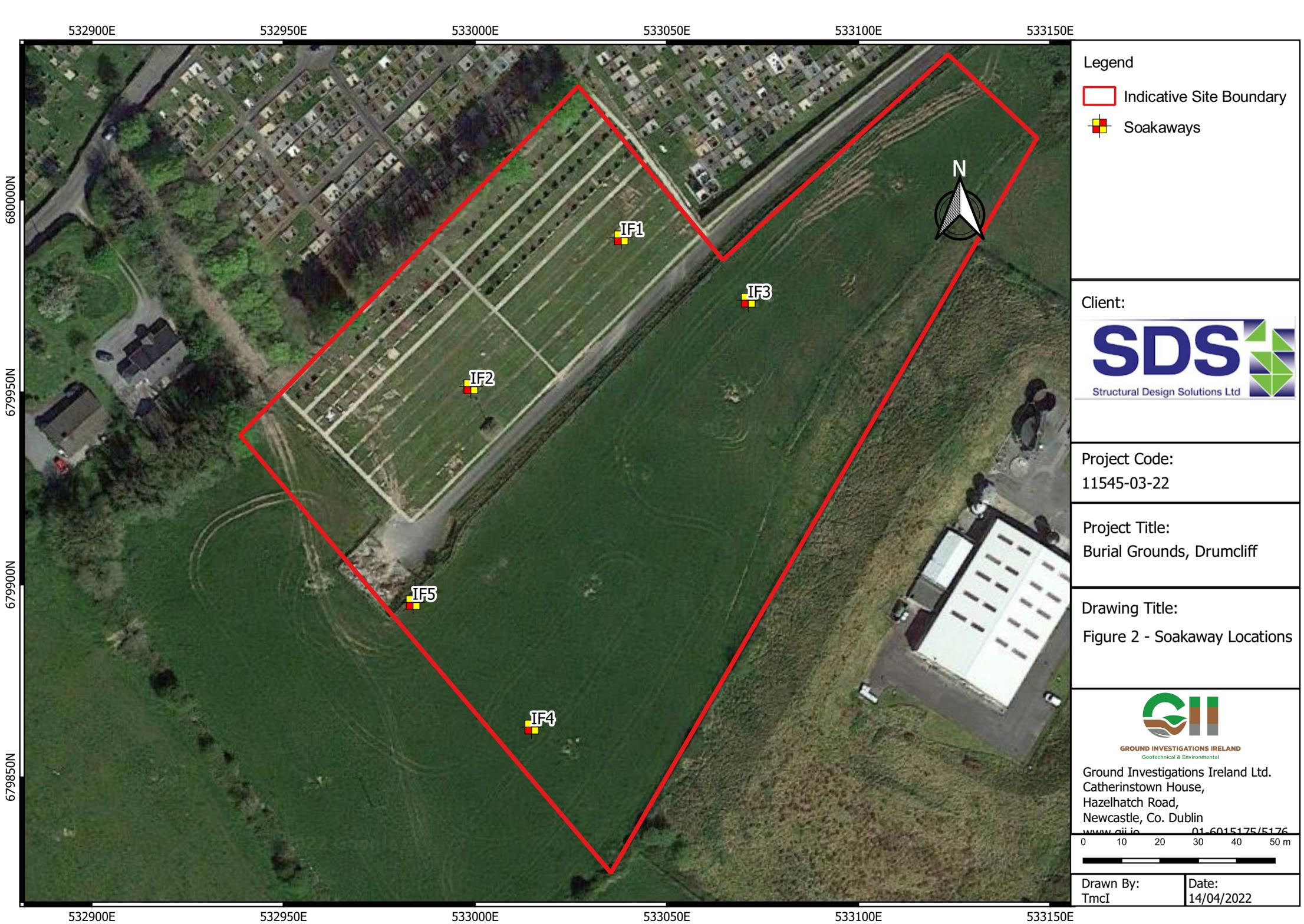
Drawn By:
BS

Date:
11/06/2020

532800E

532950E

533100E



Legend

- Indicative Site Boundary
- Soakaways

Client:



Structural Design Solutions Ltd

Project Code:
11545-03-22

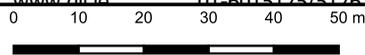
Project Title:
Burial Grounds, Drumcliff

Drawing Title:
Figure 2 - Soakaway Locations



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Drawn By: TmCI
Date: 14/04/2022

APPENDIX 2 – Trial Pit Records





Machine : 6T Excavator Method : Trial Pit		Dimensions 1.60 x 0.40 x 1.90	Ground Level (mOD) 19.43	Client SDS	Job Number 11545-03-22
		Location 533038 E 679989.8 N	Dates 08/04/2022	Engineer	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				19.28	(0.15) 0.15	Brown slightly sandy slightly gravelly TOPSOIL with grass rootlets.		
					(0.55)	MADE GROUND: Grey very clayey sandy sub-rounded to rounded fine to coarse Gravel.		
				18.73	0.70	Soft brown/grey slightly sandy slightly gravelly CLAY.		
					(0.80)			
				17.93	1.50	Firm reddish brown slightly sandy gravelly CLAY with some cobbles.		
					(0.40)			
				17.53	1.90	Complete at 1.90m		

Plan	Remarks No Groundwater encountered. Trial pit stable. Soakaway test completed in Trial Pit. Trial pit backfilled on completion.					
	<table border="1"> <tr> <td>Scale (approx)</td> <td>Logged By</td> <td>Figure No.</td> </tr> <tr> <td>1:25</td> <td>Tmcl</td> <td>11545-03-22.IF1</td> </tr> </table>	Scale (approx)	Logged By	Figure No.	1:25	Tmcl
Scale (approx)	Logged By	Figure No.				
1:25	Tmcl	11545-03-22.IF1				



Machine : 6T Excavator Method : Trial Pit		Dimensions	Ground Level (mOD) 20.80	Client SDS	Job Number 11545-03-22
		Location 532998.8 E 679951.1 N	Dates 08/04/2022	Engineer	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				20.65	(0.15) 0.15	Brown slightly sandy slightly gravelly TOPSOIL with grass rootlets.		
					(1.55)	Stiff reddish brown slightly sandy gravelly CLAY with many rounded cobbles.		
				19.10	1.70	Complete at 1.70m		

Plan	Remarks No Groundwater encountered. Trial pit stable. Soakaway test completed in Trial Pit. Trial pit backfilled on completion.					
	<table border="1"> <tr> <td>Scale (approx)</td> <td>Logged By</td> <td>Figure No.</td> </tr> <tr> <td>1:25</td> <td>Tmcl</td> <td>11545-03-22.IF2</td> </tr> </table>	Scale (approx)	Logged By	Figure No.	1:25	Tmcl
Scale (approx)	Logged By	Figure No.				
1:25	Tmcl	11545-03-22.IF2				



Machine : 6T Excavator Method : Trial Pit		Dimensions 2.30 x 0.35 x 1.90	Ground Level (mOD) 22.76	Client SDS	Job Number 11545-03-22
		Location 533071.1 E 679973.6 N	Dates 08/04/2022	Engineer	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				22.56	0.20	Brown slightly sandy slightly gravelly TOPSOIL with grass rootlets.		
					(1.70)	Soft reddish brown sandy slightly gravelly CLAY with occasional cobbles.		
				20.86	1.90	Complete at 1.90m		

Plan	Remarks No Groundwater encountered. Trial pit stable. Soakaway test completed in Trial Pit. Trial pit backfilled on completion.		
	Scale (approx) 1:25	Logged By Tmcl	Figure No. 11545-03-22.IF3



Machine : 6T Excavator Method : Trial Pit	Dimensions 1.90 x 0.35 x 1.80	Ground Level (mOD) 26.71	Client SDS	Job Number 11545-03-22
	Location 533014.6 E 679862.7 N	Dates 08/04/2022	Engineer	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				26.46	0.25	Brown slightly sandy slightly gravelly TOPSOIL with grass rootlets.		
					(1.55)	Soft reddish brown slightly sandy gravelly CLAY with occasional cobbles.		
				24.91	1.80	Complete at 1.80m		

Plan	Remarks No Groundwater encountered. Trial pit stable. Soakaway test completed in Trial Pit. Trial pit backfilled on completion.					
	<table border="1"> <tr> <td>Scale (approx)</td> <td>Logged By</td> <td>Figure No.</td> </tr> <tr> <td>1:25</td> <td>Tmcl</td> <td>11545-03-22.IF4</td> </tr> </table>	Scale (approx)	Logged By	Figure No.	1:25	Tmcl
Scale (approx)	Logged By	Figure No.				
1:25	Tmcl	11545-03-22.IF4				



Machine : 6T Excavator Method : Trial Pit		Dimensions 1.90 x 0.35 x 1.80	Ground Level (mOD) 22.46	Client SDS	Job Number 11545-03-22
		Location 532983.7 E 679895.1 N	Dates 08/04/2022	Engineer	Sheet 1/1

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
				22.31	(0.15) 0.15	Brown slightly sandy slightly gravelly TOPSOIL with grass rootlets.		
					(1.65)	Soft reddish brown slightly sandy gravelly CLAY with some cobbles.		
				20.66	1.80	Complete at 1.80m		

Plan	Remarks No Groundwater encountered. Trial pit stable. Soakaway test completed in Trial Pit. Trial pit backfilled on completion.		
	Scale (approx) 1:25	Logged By Tmcl	Figure No. 11545-03-22.IF5

APPENDIX 3 – Soakaway Results





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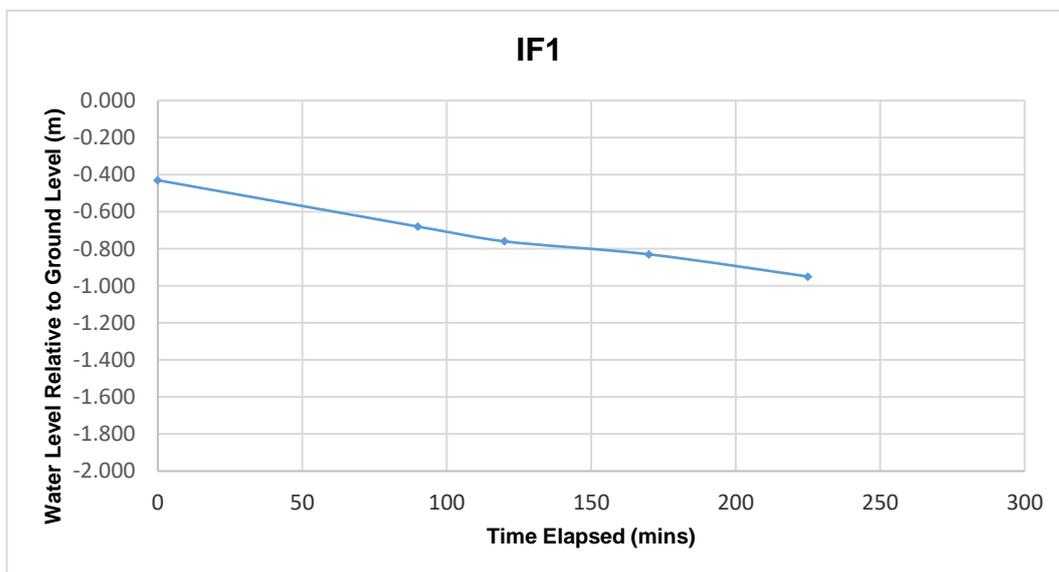
IF1

Soakaway Test to BRE Digest 365

Trial Pit Dimensions: 1.60m x 0.40m x 1.80m (L x W x D)

Date	Time	Water level (m bgl)
13/04/2022	0	-0.430
13/04/2022	90	-0.680
13/04/2022	120	-0.760
13/04/2022	170	-0.830
13/04/2022	225	-0.950

Start depth 0.43	Depth of Pit 1.900	Diff 1.470	75% full 0.7975	25%full 1.5325
Length of pit (m)	Width of pit (m)		75-25Ht (m)	Vp75-25 (m3)
1.600	0.400		0.735	0.47
Tp75-25 (from graph) (s)	21000		50% Eff Depth	ap50 (m2)
			0.735	3.58
f =	6.257E-06	m/s		





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IF2

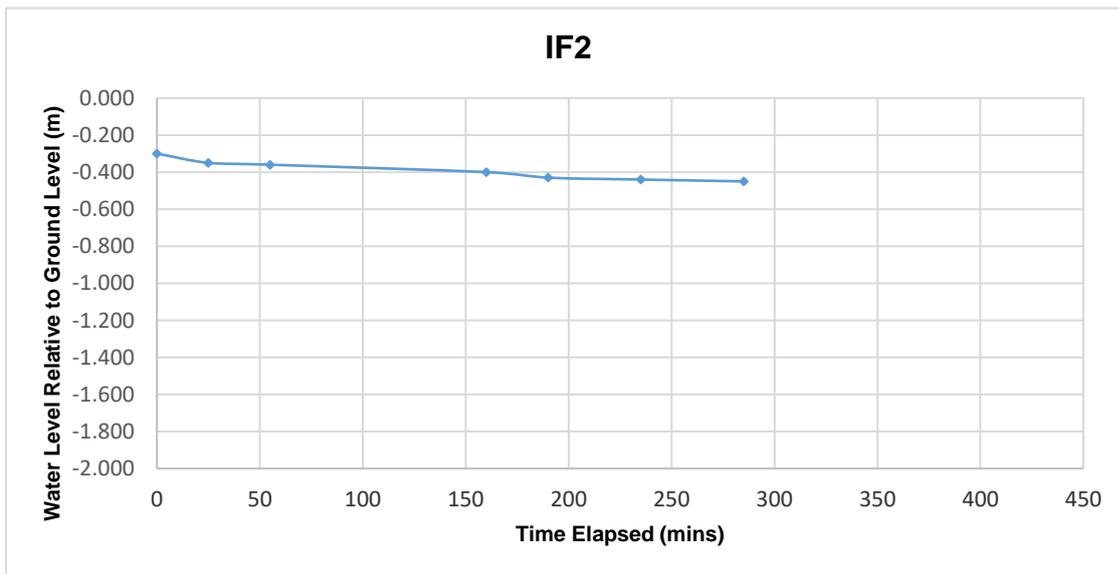
Soakaway Test to BRE Digest 365

Trial Pit Dimensions: 1.9m x 0.35m x 2.0m (L x W x D)

Date	Time	Water level (m bgl)
13/04/2022	0	-0.300
13/04/2022	25	-0.350
13/04/2022	55	-0.360
13/04/2022	160	-0.400
13/04/2022	190	-0.430
13/04/2022	235	-0.440
13/04/2022	285	-0.450

***Soakaway failed - Pit backfilled**

Start depth	Depth of Pit	Diff	75% full	25%full
0.30	2.000	1.700	0.725	1.575





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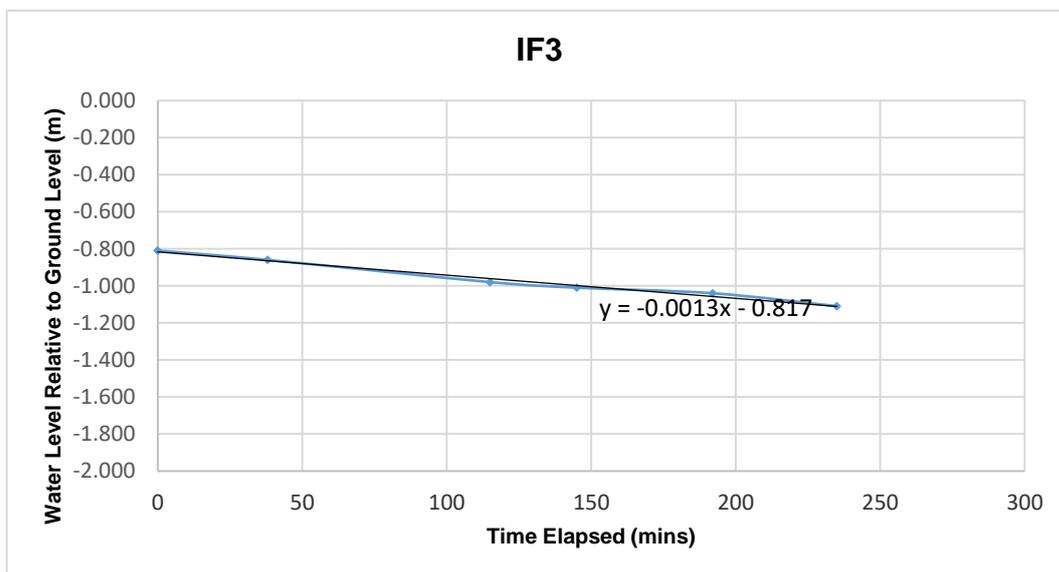
IF3

Soakaway Test to BRE Digest 365

Trial Pit Dimensions: 1.90m x 0.350m x 1.90m (L x W x D)

Date	Time	Water level (m bgl)
13/04/2022	0	-0.810
13/04/2022	38	-0.860
13/04/2022	115	-0.980
13/04/2022	145	-1.010
13/04/2022	192	-1.040
13/04/2022	235	-1.110

Start depth 0.81	Depth of Pit 1.900	Diff 1.090	75% full 1.0825	25%full 1.6275
Length of pit (m)	Width of pit (m)		75-25Ht (m)	Vp75-25 (m3)
2.300	0.350		0.545	0.44
Tp75-25 (from graph) (s)	25500		50% Eff Depth 0.545	ap50 (m2) 3.6935
f =	4.658E-06	m/s		





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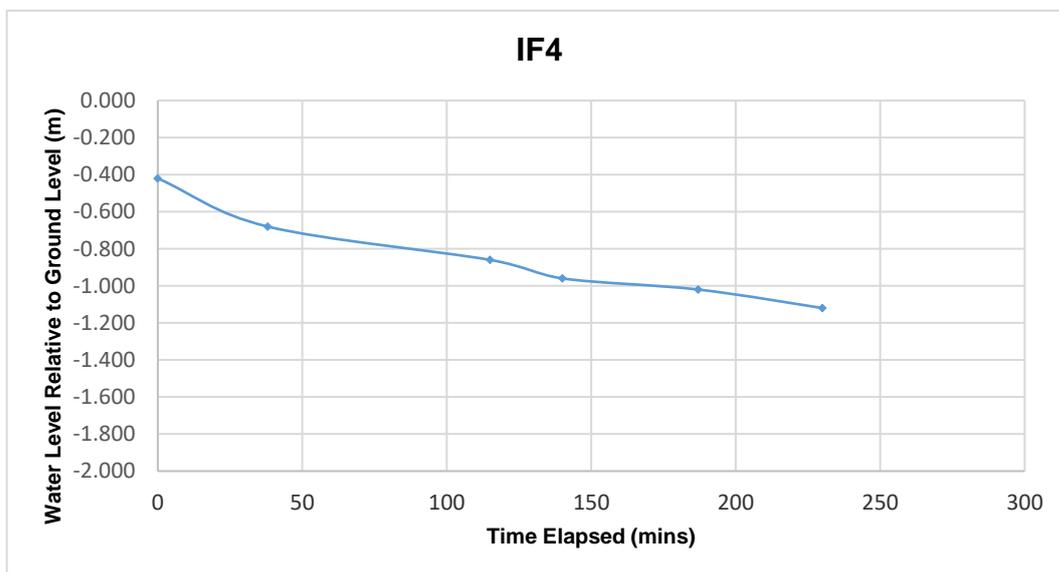
IF4

Soakaway Test to BRE Digest 365

Trial Pit Dimensions: 1.90m x 0.350m x 1.80m (L x W x D)

Date	Time	Water level (m bgl)
13/04/2022	0	-0.420
13/04/2022	38	-0.680
13/04/2022	115	-0.860
13/04/2022	140	-0.960
13/04/2022	187	-1.020
13/04/2022	230	-1.120

Start depth 0.42	Depth of Pit 1.800	Diff 1.380	75% full 0.765	25%full 1.455
Length of pit (m)	Width of pit (m)		75-25Ht (m)	Vp75-25 (m3)
2.300	0.350		0.690	0.56
Tp75-25 (from graph) (s)	28000		50% Eff Depth 0.690	ap50 (m2) 4.462
f =	4.446E-06	m/s		





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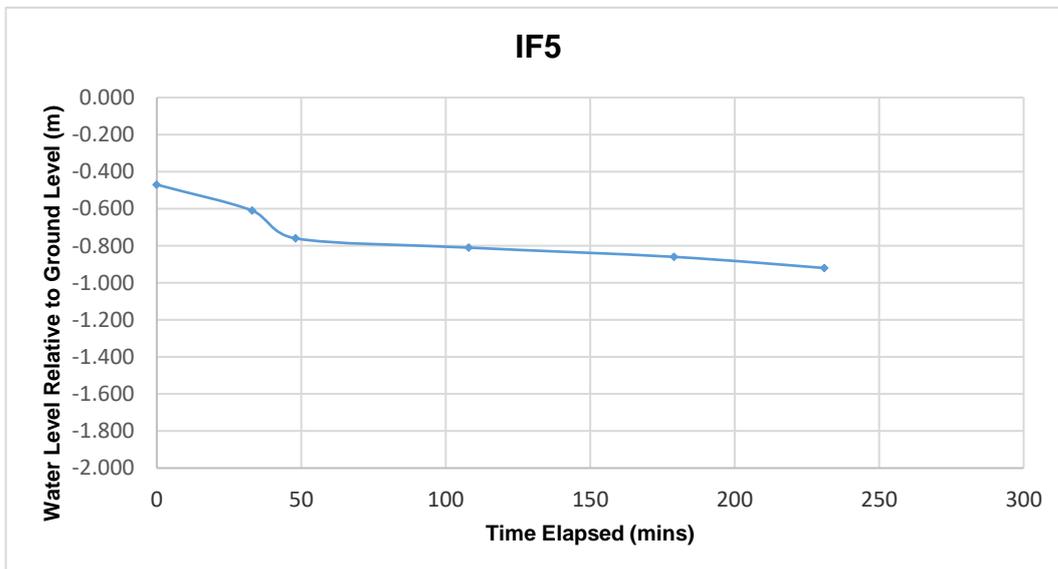
IF5

Soakaway Test to BRE Digest 365

Trial Pit Dimensions: 1.90m x 0.350m x 1.80m (L x W x D)

Date	Time	Water level (m bgl)
13/04/2022	0	-0.470
13/04/2022	33	-0.610
13/04/2022	48	-0.760
13/04/2022	108	-0.810
13/04/2022	179	-0.860
13/04/2022	231	-0.920

Start depth 0.47	Depth of Pit 1.800	Diff 1.330	75% full 0.8025	25%full 1.4675
Length of pit (m)	Width of pit (m)		75-25Ht (m)	Vp75-25 (m3)
2.200	0.350		0.665	0.51
Tp75-25 (from graph) (s)	44400		50% Eff Depth 0.665	ap50 (m2) 4.1615
f =	2.771E-06	m/s		



Appendix II – Geophysical Survey

Drumcliffe Cemetery
Ennis, Co. Clare

Geophysical Survey

Report Status: Draft

MGX Project Number: 6667

MGX File Ref: 6667d-005.doc

21st December 2022

Confidential Report To:

Hydro-Environmental Services
Dungarvan
Co. Waterford

Clare County Council
Aras Contae an Clair
New Road
Ennis
Co. Clare

Report submitted by:
Minerex Geophysics Limited

Issued by:

Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare, W23X7Y5
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Tel.: 01-6510030
Email: info@mgx.ie

Author: John Connaughton (Geophysicist)

Reviewer: Hartmut Krahn (Senior Geophysicist)



Subsurface Geophysical Investigations

EXECUTIVE SUMMARY

1. Minorex Geophysics Ltd. (MGX) carried out a geophysical survey consisting of EM31 Ground Conductivity, 2D-Resistivity and seismic refraction (p-wave) surveying for the ground investigation for the proposed extension of the Drumcliffe Cemetery in Ennis, County Clare.
2. The main objectives of the survey were to determine the ground conditions under the site, to determine the depth to rock and the overburden thickness, to estimate the strength or stiffness or compaction of overburden and the rock quality, to determine preferential ground water flows, and to detect possible karstified rock.
3. All the geophysical results show uniformity across the survey area with little variation across the site.
4. The EM31 Ground Conductivity data indicates boulder clay underlying the site. There is also an underground metal pipe indicated.
5. The 2D-Resistivity shows a thick layer of boulder clay which could be described as sandy gravelly clay and silt with cobbles and boulders.
6. The seismic refraction data was modelled with four layers and ties in well with the 2D-Resistivity data.
7. Layer 1 is described as soft or loose soil. This layer is up to 2m deep across the site.
8. Layer 2 is interpreted as very stiff boulder clay. This layer extends to depths of 2.5 – 5.5m below ground level (bgl)
9. Layer 3 is interpreted as hard boulder clay. This layer has a thickness of 4 – 9.5m.
10. The top of the good to very good limestone is interpreted at depths of 8.5 – 13.5m bgl.
11. The survey area is underlain by a thick layer of highly consolidated boulder clay.
12. This overburden would have a low ground water permeability.
13. There is no indication of karstified limestone within the underlying bedrock to the depth of the survey. The thick highly consolidated boulder clay overlying the limestone would provide good protection from any potential karstified limestone being affected by ground water flows.

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Map 1: Geophysical Survey Location Map	1 x A3	6667d_Drawings.dwg
Map 2: EM31 Ground Conductivity Contour Map	1 x A3	6667d_Drawings.dwg
Figure 1: Models of Geophysical Survey	1 x A3	6667d_Drawings.dwg
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1. INTRODUCTION

1.1 Background

Minerex Geophysics Ltd. (MGX) carried out a geophysical survey for an extension of the Drumcliffe Cemetery in Ennis, Co. Clare. The survey consisted of EM31 ground conductivity, 2D-Resistivity and seismic refraction (p-wave) measurements. The survey was commissioned by Hydro-Environmental Services.

This survey utilized various complimentary geophysical methods to improve final interpretations. The role of geophysics as a non-destructive fast method is to provide a geological interpretation over a wide area to complement direct ground investigations at specific locations. The direct ground investigation results can be used to improve the initial geophysical results and interpretation.

The survey was aimed both at investigating the ground conditions and to indefinitely potential groundwater flow paths under the site.

1.2 Objectives

The main objectives of the geophysical survey were:

- To determine the ground conditions under the site
- To determine the depth to rock and the overburden thickness
- To estimate the strength or stiffness or compaction of overburden materials and the rock quality
- To determine the type of overburden and rock
- To detect lateral changes within the geological layers
- To detect possible karstified zones within the rock or karst features
- To identify potential groundwater flow paths under the site

1.3 Site Description

The site is located in the southeast corner of the existing Drumcliffe Cemetery. There is a track which runs through the cemetery to the survey location. The NW part of the survey area is within the cemetery ground while the rest of the area is within an agricultural grass field. The Drumcliffe Water Treatment Plant borders the site to the SE.

Elevations on site rise from 19.3mOD in the NW to 31.7 in the SE.

1.4 Geology

Online geological maps of Ireland (GSI, 2022) give the following information:

The overburden geology consists of till derived from limestones.

In terms of rock the survey area is underlain by the Burren Formation, described as pale grey clean skeletal limestone.

The Burren formation is karstifiable and there is a swallow hole noted just north of the cemetery. The path of the underground watercourse is towards the south and it is shown as passing under the survey area. The connection has been proven by tracer tests by the Geological Survey of Ireland.

There are no faults or shallow rock recorded near the site.

1.5 Report

This report includes the results and interpretation of the geophysical survey. Maps, figures and tables are included to illustrate the results of the survey. More detailed descriptions of geophysical methods and measurements can be found in GSEG (2002), Milsom (1989) and Reynolds (1997).

The description of soil, rock and the use of geotechnical terms (soft, stiff, dense etc) follows Eurocode (2007) and BSI (2015) standards. The terms are defined in the standards and the physical parameters are related from experience. This geophysical survey has been acquired, processed, interpreted and reported in accordance with these guidelines.

A digital OSI map was provided by the client and is used as the background map in this report. Elevations were surveyed on site and are used in the vertical sections.

The interpretative nature and the non-invasive survey methods must be taken into account when considering the results of this survey and Minerex Geophysics Limited, while using appropriate practice to execute, interpret and present the data, give no guarantees in relation to the existing subsurface.

2. GEOPHYSICAL SURVEY

2.1 Methodology

The methodology consisted of using EM31 Ground Conductivity measurements across the site and 2D-Resistivity surveying and Seismic Refraction surveying, along proposed locations crossing the survey area.

The survey locations are indicated on Map 1. The lines, and parameters are tabulated in Table 1.

Table 1: Geophysical Survey Locations and Acquisition Parameters

Resistivity Line	Electrode Spacing/m	Number of Electrodes	Line Length/m
R1	3	40	117
R2	3	32	93
R3	3	77	228
SUM			438
Seismic Line	Geophone Spacing/m	Number of Geophones	Line Length/m
S1	3	40	117
S2	3	32	93
S3	3	77	228
SUM			438

2.2 EM31 Ground Conductivity

The EM31 ground conductivity survey was carried out over the area indicated in Map 1 on lines nominally 10 m apart. Along each line a reading of ground conductivity was taken every second while walking along, thereby resulting in a survey grid of nominally 10 x 2 m. The locations were measured with a sub-meter accuracy SERES DGPS system attached to the EM31 and all data was jointly stored in a data logger. The conductivity meter was a GEONICS EM31 with Archer2 data logger and NAV31 data acquisition software. The instrument was compared to base station readings and no EM drift was recorded.

EM31 ground conductivity determines the bulk conductivity of the subsurface over a typical depth between 0 and 6m bgl. and over a radius of approx. 5m around the instrument. When looking for clay, silt and water infill within rock occurring at relatively shallow depth the EM31 can find anomalous rock zones with a vertical extent of approx. 3m. The measurements are disturbed by metal and other conductive objects in close proximity to the instrument, and therefore no geological interpretations can be made in the vicinity of such

man-made objects. Either readings were not taken near sources of interference, or notes were taken by the surveyor in order to remove these during processing or to account for these in the interpretation.

2.3 2D-Resistivity (ERT)

2D-Resistivity lines were surveyed with electrode spacing of 3m, up to 64 electrodes per set-up and a maximum length of 189m per set-up. The readings were taken with a Tigre Resistivity Meter, Imager Cables, stainless steel electrodes and a laptop with ImagerPro acquisition software.

During 2D-Resistivity surveying, data is acquired in the form of linear arrays using a suite of metal electrodes. A current is induced into the ground via a pair of electrodes whilst a potential difference is measured across a second pair of electrodes. This allows for the recording of the apparent resistivity in a two-dimensional arrangement below the line. The data is inverted after the survey to obtain a model of subsurface resistivities. The generated model resistivity values and their spatial distribution can then be related to typical values for different geological materials.

The penetration depth of a resistivity set-up increases towards the centre where it reaches depths of over 15m.

2D-Resistivity has previously proven zones of anomalous or karstified rock with lateral extents of 5m and more.

2.4 Seismic Refraction

Seismic refraction lines were surveyed with geophone spacing of 3m and 24 geophones per set-up resulting in a 69m length per set-up. The recording equipment consisted of a 24 Channel GEOMETRICS ES-3000 engineering seismograph with 4.5Hz vertical geophones. The seismic energy source consisted of a hammer and plate. A zero-delay trigger was used to start the recording. Normally 7 shot points per p-wave set-up were used.

Set-ups were acquired in longer continuous lines using common shot points between set-ups and concatenating into longer lines at the processing stage.

The seismic refraction survey method focuses on propagating p-waves travelling through the subsurface, which are generated by hitting a hammer on a plate or other source. As the wave propagates through the subsurface, its velocity varies as it travels through overburden, rock with different elastic properties, and along geological boundaries. Velocity data is recorded via the surveying equipment, which is then processed, allowing geological layer thicknesses and boundaries to be established.

Seismic Refraction generally determines the depth to horizontal or near horizontal layers where the compaction or strength or rock quality changes with an accuracy of around 20% of the depth to that layer.

Where the layers are shallower than the geophone spacing depth deviations of +/- 1m to top of layers can occur. Where low velocity layers or shadow zones are present (e.g., below solid ground surface) or where layers dip with more than 20 degrees angle the accuracy becomes much less.

The seismic refraction set-ups with 69m individual length have a reasonable penetration depth of around 15m. An internationally accepted maximum depth estimate for a seismic refraction set-up is 1/6 of the set-up length including offshots. The depth penetration varies according to the velocity structure of the subsurface. In this report we used a depth of 15m bgl. where the seismic modelling was ended as deeper modelling becomes less meaningful.

2.5 Site Work

The data acquisition was carried out between the 15th and 16th of December 2022. The weather conditions were fair throughout the acquisition period. Health and safety standards were adhered to at all times. The locations and elevations were surveyed with a Carlson NR3 RTK-GPS to accuracy < 0.05m.

3. RESULTS AND INTERPRETATION

The interpretation of geophysical data was executed utilizing the known response of geophysical measurements, typical physical parameters for subsurface features that may underlay the site, and the experience of the authors.

3.1 EM31 Ground Conductivity

The EM31 ground conductivity values were contoured and gridded with the SURFER contouring package. The contours are created by gridding and interpolation and care must be taken when using the data. The contour map is overlaid over the location and base map (Map 2) and the values in milliSiemens/metre (mS/m) are indicated on the colour scale bar.

The natural conductivity levels are very uniform across the survey area ranging from 5 to 9 mS/m. This indicates a boulder clay overburden across the survey area with little variation in composition. The negative and very low readings (Blue) along the north indicate a line of buried metal (like a pipe) while the higher readings (Red) along the border of the cemetery and in the SE along the boundary with the Water Treatment Plant are due to interference from metal fencing. The line of slightly higher conductivities (Yellow) running NW-SE is related to a former field boundary.

3.2 2D-Resistivity (ERT)

The 2D-Resistivity data was positioned and inverted with the RES2DINV inversion package. The programme uses a smoothness constrained least-squares inversion method to produce a 2D model of the subsurface resistivities from the recorded apparent resistivity values. Three variations of the least squares method are available and for this project the Jacobian Matrix was recalculated for the first three iterations, then a Quasi-Newton approximation was used for subsequent iterations. Each dataset was inverted using seven iterations resulting in a typical RMS error of <3.0%. The resulting models were colour contoured with the same resistivity scale for all lines and they are displayed as cross sections (Figure 1).

Resistivities are characteristic for certain overburden and rock types. If there is a high content of clay minerals (which are electrically conductive) then the overburden resistivity will be lower than as if there is a high content of clastic grains like sand or gravel. The purer the clay and the lower the sand and gravel content, the lower the resistivity. Water content in overburden layers can influence the resistivities, but generally clay content has a more dominating effect.

Within bedrock types like clean limestone, high resistivities indicate a fresh, strong, unweathered rock. As the weathering in the rock increases the resistivity gets lower because of weathering products, remineralisation of rock and infill of cracks, faults and voids with clay and water. Weathering within rock is typically indicated by lower resistivity values in the cross sections.

The resistivities cover a range typical for materials from clay rich overburden (low resistivities) to fresh strong unweathered bedrock (high resistivities). The ranges have been taken into the consideration for the

interpretation. The overburden on this site is dominated by medium resistivity values (125 - 500 Ohmm) which typically indicate a boulder clay. High resistivities at depth (>500 Ohmm) indicate a clean limestone bedrock.

3.3 Seismic Refraction

The seismic refraction data was positioned and processed with the SEISIMAGER software package to give a layered model of the subsurface. The number of layers has been determined by analysing the seismic traces and 4 layers were used in the models. All seismic lines were subject to a standardised processing sequence which consisted of a topographic correction which was based on integrated elevation data, first break picking, tomographic inversion, travel-time computation via ray-tracing and velocity modelling. Residual deviations of typically 0.4 to 1.8 msec RMS have been obtained for each line. Following each processing stage QC procedures were adhered to. The resulting layer boundaries are shown as thick lines overlaid on the 2D-Resistivity cross sections (Figure 1). The average seismic velocities obtained within the layers are annotated on the sections as bold black numbers.

The p-wave seismic velocity is closely linked to the density of subsurface materials and to parameters like compaction, stiffness, strength and rock quality. The higher the density of the subsurface materials the higher the seismic velocity. More compacted, stiffer, denser and stronger material will have a higher seismic velocity. For rock, the seismic velocity is higher when the rock is stronger, less weathered and has a higher quality. If the rock is more weathered, broken, fractured, fissured or karstified then the seismic velocity will be reduced compared to that of intact fresh rock.

Because of the above relationship, the seismic refraction method and seismic velocities are suitable to investigate ground where the layers get denser, more compacted and stronger with depth. A disadvantage is that some materials may have the same seismic velocity hard or very dense highly consolidated overburden and a weathered rock can have the same seismic velocity range (as could be the case in the layer 3 below).

The modelled seismic data has created the following layered ground model:

Layer 1 has a thickness of up to 2m and seismic velocities of 200 - 300m/s. This overburden would be soil with a soft or loose stiffness or compaction.

Layer 2 was modelled with a velocity of 1600m/s and reaches a depth between 2.5 and 5.5m. The velocity indicates overburden material with very stiff strength or compaction.

Layer 3 velocities of 2400m/s indicate predominantly overburden with hard strength or compaction. The thickness or depth varies between 4 and 9.5 m.

Strong rock is indicated by seismic velocities of 4500m/s and the top of this strong rock varied between 8.5 and 13.5m.

3.4 Interpretation of Resistivity and Seismic Refraction

Table 2 summarises the interpretation. The stiffness or compaction and the rock strength or quality have been estimated from the seismic velocity. The estimation of the excavatability for the bedrock has been made according to the caterpillar chart published in Reynolds (1997). The geotechnical assessment for rippability will have to take factors like rock type and jointing into account and the estimation in this report is solely based on the seismic velocities.

Interpreted cross sections are shown in Figure 2. The interpretation has been made from all available information. For overburden layers and the top of the rock the seismic refraction data has been used as seismic refraction is the best method to delineate layer boundaries. The resistivity models have been used to delineate two generalised types of rock and to indicate rock head where no seismic refraction data was acquired. Resistivity data is better suited to show rock types and features within the rock while seismic refraction velocities are indicating the change of compaction, stiffness or rock quality with depth. Along short sections where only one data type is available an interpolation for the interpreted layers was made.

Table 2: Summary of Interpretation

Layer	General Seismic Velocity Range (m/sec)	General Resistivity Range (Ohmm)	Stiffness or Compaction or Rock Quality	Interpretation	Estimated Excavation Method
1	200 - 300	Any	Soft or Loose	Soil	Diggable
2	1600	125 - 500	Very stiff	Boulder Clay	Diggable
3	2400	125 - 250	Hard	Boulder Clay	Diggable
4	4500	>500	Good to very good rock	Clean Limestone	Breaking & Blasting

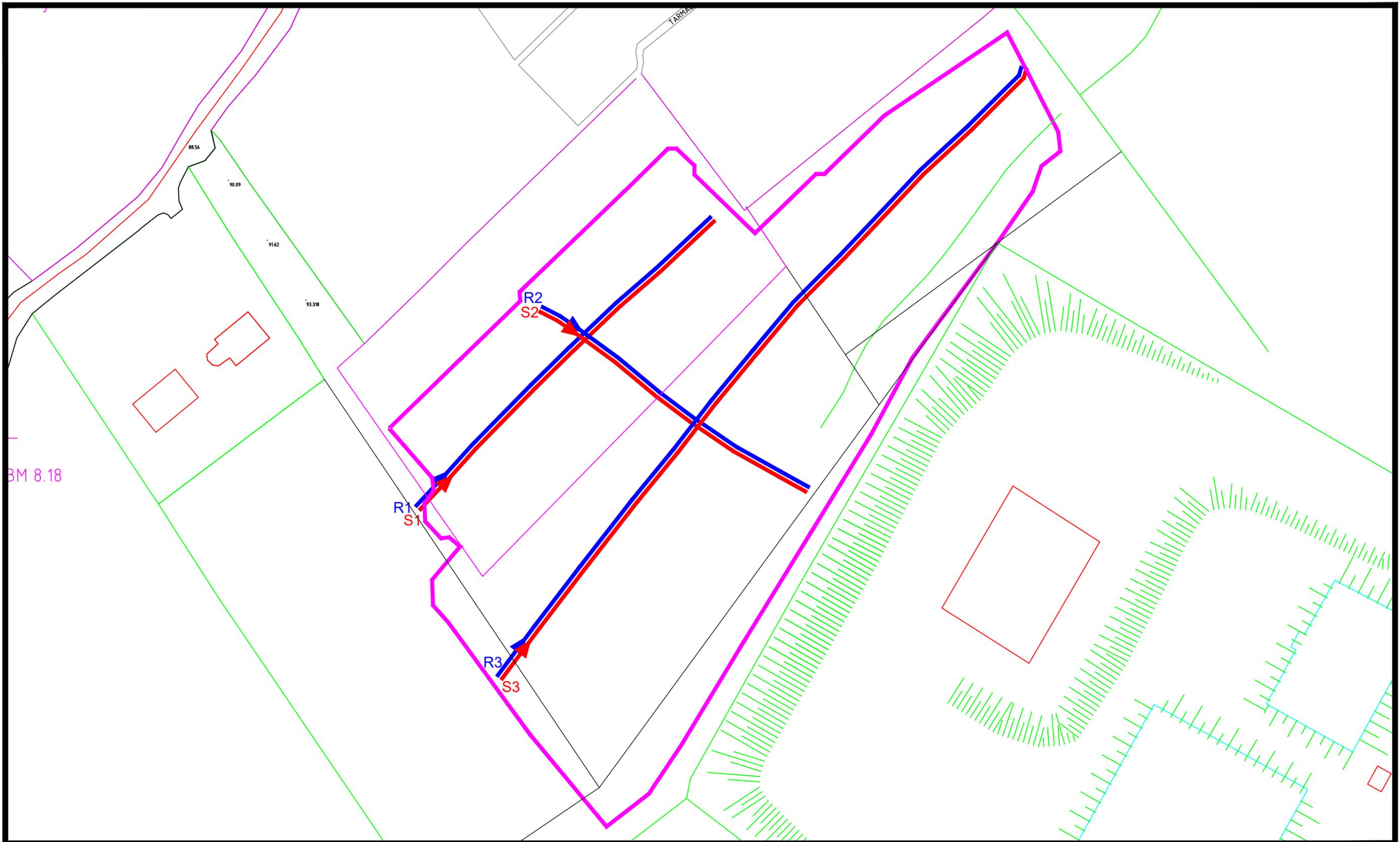
4. CONCLUSIONS

The following conclusions are made:

- The geophysical surveys carried out for the Drumcliffe Cemetery extension consisted of EM31 Ground Conductivity, 2D-Resistivity and seismic refraction surveying.
- At all locations there was a strong correlation between all three geophysical survey methods.
- The EM31 Ground Conductivity data shows a consistent boulder clay overburden throughout the survey area.
- The 2D-Resistivity data shows thick boulder clay across all three lines. High resistivities at depth indicate a clean limestone bedrock.
- The seismic refraction data was modelled with a total of four layers.
- Layer 1 is interpreted as soft or loose soil. This layer is up to 2m thick.
- Layer 2 reaches depths of 2.5 – 5.5m bgl and is interpreted as very stiff boulder clay.
- Layer 3 is described as hard boulder clay and has a thickness of 4– 9.5m.
- The top of the good to very good limestone layer (Layer4) is found at depths of 8.5 – 13.5m bgl.
- The data is very uniform across the survey area with only small variations in the overburden composition and rock depth across the site.
- The thick layer of clay dominated boulder clay would cause low ground water permeability.
- Within the rock layer there is no indication of karstified limestone. The thick overlying highly consolidated glacial till will provide good protection from any underlying karstified limestone that may be present deeper than the survey depth.

5. REFERENCES

1. **BSI, 2015.** BS5930, Code of Practice for Ground Investigations, British Standards Institute 2015
2. **Eurocode, 2007.** EN 1997-2:2007. Eurocode 7. Part 2 Ground Investigation and Testing 2007
3. **GSEG, 2002.** Geophysics in Engineering Investigations. Geological Society Engineering Geology Special Publication 19, London, 2002
4. **GSI, 2022.** Online Bedrock Geological Map of Ireland. Geological Survey of Ireland 2022
5. **Milsom, 1989.** Field Geophysics. John Wiley and Sons, 1989
6. **Reynolds, 1997.** An Introduction to Applied and Environmental Geophysics. John Wiley and Son, 1997
7. **Weaver, 1975.** Geological Factors significant in the Assessment of Rippability, 1975



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CLIENT Hydro Environmental Services
Clare County Council
PROJECT Drumcliffe Cemetery, Co. Clare
Geophysical Survey
TITLE Map 1: Geophysical Survey
Location Map

SCALE: 1:1000 @ A3
PROJECT: 6667
DRAWN: JS
DATE: 20/12/2022
MGX FILE: 6667d_Drawings.dwg
STATUS: Draft

Geophysical Survey Locations:

- R2 2D-Resistivity Line
- S1 Seismic Refraction Line
- EM31 Survey Area

Locations are in Irish Transverse Mercator (ITM), Elevations are in mOD (Malin Head)

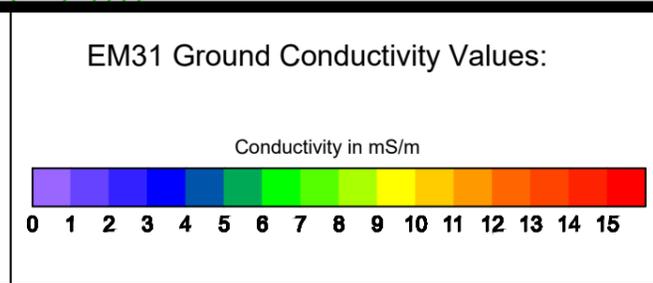




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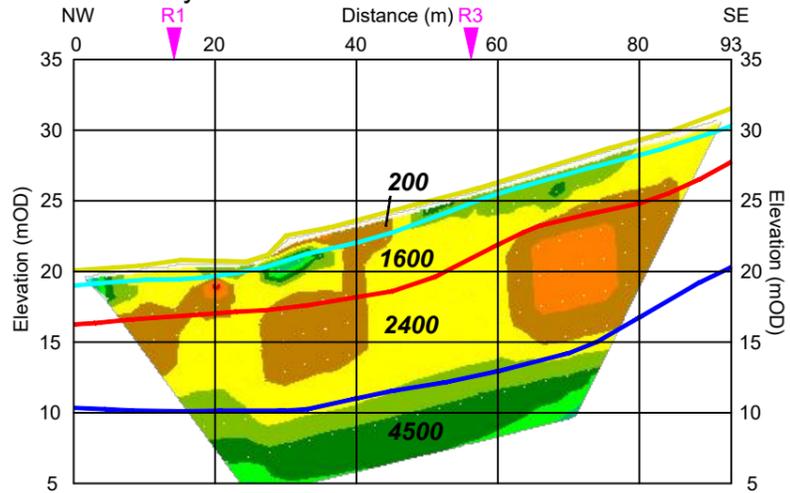
CLIENT	Hydro Environmental Services Clare County Council
PROJECT	Drumcliffe Cemetery, Co. Clare Geophysical Survey
TITLE	Map 2: EM31 Ground Conductivity Contour Map

SCALE:	1:1000 @ A3
PROJECT:	6667
DRAWN:	JS
DATE:	20/12/2022
MGX FILE:	6667d_Drawings.dwg
STATUS:	Draft

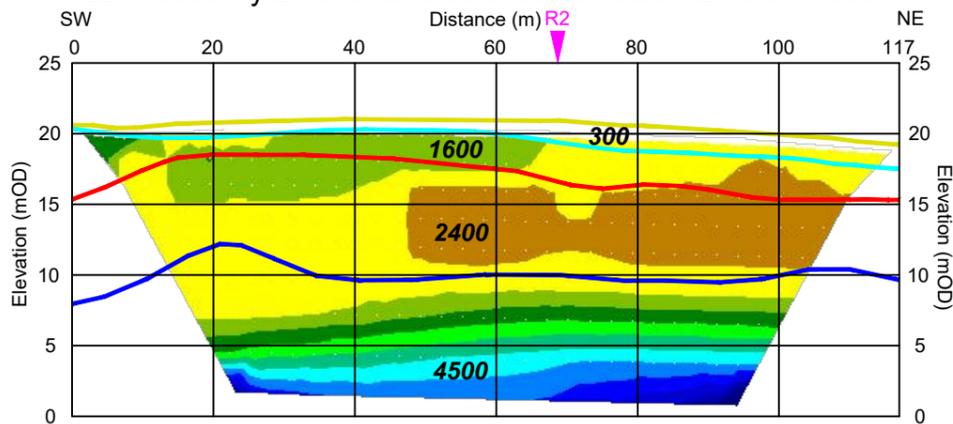


The map shows the EM31 ground conductivity contours in mS/m. The negative and low (blue) conductivities indicate buried metal. The middle range (green) values indicate boulder clay. The yellow NW-SE line is a former field boundary. The high (red) values indicate interference from metal objects (fences).

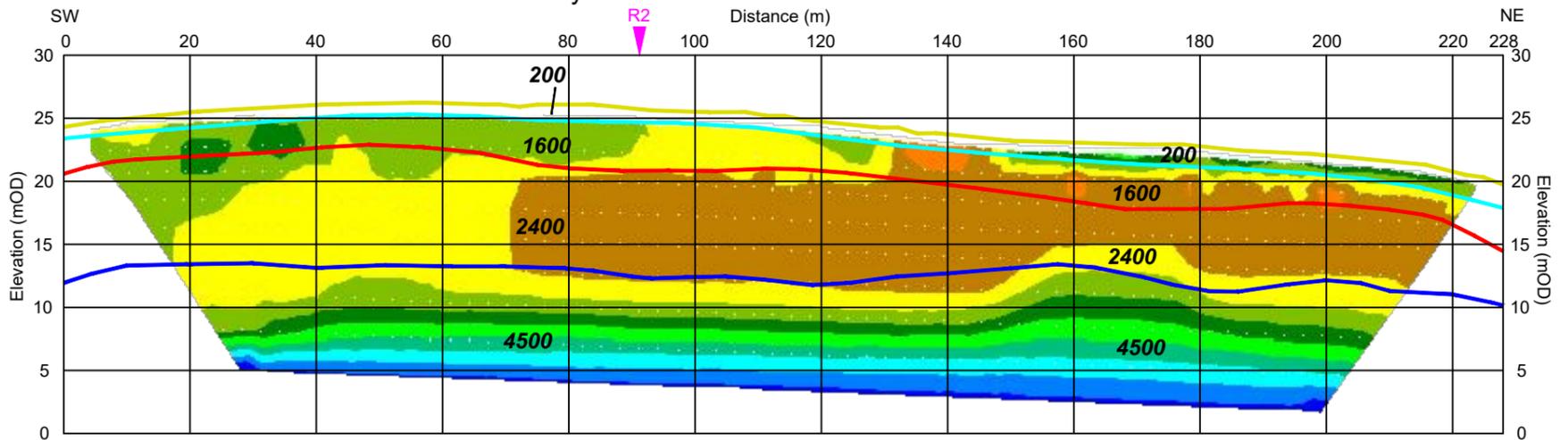
2D-Resistivity Line R2 and Seismic Refraction Line S2 Model



2D-Resistivity Line R1 and Seismic Refraction Line S1 Model



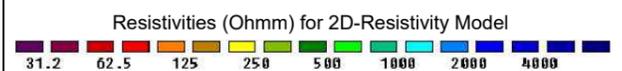
2D-Resistivity Line R3 and Seismic Refraction Line S3&4 Model



Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (200 - 300 m/s)
- Top of Layer 2 (1600 m/s)
- Top of Layer 3 (2400 m/s)
- Top of Layer 4 (4500 m/s)
- 1600** Seismic Velocity in m/s

2D-Resistivity Model Values:



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CLIENT Hydro Environmental Services
Clare County Council

PROJECT Drumcliffe Cemetery, Co. Clare
Geophysical Survey

TITLE Figure 1: Models
of Geophysical Survey

SCALE: 1:1000 @ A3, VE x 2

PROJECT: 6667

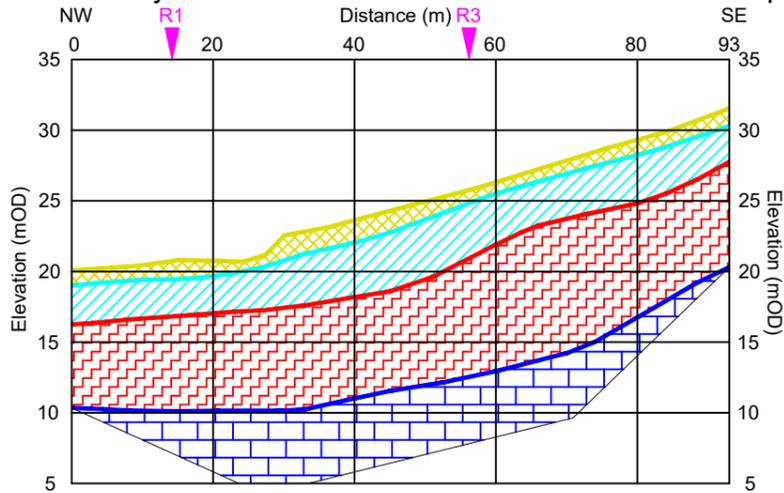
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DATE: 20/12/2022

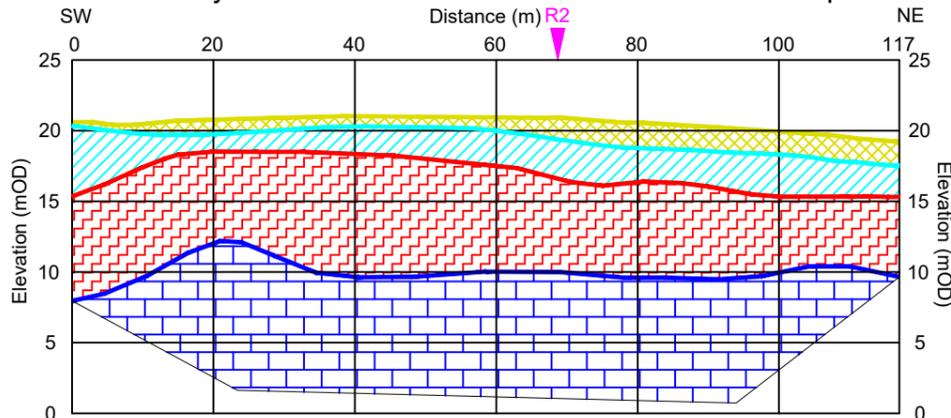
MGX FILE: 6667d_Drawings.dwg

STATUS: Draft

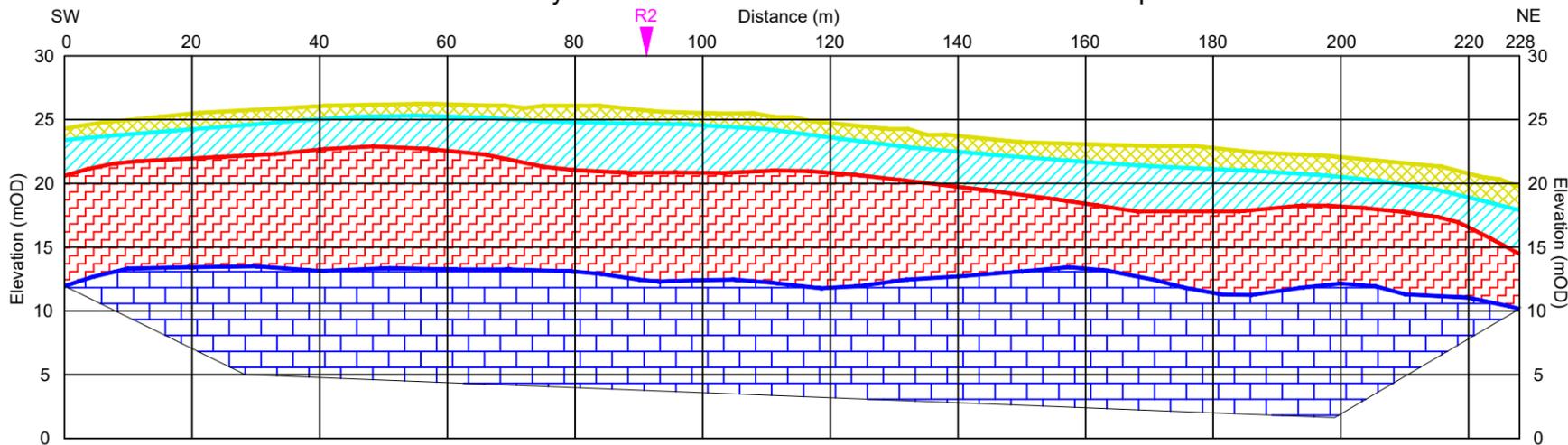
2D-Resistivity Line R2 and Seismic Refraction Line S2 Interpretation



2D-Resistivity Line R1 and Seismic Refraction Line S1 Interpretation



2D-Resistivity Line R3 and Seismic Refraction Line S3&4 Interpretation



Layers from Seismic Refraction Model:

-  Ground Surface/Top of Layer 1 (200 - 300 m/s)
-  Top of Layer 2 (1600 m/s)
-  Top of Layer 3 (2400 m/s)
-  Top of Layer 4 (4500 m/s)

Interpretation:

-  1 Soft or loose Soil
-  2 Very stiff Boulder Clay
-  3 Hard Boulder Clay
-  4 Good to very good clean Limestone

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APPENDIX II: Tobin memo/email 20/04/2023

Memorandum

Date: 20/04/2023
To: Connie O'Driscoll,
Cc: Coran Kelly, Darren Clarke
From: Natalie Duncan
Ref: 11497
Re: Drumcliff cemetery planning assessment

Background

Tobin were engaged by Uisce Éireann on 10th March 2023, regarding a proposed part 10 planning submission by Clare County Council for the extension of an existing burial ground at Drumcliff, Ennis, Co. Clare. In particular, to carry out a screening of the investigations carried out by HES in 2022 which assessed the risk of the development on Ennis public water supply, Drumcliff springs and water treatment plant.

Information sources

This report is based on the review of the following information/reports available to Tobin:

- Hydro environmental Services, 2023. Memo: Drumcliff PWS and Proposed Drumcliff Burial Ground.
- Documents associated with Planning Application Reg. No. 228008 (<https://www.eplanning.ie/ClareCC/AppFileRefDetails/228008/0>)
 - Site location map
 - Site layout plan
 - Sections
 - Appropriate Assessment Screening Report
- GSI mapviewer
- EPA mapviewer
- Uisce Éireann internal databases
- EPA (2011). Guidance on the authorisation of discharges to groundwater.
- DAERA NI (2019). Practice Guide Cemeteries, Burials and Water Environment. A good practice guide for applicants and planning authorities when planning cemetery developments or extensions.
- Buckley, C. (2012). Graveyards and groundwater. Proceedings of the 32nd Annual Groundwater Conference, IAH (Irish Group)

Location and description of proposed works:

Drumcliff cemetery is located ca. 2 km northwest of Ennis, Co. Clare (Figure 1). The proposed development covers an area of ca. 9.8 acres.

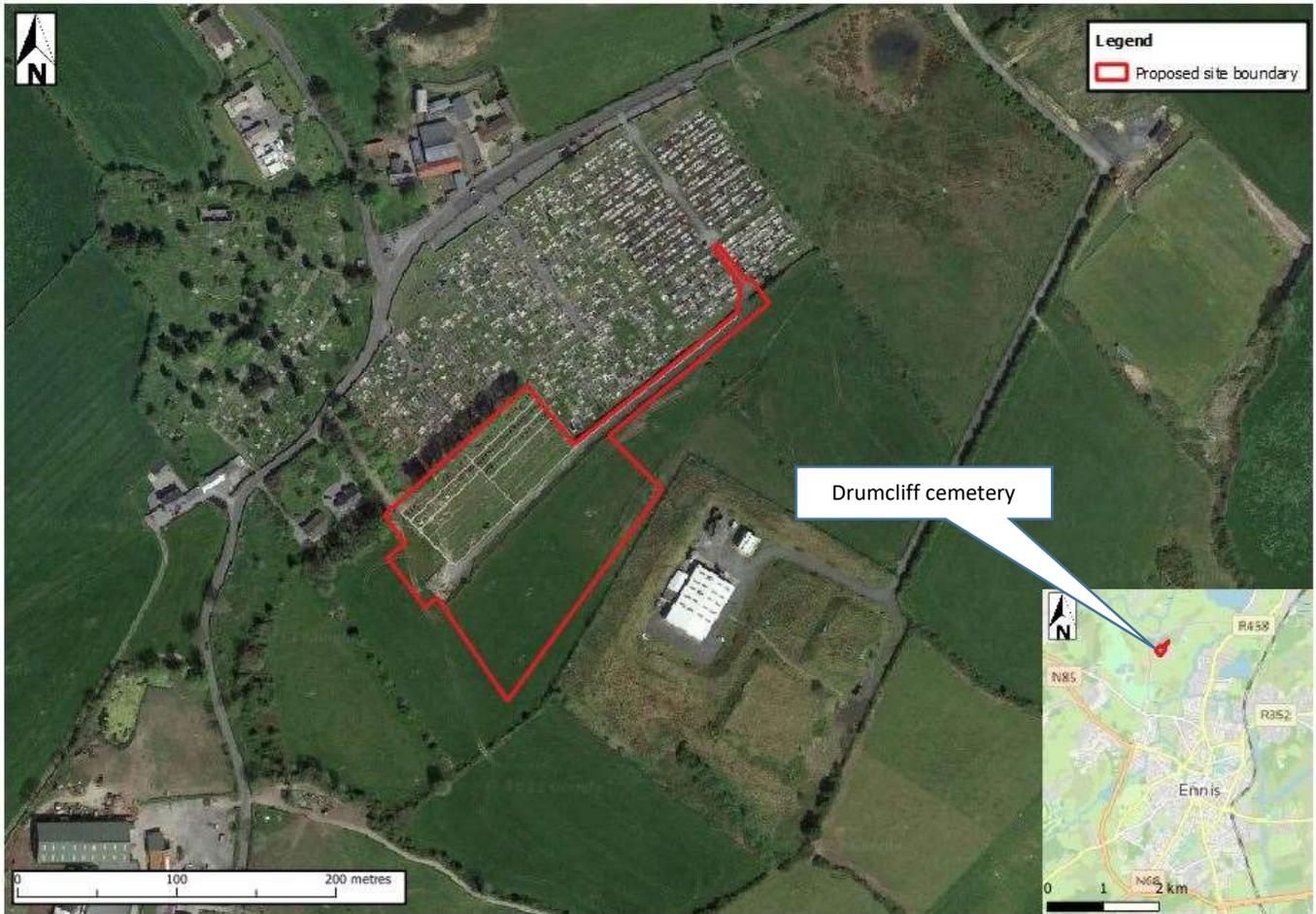


Figure 1 Location of the proposed extension of Drumcliff cemetery

A detailed map of the proposed development is provided in Figure 2. It comprises improvement works to St Brigids Section E and the development of an extension to the existing Burial Ground, including:

- An addition of circa 350 double plots including provision for ash plots,
- Access road improvements including lay-bys, turning circle and traffic calming measures,
- Parking; 23 standard spaces, 6 Wheelchair accessible spaces,
- Footpaths,
- Drainage,
- Planting and landscaping including Columbarium and Reflectance Garden, and
- Associated Site Works.

It is understood, from looking at the proposed site cross sections submitted in the planning application, that “double plots” are side-by-side, to a total depth of 1.8 mbgl and not stacked on top of each other.

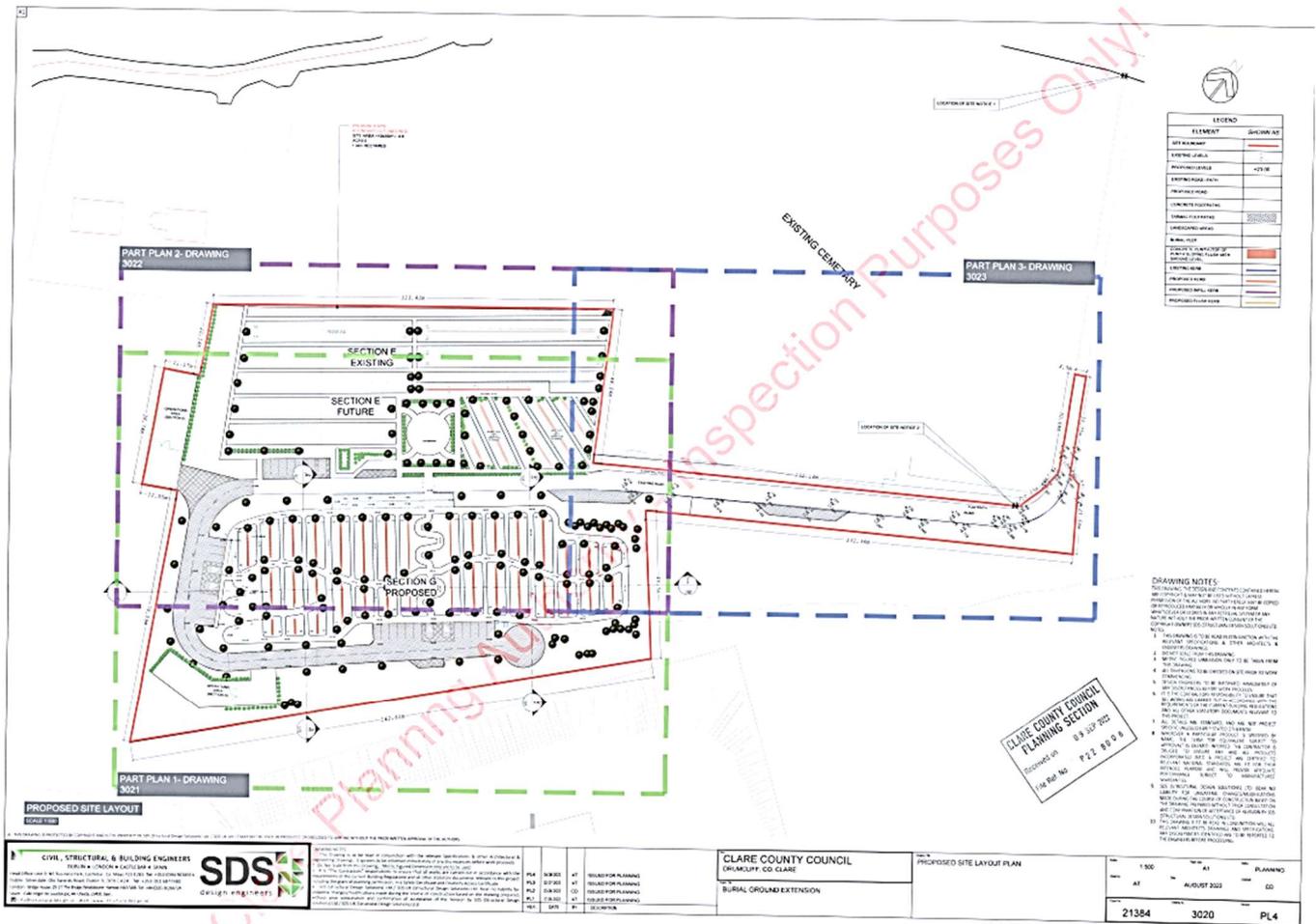


Figure 2 Proposed site layout of Drumcliff cemetery extension.

Location and physical setting of Ennis Public Water Supply (Drumcliff springs source):

Ennis PWS is supplied by one groundwater spring source, Drumcliff Springs, located ca. 1 km south of the cemetery site. The Source Protection Zone to this spring source has been delineated and encompasses the cemetery site. Figure 3 shows the location of the source springs and Zone of Contribution in relation to Drumcliff cemetery.

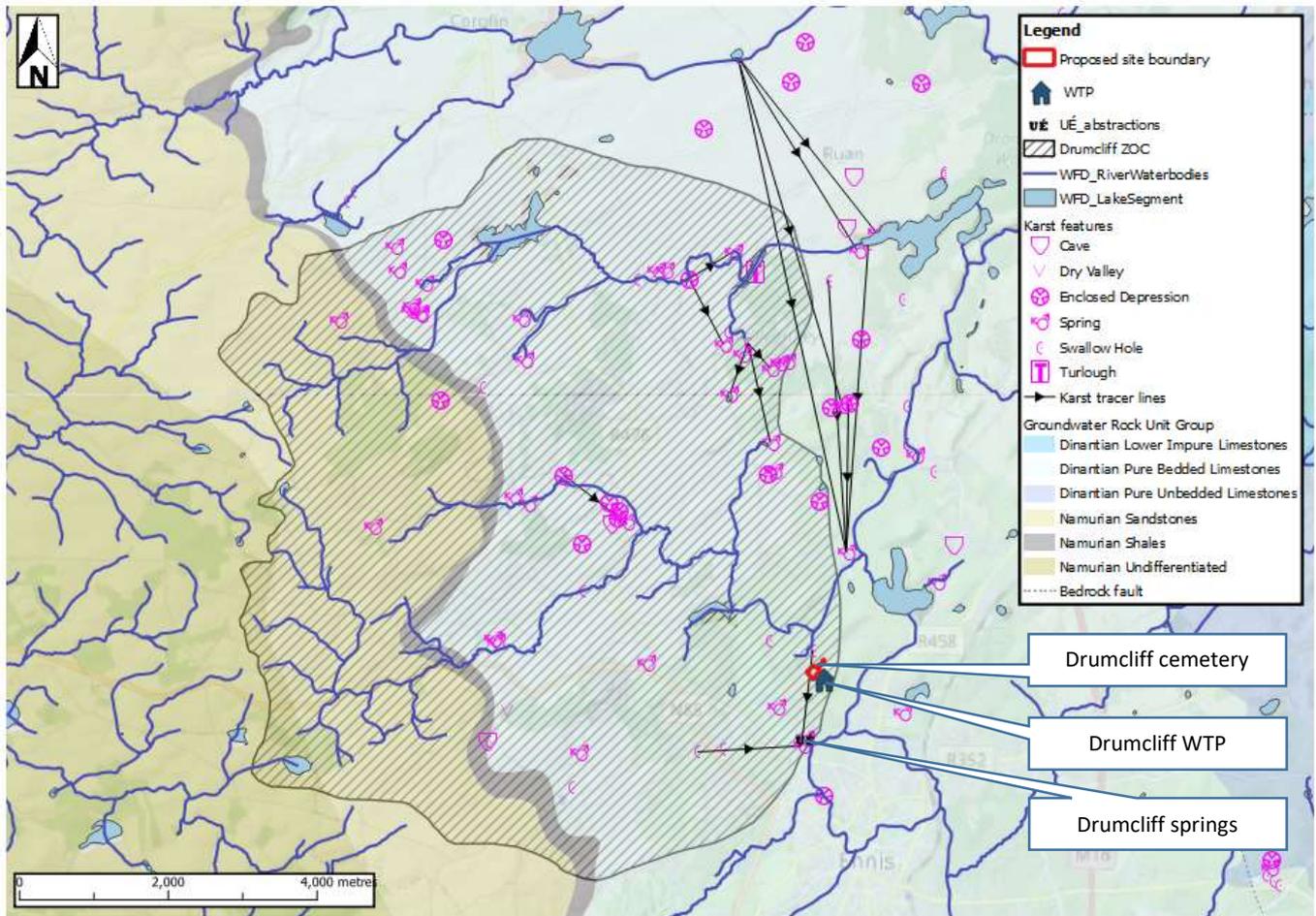


Figure 3 Regional setting.

The cemetery and the source springs are located within Dinantian Pure bedded limestones, which is a Regionally Important Karstified bedrock aquifer, dominated by conduit flow (Rkc). Karst features are common in the area, including the source springs and a number of swallow holes. Dye tracing from a swallow hole located ca. 50 m north of the cemetery proves a connection to Drumcliff springs that flows beneath the cemetery site and proposed extension boundary.

The cemetery and the proposed extension are located on the flank of two drumlins. These drumlins are expected to give rise to relatively deep till subsoils at their centres (Tills derived from Devonian sandstones) with 'moderate' permeability (GSI). Consequently, the groundwater beneath the site and extension has 'moderate' vulnerability under the drumlins in the northwest and southeast, and 'high' vulnerability in the centre, between the drumlins where subsoils are expected to be shallower (Figure 4). There are no surface water features mapped within the cemetery and extension boundary, there is also no known risk of fluvial or groundwater flooding within this boundary.

The apparent presence of deeper, 'moderate' permeability subsoils, and the lack of surface water features that could act as a contaminant pathway, reduces the risk of groundwater contamination. A site specific investigation and risk assessment were carried out for the proposed extension in 2022, by Hydro Environmental Services (HES). The next section summarises and assesses the outcomes and builds on these outcomes.

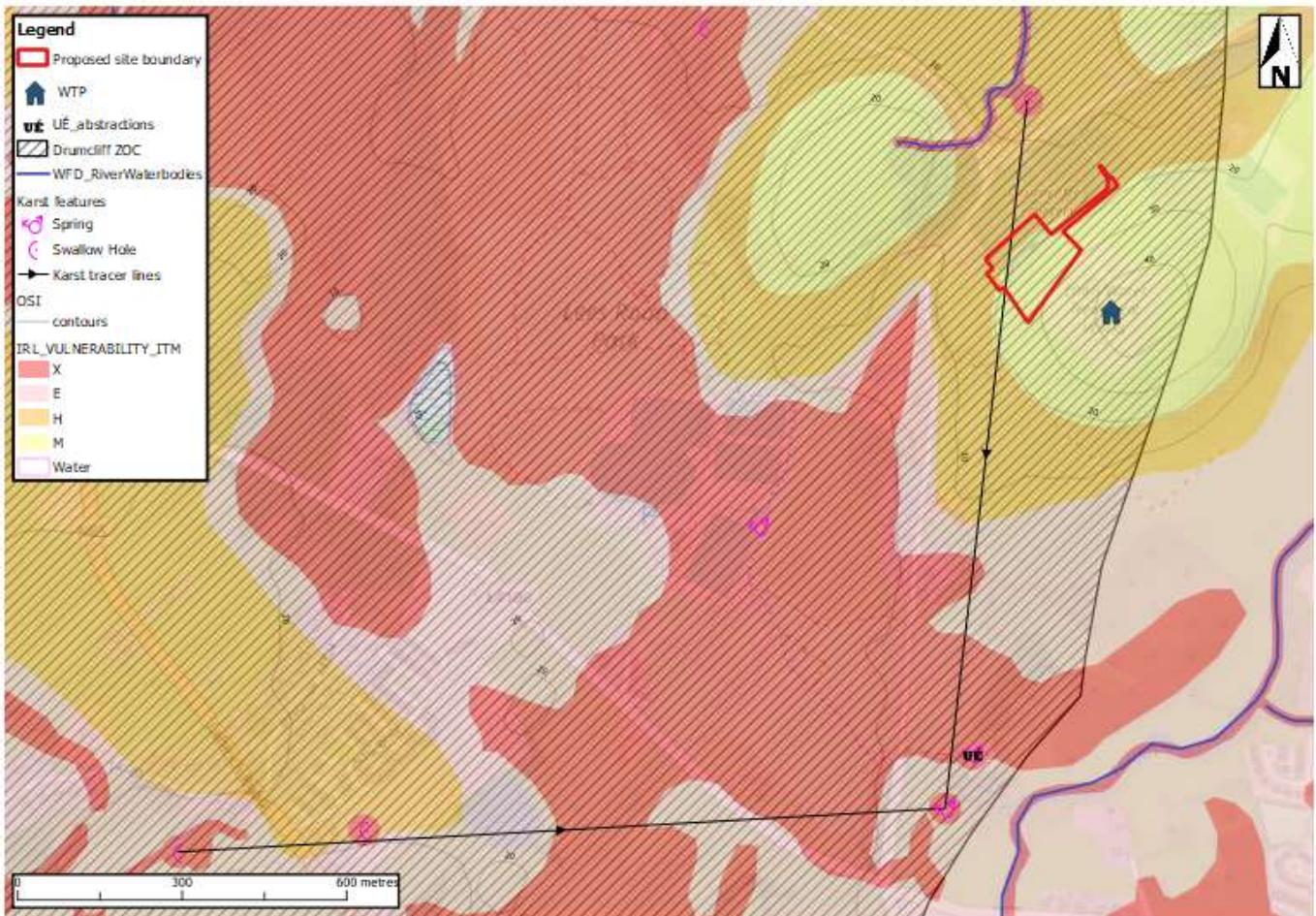


Figure 4 Groundwater vulnerability

Discussion of the HES site investigations and risk assessment and recommendations for further actions:

The risk assessment carried out by HES includes an assessment of the potential impacts of both the construction and operational phases of the development. The site investigations (locations shown in Figure 5) consisted of:

1. Site walkover to observe existing ground conditions.
2. Excavation of 5 trial pits to between 1.7-1.9 mbgl and BRE digest infiltration tests.
3. Geophysics, comprising a conductivity survey and a resistivity survey, to investigate subsoil type and compaction, depth to bedrock, potential groundwater flow paths under the site and the presence of karst features.

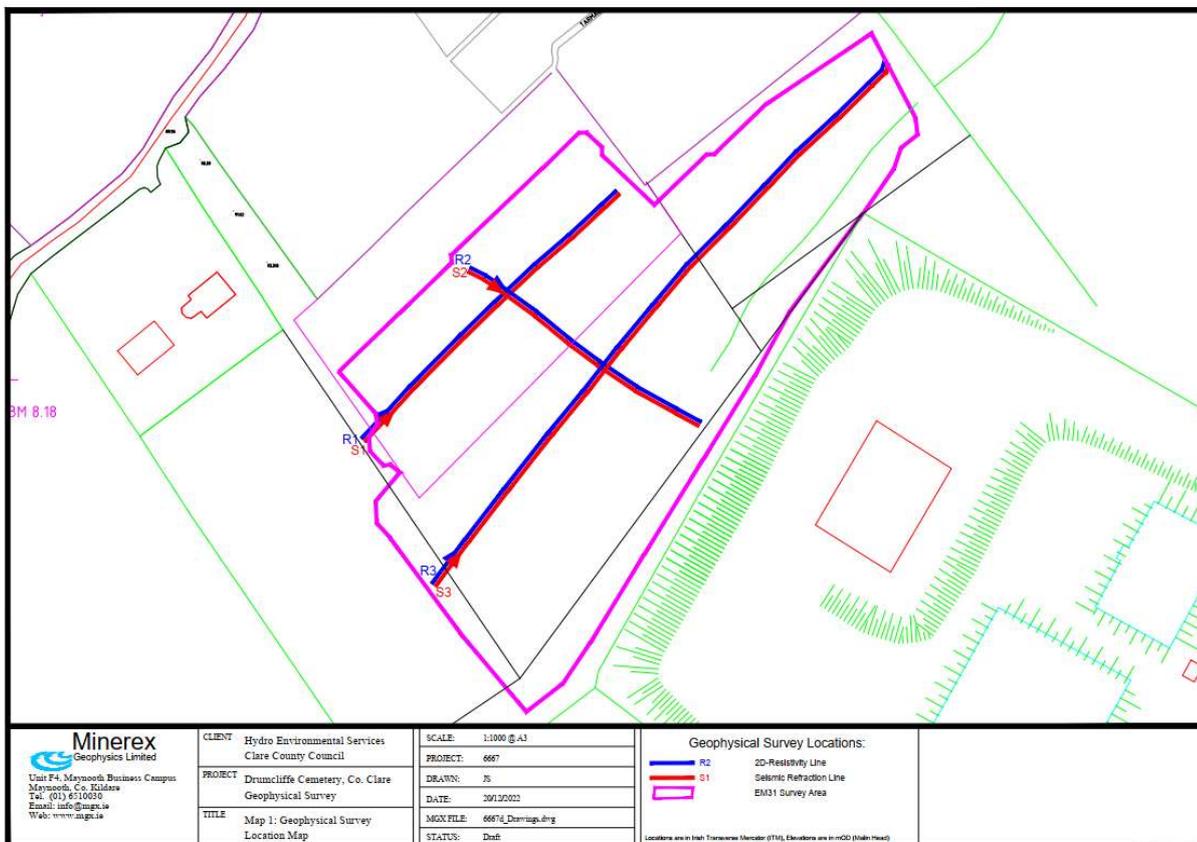
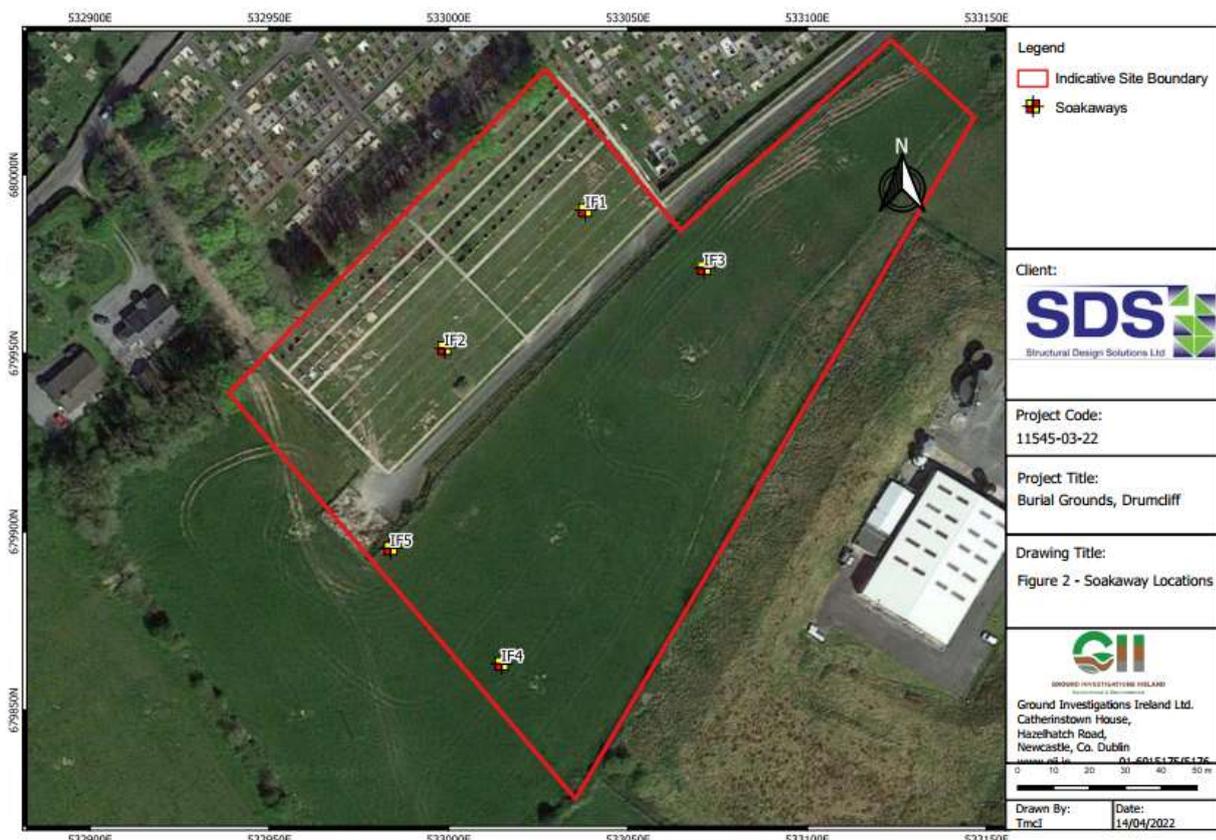


Figure 5 Site investigations – location of trial pits and geophysical survey lines.

Surface water:

The site walkover encountered surface water at one location within the site boundary, close to the trial pit location IF 3 at the centre of the proposed development. It was considered to be standing water over impermeable soils. The closest mapped surface water feature is located on the northern perimeter of the “old” Drumcliff cemetery, located ca. 175 m from the proposed extension. There is no risk of surface water flooding (www.floodinfo.ie)

Subsoils:

Trial pits, dug to between 1.7 - 1.9 mbgl. The subsoils have been interpreted to have a texture that is ‘slightly sandy gravelly CLAY with some cobbles’ (HES, 2023).

The Soakaway tests were carried out to BRE 365, which is a surface water soakaway test designed in the UK for UK soil conditions. The tests carried out at the site suggest permeabilities in the ‘moderate’ range (GSI, 2003).

The results of the geophysical survey (2D resistivity and EM 31 ground conductivity) have been interpreted as showing a thick layer of clay (8.5 – 13.5 m of subsoils) across the site, indicating low to moderate groundwater vulnerability, and no indication of karstified limestone. No groundwater was encountered within the subsoils and it was determined that the unsaturated zone remains greater than 1 m below the base of the gravesite throughout the year.

IF 1		IF 2		IF 3		IF 4		IF 5	
Description	Depth (m)	Description	Depth (m)	Description	Depth (m)	Description	Depth (m)	Description	Depth (m)
TOPSOIL	0 - 0.15	TOPSOIL	0 - 0.15	TOPSOIL	0 - 0.20	TOPSOIL	0 - 0.25	TOPSOIL	0 - 0.15
MADE GROUND	0.15 - 0.70	Slightly sandy gravelly CLAY with many rounded cobbles	0.15 - 1.70	Sandy slightly gravelly CLAY with occasional cobbles	0.20 - 1.90	Slightly sandy gravelly CLAY with occasional cobbles	0.25 - 1.80	Slightly sandy gravelly CLAY with some cobbles	0.15 - 1.80
Slightly sandy slightly gravelly CLAY	0.70 - 1.50								
Slightly sandy gravelly CLAY with some cobbles	1.50 - 1.90								
Soakaway dimensions (l/w/d)									
1.6x0.4x1.8		1.9x0.35x2.0		1.9x0.35x1.9		1.9x0.35x1.8		1.9x0.35x1.8	
Infiltration rate (m/s) (BRE 365 method)									
6.257 x E-06		Not recorded (too slow)		4.658 x E-06		4.446 x E-06		2.771 x E-06	

Groundwater levels and flow direction:

Groundwater was not encountered during the site investigation and was interpreted to be >1 m below the base of the gravesite. Subsoil augering to at least 1 m below the base of the gravesite is recommended to confirm this.

Water quality:

No water quality testing was carried out during the investigation; however, it was noted that water samples from both the Poulacorey swallow hole (located close to the northern boundary of the existing gravesite) and the Drumcliff springs supply, have been analysed historically for Nitrates and Ammonia.

Conclusions:

The investigations carried out by HES was evaluated with reference to DAERA NI (20019) Practice guide for cemeteries, burial and the water environment, and EPA (2011) Guidance on the authorisation of discharges to groundwater. The information obtained does not appear to highlight concern with regard risk to the Drumcliff springs.

- The site boundary for the proposed burial plots are >250 m away from the Drumcliff springs.
- There are no surface water features within 50 m of the site boundary and there is no risk of flooding.
- There are no field drains within 10 m of the site boundary.
- Bedrock and groundwater is indicated in the investigation reports to be greater than 1 m below the base of the burial pit.
- No sand or gravel subsoils were encountered within the survey area and there was no groundwater encountered within the trial pits.
- The interpreted thickness and the subsoil texture suggest moderate groundwater vulnerability.

The intrusive investigations prove subsoils depth to approximately 2 m. It is understood that the base of the grave plots is designed for 1.8 mbgl. It is understood from this, that the criteria for the unsaturated depth should be at a minimum of 2.8 mbgl. It may be useful to further investigate the depth of subsoils to at least 1 m below the design base of the grave plots, and it may be useful to include for particle size distribution analysis of subsoils.

APPENDIX III: Supporting Photographs of Soakaway Tests

Drumcliffe Burial Ground – Soakaway Photographs

IF1



Drumcliffe Burial Ground – Soakaway Photographs



Drumcliffe Burial Ground – Soakaway Photographs

IF2



Drumcliffe Burial Ground – Soakaway Photographs



Drumcliffe Burial Ground – Soakaway Photographs

IF3



Drumcliffe Burial Ground – Soakaway Photographs



Drumcliffe Burial Ground – Soakaway Photographs

IF4



Drumcliffe Burial Ground – Soakaway Photographs



Drumcliffe Burial Ground – Soakaway Photographs

IF5



Drumcliffe Burial Ground – Soakaway Photographs



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